BRIDGING THE MEDICAL KNOWLEDGE AND PRACTICE GAP: ANTECEDENTS OF SUCCESSFUL SCIENTIST-PHYSICIAN COLLABORATION

by

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Submitted in partial fulfillment of the requirements

For the degree of Doctor of Philosophy

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DEDICATION

To my whole family including my parents, my lovely nieces and nephews (Jennifer, Yulianna, Yiyin and Ryan), my sister-in-laws (Huiyun and Xiufen) and my brothers (Chun and Fei) for their understanding, encouragements and support, and to my husband, who is there when I really need him.

Ryan, although I am done with my dissertation of PhD in management for now, I have not done with homework yet. You will know when you grow up that homework is not only for kids, because learning is a lifelong process!

----- Spring 2014, Cleveland, OH, USA-------
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ACKNOWLEDGEMENTS

My biggest appreciation goes to Daniel Simon for his great support that has made my study at the Weatherhead School of Management possible. Without his support in many ways, this thesis would not be possible. I am grateful forever!

I would like to thank Kalle Lyytinen, the Chair of my dissertation committee for his guidance and advice. I would also like to gratefully acknowledge my other doctoral committee members comprised of Richard Boland, Antoinette Somers and Daniel Simon for discussions, advice, feedback, correcting my English, comments and suggestions and wonderful support. The valuable discussions, interactions, and encouragement have made this process enjoyable.

Thanks go to Ann Kowal Smith and David Aron for helpful discussions and for helping me in recruiting qualitative study participants. Thanks go to Gary Hunter as well for reading and providing comments and suggestions to my quantitative paper, to James Gaskin for his wonderful tools and videos, to Jagdip Singh for pushing us further on statistics.

Special thanks go to Sue Nartker and Marilyn Chorman, for being patient with me by keeping my name in their email listing for a long time before I decided to join the program, as well as for their helps and kindness over the years. Thanks also go to Alexis Antes who reached out to help me when I really needed it.

Thanks to my colleague and friend Phil Cola, to CTSA of CWRU for helping to distribute the survey; to some of my colleagues and friends for being supportive, and being good listeners.
A special thanks to all the known and anonymous participants of my research, for taking time out of their busy schedule to grant me interviews, and for completing the survey, as well as for providing me with feedbacks on the survey. Without their kindness and generosity in time and in sharing their experiences, this research would be impossible.

My deep gratitude goes to my classmates--an extraordinary group of individuals for their inspirations, their friendship, their support, their generosity, their kindness, for correcting my English, for sharing their reading notes, and lastly for caring about me… I have felt very lucky that I joined the program at the right time and right place to be friends with and be inspired by them!
# LIST OF ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AO</td>
<td>Academic Outcome</td>
</tr>
<tr>
<td>APC</td>
<td>Academic Promotion Criteria</td>
</tr>
<tr>
<td>AR</td>
<td>Academic Reward</td>
</tr>
<tr>
<td>CBSEM</td>
<td>Covariance Based Structural Equation Model Analysis</td>
</tr>
<tr>
<td>CE</td>
<td>Communication Effectiveness</td>
</tr>
<tr>
<td>CFA</td>
<td>Confirmatory Factor Analysis</td>
</tr>
<tr>
<td>ChallMotv</td>
<td>Challenge Motivation</td>
</tr>
<tr>
<td>CO</td>
<td>Clinical Outcome</td>
</tr>
<tr>
<td>CompMotv</td>
<td>Compensation Motivation</td>
</tr>
<tr>
<td>CR</td>
<td>Clinical Reward</td>
</tr>
<tr>
<td>DV</td>
<td>Dependent Variable</td>
</tr>
<tr>
<td>EFA</td>
<td>Exploratory Factor Analysis</td>
</tr>
<tr>
<td>FDA</td>
<td>Food and Drug Administration</td>
</tr>
<tr>
<td>IV</td>
<td>Independent Variable</td>
</tr>
<tr>
<td>KT</td>
<td>Knowledge Transfer</td>
</tr>
<tr>
<td>LAD</td>
<td>Level of Access Difficulty</td>
</tr>
<tr>
<td>NIH</td>
<td>National Institute of Health</td>
</tr>
<tr>
<td>OCM</td>
<td>Organizational Collaboration Mechanism</td>
</tr>
<tr>
<td>PI</td>
<td>Professional Identity</td>
</tr>
<tr>
<td>PLD</td>
<td>Professional Language Difference</td>
</tr>
<tr>
<td>PSCD</td>
<td>Perceived Socio-Cultural Difference</td>
</tr>
<tr>
<td>RecgMotv</td>
<td>Recognition Motivation</td>
</tr>
<tr>
<td>SEM</td>
<td>Structural Equation Model</td>
</tr>
<tr>
<td>SPE</td>
<td>Satisfaction on Process Effectiveness of Collaboration</td>
</tr>
<tr>
<td>SPP</td>
<td>Scientist Physician Partnership</td>
</tr>
<tr>
<td>SS</td>
<td>Social Support</td>
</tr>
<tr>
<td>SVG</td>
<td>Shared Vision/Goals</td>
</tr>
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<td>TR</td>
<td>Translational Research</td>
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Bridging the Medical Knowledge and Practice Gap: Antecedents of Successful Scientist Physician Collaboration

Abstract

by

YUNMEI WANG

The substantial resources being invested in biomedical research have generated revolutionary discoveries in medical science. However, only about 14% of research findings make their way into clinical practice to benefit patients. And this 14% takes on average 17 years to be utilized into practice. This gap between science and practice has been labeled as “the Valley of Death”. Improving scientist-physician partnership (SPP) has recently been identified as a mechanism that could improve the transfer of medical science to clinical practice. However, research on SPP is scarce, and the mechanisms of SPP are unclear. I report on an exploratory multi-phase mixed method study of the experience of SPP by both physicians and scientists. Specifically I ask: what is involved in SPP, and what relationships and factors influence SPP and its outcomes at personal, organizational and socio-cultural levels?

I used a grounded theory approach in the first phase to identify the factors involved in SPP. My interviews with scientists and physicians revealed that the gap between medical knowledge and clinical practice is not only a language translation problem, but a wide cross-professional collaboration challenge, in which individual attributes, organizational structures and socio-cultural forces all affect the participation in and success of SPP. In order to confirm and validate the findings of the qualitative study,
a theoretical model founded on phase 1 was formulated and empirically tested using a survey of 440 physicians and scientists who have had cross-professional collaboration experiences. Three studies compose the second phase. The first study focuses on the role of personal attributes influencing SPP. I find that professional identity, recognition motivation, challenge motivation, introversion and conscientiousness all affect SPP satisfaction and outcomes directly or indirectly. The second study investigates the influence of institutional forces and organizational infrastructure on SPP. I find that academic promotion criteria serves as an incentive and has a positive effect on communication and SPP outcomes, including satisfaction and academic and clinical outcomes. Organizational collaboration mechanisms have a positive effect on communication, and communication mediates the effects of institutional factors including academic incentives and organizational collaborative mechanisms on satisfaction and academic outcomes. Difficulty to Access collaborators is negatively related to SPP effectiveness. The third study examines the impact of socio-cultural factors. This study uncovers the link between shared vision and goals, mutuality, perceived socio-cultural difference, professional language difference and social support with SPP outcomes.

Overall, this research makes theoretical and empirical contributions to literature on SPP and to cross-professional collaboration research. It provides novel insights about and practical implications for SPP in medical knowledge production and transfer. The findings are useful for understanding other inter-professional collaborations, and for informing institutional policy makers, organizational decision makers and individual collaborators.
Key Words: scientist physician partnership; collaboration; individual attribute; organizational factor; socio-cultural influence; academic outcome; clinical outcome.
SECTION I: INTRODUCTION

The Importance of the Topic

Medical Science and Practice Gap

Significant resources have been invested in biomedical research in the USA (Kerner, 2006). For example, the National Institutes of Health (NIH) alone has earmarked $30-$32 billion annually for research since 2008 yielding vast knowledge as evidenced by the revolutionary discoveries in medicine such as the completion of Human Genome Project in 2003, and by the number of publications generated from sponsored research projects (Grol & Grimshaw, 2003; Kerner, Rimer, & Emmons, 2006). However, the contribution of research to the improvement of human health is limited, largely due to the slow adoption of research findings by the medical profession (Berwick, 2003; Glasgow, 2003; Lenfant, 2003). It has been estimated, that only 14% of research findings benefit patients (Balas & Boren, 2000 as cited by Westfall Mold & Fagnan, 2007). Moreover, it takes this 14% an average of 17 years to reach the patient. This demonstrates a “very real gulf separating cutting edge laboratory discoveries from their transformation into effective treatments” (Nabel, 2010). Adoption and implementation of medical knowledge involve multiple systems including: academia, medical centers, professional governing bodies, legislation, funding agencies, regulatory agencies, pharmaceutical industry, insurance industry, legal system (intellectual property) and community systems.

There are many reasons for the gap between medical research and practice (Glasgow & Emmons, 2007; Rye & Kimbley, 2007; Scott, Plotnikoff, Karunamuni, Bize, 1

1 This dissertation research is a result of the collaborative effort of Yunmei Wang and the guidance of the committee members. However, for the purpose of this dissertation only, “I”, “My” and “Me” are used instead of “We”, “Our” or “Us”. Due to the way this research was conducted, with four individual papers written, some repetitions in the main body of the thesis and four individual papers are unavoidable.
& Rodgers, 2008). For example, “policy-makers and practitioners lack the skills and incentives to access and apply evidence” (Maynard, 2007: 251). The adoption of innovative research findings by provider organizations presents managerial and financial challenges for the adopting organizations (Rye & Kimbley, 2007). However, the extremely slow adoption of aspirin and beta-blockers in the management of myocardial infarction patients by physicians has nothing to do with financial factors (Lenfant, 2003).

Physician’s skills and attitudes and the attributes of the innovative research are important factors in the adoption of the innovation (Cabana et al., 1999; Scott et al., 2008; Titler, 2007). Other knowledge transfer barriers include: group psychology, peer influence, social marketing, and organizational characteristics (Cabana et al., 1999; Colditz et al., 2008; Titler, 2007; Young et al., 2003). The invisible influence of opinion leaders as both facilitators and inhibitors in the acceptance of an innovation is a critical factor as well (Fitzgerald et al., 2003).

Knowledge Translation

The failure to apply research findings to clinical practice timely has been framed as a problem of knowledge translation (Graham et al., 2006; Sung et al., 2003). As Lenfant (2003: 869) writes, “moving this knowledge off the shelves and into practice, making it relevant and accessible to practitioners and patients, achieving a true marriage of knowledge with intuition and judgment—all this requires translation”, and “the output of biomedical science is getting lost in translation”. Since the gap has been viewed as a problem of “translation”, the majority of the efforts to reduce the research and practice gap have focused on increasing “translation” efficiency and volume. Promoting translational research (TR) (Crist et al., 2004; Zerhouni, 2007) and emphasizing the
importance of the translators (i.e. physician scientists) are two important ways this has been done. Physician scientists are individuals who have an MD degree or a combined MD-PhD degree. They participate in both scientific research and clinical endeavors as a career role (Ley & Rosenberg, 2005).

Many initiatives, including funding and educational programs, have been used to promote translational research and to encourage physicians’ involvement in research (Harrington, 2006; Varki & Rosenberg, 2002; Zerhouni, 2007). Despite many warnings (Goldstein & Brown, 1997; Wyngaarden, 1979) and efforts—such as loan payment programs, training grants, fellowships (Ley & Rosenberg, 2005; Varki & Rosenberg, 2002)—physician scientist has been repeatedly described as a fragile, endangered and vanishing species for more than three decades (Rosenberg, 1999; Schafer, 2010; Weatherall, 1991; Zemlo et al., 2000).

The Critical Role of Scientist-Physician Partnership (SPP)

The attributes of innovative research (Titler, 2007; Scott, 2007) and physicians’ skills and attitudes (Cabana et al., 1999; Scott et al., 2008) are among the many barriers to transfer medical knowledge into clinical practice (Figure 1). Research into primary care practice-based research networks has found, “less translation is required to apply research to practice when clinicians are involved in deciding what to study, how to study, and how to evaluate and present the results” (Mold & Peterson, 2005: s12). Therefore, the engagement of both academics and practitioners is essential in the transformation of research findings into clinical practice (Pettigrew as cited by Van De Ven, 2007: 262). Many have called for increased scientist-physician partnership (SPP) to produce knowledge that is valuable for clinical practice and easy to transfer (Kerner, 2006; Kerner
& Hall, 2009; Moskowitz & Thompson, 2001). In addition, physicians’ participation in knowledge generation activities through collaboration with scientists will improve their attitude and skills in the adoption of medical knowledge into clinical practice.

In this dissertation, I use partnership and collaboration interchangeably to refer to the relationship between research scientists and physicians who “work or act together” and “work with” each other in creating and transferring biomedical knowledge into practice. The definition of partnership I adopted is: “Partnership involves co-operation, i.e. “to work or act together” and in a public policy can be defined as co-operation between people or organizations in the public or private sector for mutual benefit” (Holland, 1984 cited in McQuaid, 2000:2). Collaborative practice is defined as “an interprofessional process for communication and decision making that enables the separate and shared knowledge and skills of care providers to synergistically influence the client/patient care provided” (Way et al., 2000: 3).

FIGURE 1
The Role of Physician-Scientist Partnership in Knowledge Transfer
Understanding factors that influence scientist physician partnership (SPP) is essential for improving knowledge generation, adoption and implementation outcomes in healthcare. Investigation of traits and behaviors of both collaborating partners is essential to uncover the underlying mechanism that influences SPP and collaboration outcomes.

Only a few empirical studies have addressed adoption and implementation of medical knowledge from the individual perspectives of physicians (Scott et al., 2008), funding agencies (Tetroe et al., 2008), and decision makers (Dobbin et al., 2007). As Zwarenstein and Reeves (2006: 52) pointed out, “there is very little rigorous research that considers knowledge translation, continuing education, or research utilization in the interprofessional context.” There are no empirical studies from the perspective of scientists in knowledge generation or clinical application. Literature and empirical studies on the interactions between research scientists and physicians in knowledge generation and transfer are largely missing. A multi-perspective and multi-level analysis of practitioner (physicians) and researcher (scientists) collaboration is also lacking. "Unless we understand how actors socially construct their accounts of action and how actors constitute the character of their actions..., we will continue to fail ... to furnish satisfactory answers to the long-standing questions" (Mulkay et al., cited by Boland & Tankasi, 1995: 355).

Research Aim and Research Questions

The overall goal of this research is to identify the facilitating and inhibitory factors of scientist physician partnership in biomedical knowledge generation and transfer, and to investigate the factors that predict SPP outcomes. The questions asked are: what are the factors involved in scientist-physician collaboration? What are the
relationships between the identified factors? How do these factors affect SPP? What is the prevalence of the impacts of the identified factors on SPP outcomes? What factors predict effectiveness of scientist-physician collaboration? Specifically, there are four research questions this research attempted to address in four studies across qualitative and quantitative phases.

Qualitative phase:

Study 1: What are the factors that facilitate or inhibit scientist-physician partnership in knowledge generation and application to practice? What are the lived experiences of scientists and physicians in biomedical research especially during the application of biomedical science into practice?

Quantitative phase:

Study 2: To what extent do individual factors influence scientist-physician partnership performance including satisfaction, academic and clinical outcomes?

Study 3: To what extent do organization factors affect scientist-physician partnership outcomes?

Study 4: To what extent do socio-cultural factors affect scientist-physician partnership outcomes?

**Research Design and Methodology**

Research questions dictate research methodology (Tashakkori & Teddlie, 2008). To answer the above research questions, an exploratory and open sequential mixed method approach was designed to discover the mechanisms of scientist-physician partnership in biomedical research and knowledge transfer. Given the inadequate literature on scientist-physician collaboration, and our lack of understanding of the
challenges and opportunities in scientist-physician collaboration, a mixed-method approach was deemed beneficial and appropriate for this research.

**Qualitative Strand**

Qualitative method emphasizes on the process, meanings and social aspects of a phenomenon. This method allowed me to gain the understanding of the dynamic and social lived experience of the scientist-physician collaboration. In this first phase of study, I interviewed both parties involved in scientist-physician collaboration to identify the enablers and inhibitors of scientist-physician collaboration by asking them about their lived experiences concerning the collaboration. Without presupposing any factors that influence scientist physician partnership (SPP), this phase generated theory of SPP grounded on the experiences of physicians and scientists in SPP.

**Quantitative Strand**

A quantitative phase (phase 2) was then carried out to test, validate, and generalize the qualitative findings in a larger context. The quantitative phase investigated the causal links among the identified factors and the prevalence of their impacts on SPP effectiveness. To do so, a psychometric survey instrument was developed to test the hypotheses. This instrument was developed based on the findings of phase 1, the literature review, and triangulation. The quantitative data provided estimates of the prevalence of the factors that emerged from prior qualitative analysis. This phase made it possible to explore the causal links between these factors and the outcomes of SPP. The quantitative component of this research assisted in the interpretation and generalization of qualitative findings. It validated, complemented, and extended the qualitative findings to a larger population. In summary, applying a mixed-method (quantitative and qualitative)
approach in research improved the validity and reliability of research findings (Silverman, 2011).

**Figure 2
Overall Study Design**

Research Outline

The overall design of this research consists of three phases totaling four studies. First, a qualitative phase (study 1) was conducted to identify factors involved in SPP by interviewing 26 of the actors involved (i.e. scientists in academia, physicians in clinical practice, and physician-scientists who reside in both research and practice worlds). Semi-structured interviews were carried out with hospital-affiliated practicing physicians and university or hospital-based research scientists to explore and identify factors, patterns, and themes involved in SPP. Second, a quantitative phase to validate, complement, and extend the findings of qualitative study at a large context by analyzing psychometrical data collected from 440 physicians, scientists and physician scientists. The second phase is composed of three studies. Study 2 focused on the effects of individual attributes on SPP. Study 3 focused specifically on institutional and organizational factors that influence SPP effectiveness. Study 4 analyzed the roles of
socio-cultural factors on SPP outcomes. Finally, findings from all four studies were integrated. As part of this integration, estimates of impact of different factors on the outcomes of SPP and on the collaboration process were compared. In addition, the moderating effect of organization collaboration mechanisms on many relationships between collaboration influencing factors and SPP outcomes were investigated.

**Significance of This Research**

This research reveals many institutional and socio-cultural factors at both personal and organizational levels that influence the effectiveness of (SPP). I find that factors at personal, organizational and socio-cultural levels hinder or facilitate the effectiveness of SPP and outcomes of translational research. In addition, this research also generated some findings that are inconsistent with existing literature or traditional beliefs on the impacts of, for example: academic culture, motivation, physician-scientists, professional language differences, and social-cultural differences.

Data triangulation of qualitative and quantitative findings from the multiple phase study provides a better understanding of the SPP mechanism. The research suggests that the gap between medical science and clinical practice (the “Valley of Death”) is not only a knowledge translation problem, but also a result of socio-cultural and institutional problems. The research makes theoretical contributions to the missing literature on SPP, a complex form of cross-professional collaboration. The findings of this research also provide insights and practical implications on the improvement of medical knowledge transfer through improved SPP. To my knowledge, this is also the first study on factors that influence cross-professional collaboration in the context of biomedical research that
studies a range of factors involved in SPP covering individual, institutional and social levels in the same study.

**Structure of Remaining Sections**

The remainder of this dissertation introduction is organized in the following sequence. In section II, I review the relevant literature including research context and collaboration antecedents, and enablers and inhibitors of cross-professional collaboration. In section III, I describe the theoretical perspectives that guided this research. In section IV, I present the research design and methodology in details including why a mixed-method design was chosen for this research. In section V, I overview the findings of the four individual studies as well as findings of the integrated studies. I section VI, I present a conclusion and discussion of the significance and implications of this research. In section VII, I discuss the contributions and implications of this research. Finally, in section VIII, I conclude this dissertation with limitations of the research, and propose some research areas for further investigation. The four completed studies are attached at the end of this proposal as appendices.
SECTION II: LITERATURE REVIEW

This section includes three sub-sections. The first sub-section reviews the research context of this research in detail. It consists of the medical practice gap, an overview of knowledge transfer theories, the framing of this gap as a translation issue, as well as the role of SPP in medicine. The second sub-section presents the antecedents of cross-professional collaboration. The third sub-section overviews the “constrainers and enablers” of cross-professional collaborations.

Research Context

The Valley of Death

One of the most persistent problems in healthcare management is that not all useful research findings are adopted or adopted promptly for the ultimate benefit of patients (Berwick, 2003; Glasgow et al., 2003; McGlynn et al., 2003). Crist et al. (2004: 477), after examining articles published in several basic science journals from 1979 to 1983, found that “only one in four promising technologies resulted in a published randomized trial and fewer than one in 10 entered clinical use within 20 years of the index basic science publication.”

The slow uptake of evidence-based medicine in primary care practice has resulted in the loss of potential benefits for patients (Amsterdam et al., 2002; Graham et al., 2006; Grol & Grimshaw, 2003; Lenfant, 2003), and the failure to fully leverage the investment of research and financial resources (Dougherty & Conway, 2008). “The gap between public health research and public health practice has been described repeatedly” (Colditz et al., 2008: 144), and it has been labeled as the ‘Valley of Death’, a place where
neither basic researchers, busy with discoveries, nor physicians, busy with patients, are keen to venture (Butler, 2008: 840).

Knowledge transfer occurs in a complex system of interactions among researchers, patients, physicians and other decision makers, such as hospital administrators and insurance companies (Dobbins et al., 2007; Estabrooks et al., 2006; Ploeg et al., 2007; Sinuff et al., 2007; Zwarenstein & Reeves, 2006). The blocks between medical research and clinical practice can be overcome only by the collaborative efforts of these multiple system stakeholders (Sung et al., 2003: 1278).

Studies have been conducted to address the issues of application of medical research knowledge into practice from the perspectives of physicians (Cabana et al., 1999; Scott et al., 2008), directors of applied research organizations (Lavis et al., 2003), funding agencies (Tetroe et al., 2008), clinical professionals (Fitzgerald et al., 2003), and hospital decision makers (Dobbin et al., 2007). Studies on other stakeholders include: administrators, nursing staff and project leaders (Ploeg et al., 2007), senior management (Bradley et al., 2004) and leaders (Edmondson, 2003; Gifford et al., 2008).

Adoption of knowledge also involves diverse parties such as: politicians, policy makers, the public, the media, educators, insurers and other consumers. Many organizations are part of this process as well. This includes: hospitals, research institutes, professional organizations, consumer groups, public media, industry, insurance companies, funding agencies, and advocacy groups (Dougherty & Conway, 2008; Estabrooks et al., 2006; Lavis et al., 2003; Sung et al., 2003; Titler, 2007). Dopson and Fitzgerald (2006) note the complicated and contextual interactions between different professional groups involved in knowledge transfer. They propose to design diffusion and
implementation strategies that acknowledge this complexity in organizational change processes. Given the complexity, Best and others (2003, 2008, 2010) propose to use system-thinking models in translation of biomedical theory into effective health promotion strategy.

**Knowledge Transfer Theory and Translational Research**

**Knowledge transfer (KT) theory.** There are many KT models and frameworks with the purpose to guide practice, research and theory (Dobbins, 2010; Fitzgerald et al., 2003; Graham & Tetroe, 2009; Graham et al., 2006; Lang et al., 2007; Mitton et al., 2007; Sudsawad, 2007; Sussman et al., 2006; Wandersman et al., 2008). Graham and Tetroe (2007) identified 31 models from papers published between 1983 and 2006 on KT. The similarities and differences of various theoretical models were illustrated from organizational innovation, health, and social sciences perspectives (Estabrooks et al., 2006: 25). In addition, the following factors also have to be considered in the implementation of adopting the knowledge of research into practice: organizational context and culture, organizational resources and support, attributes of change or innovation, nature of the evidence or knowledge, the audience, and implementation-related factors (Graham & Tetroe, 2007).

**Translational research (TR):** Among many identified barriers and proposed KT models, TR has been the buzzword and main focus in the medical research community to move discovery into practice (Woolf, 2008; Zerhouni, 2007). Translational research is “the application of basic scientific discoveries into clinically germane findings and, simultaneously, the generation of scientific questions based on clinical observations” (Rustigi, 1999). It “occurs at the interface of basic and clinical Research” (Crist et al.,
Many efforts and initiatives, including research funding and educational programs, have been made to enhance and improve TR (Crist et al., 2004; Harrington, 2006; Zerhouni, 2007). It has been believed that TR requires the participation of physician-scientists as the translator for the languages of science and clinical care.

**Physician scientist:** Physician-scientists are trained in both medicine and research, they are the natural “translators.” They are “essential to the orderly introduction of scientific advance into clinical practice” (Wyngaarden, 1981: 416). The critical role of physician scientists in bringing science to medicine has been emphasized since the 1960s when the MD-PhD program was created (Goldstein & Brown, 1997; Rosenberg, 1999). However, the declining interest in research in general and in translational research among physicians, including the ones with MD-PhD degrees (Moskowitz & Thompson, 2001; Zemlo et al., 2000), suggests different approaches should be considered.

**The Problem Frame: Translation or Cross-Professional Collaboration?**

Proper formation of a problem is essential to its solution because whether a certain result is true or not is relative to the methodological approaches used at the time (Knorr-Celina, 1999). Knorr-Cetina (1999) argues that reality, including scientific facts, is not given; it is constructed through interpretation, accidental events and negotiation.

The Valley of Death has generally been considered to be a “lost in translation” and knowledge “translational” problem (Graham et al., 2006: Lenfant, 2003). Numerous efforts have been in place to promote “translational research” and to emphasize the role of the natural translator physician-scientists. However, emphasis on solving knowledge translation problems has not produced the desired outcome of narrowing the Valley of Death. The unsuccessful effort to focus on one “community of knowledge” (i.e.
physician-scientists) suggests that the research-practice gap problem could and should be formed differently, and different strategies should be explored to improve the medical knowledge transfer.

Medical knowledge that is not applied into clinical practice can also be seen as an unfinished or unmarketable product in the industry. The medical community can learn insights from production innovation to narrow the gap between research and practice. Dougherty (1992: 179) points out that the commercial success of a new product depends on how well the product's design meets customers' needs and on the collaboration among the technical, marketing, manufacturing, and sales departments. Her study reveals that product innovators often do not link technological and market issues, and often do not collaborate across departments.

Collaboration across boundaries is essential given the shortage of physician-scientists, and has been proven successful. As Nobel Laureates Goldstein and Brown (1997: 2,808) write:

> It is increasingly difficult for a single individual simultaneously to fill the roles of physician and scientist. There is one sure way to cover this spectrum: collaboration. Perhaps more powerful is a collaboration in which one partner permanently plays the role of physician and the other is the scientist. Such collaborations work best when each of the partners has some training and experience in the discipline of the other so that they can readily exchange ideas and insights.

> “The complexity of the challenges of translating lessons learned from science to public health, primary care, or disease specialty service settings requires a multifaceted partnership approach to accelerate the translation of research into practice” (Kerner, 2006: 72). Colon-Emeric et al. (2006) addresses the need to develop interventions to
improve interdisciplinary collaboration. Wandersman et al. (2008), based on aspects of the research-to-practice model and the community-centered model, presents a framework consisting of three systems including funders, practitioners and researchers. Soklaridis and colleagues (2007: 1199) conducted a qualitative study on health care professionals including nurses, pharmacists, speech language pathologists, occupational and physical therapists, social workers, and family medicine practitioners. They point out that: unless academic settings are developed to provide the necessary training for primary health care professionals to work in teams, the new generation of health care professionals will continue to work in status quo environments, and reform initiatives are unlikely to become sustainable over time.

**Scientist-Physician Partnership**

Zwarenstein and Reeves (2006: 52) argue, “improved inter-professional collaboration may facilitate evidence-based care.” Indeed, the U.S. Veterans Health Administration has made considerable advances in systematically implementing evidence into practice through a system-level program focused on collaboration and partnerships among policy makers, clinicians and researchers (Stetler et al., 2008: 1, 9). A long-term researcher-practitioner “partnership may help to more quickly translate research findings into practice settings and help ensure that health care organizations sustain the intervention program beyond the end of the funded project”(Sussman et al., 2006: 30).

**Physician’s role in knowledge transfer:** The physician, as the main intended adopter of research knowledge for the benefit of patients, plays a critical and essential role in the adoption and implementation of research findings into practice. For example, the rapid adoption of low molecular weight heparin in the management of cardiovascular
diseases demonstrated the impact and importance of clinicians on the translation of research into practice (Denis et al., 2002). However, physicians also can hinder the translation process (Lenfant, 2003). Among the many barriers to a physician’s success with translation are: lack of awareness, lack of familiarity, lack of agreement, lack of self-efficacy, and lack of outcome expectancy (Graham & Tetroe, 2007). A lack of organizational support and guidelines also reduce translation by physicians. Lack of organizational support has been identified as one of many reasons for physicians’ failure to adhere to guidelines (Cabana et al., 1999; Scott et al., 2008).

Although leadership plays an important role in the implementation of guidelines (Gifford et al., 2008), general managers in hospitals have relatively little influence when compared with clinicians, especially doctors (Dopson & Fitzgerald, 2006). Young’s (2003) survey of Australian surgeons revealed that peer opinion leaders were rated more influential than clinical audits in influencing them to change their practice. In short, physicians can serve as both facilitators and inhibitors of implementing research findings in practice (Dopson et al., 2010).

Scientist’s role in knowledge transfer: Being recognized as knowledge generators, scientists actively engaging themselves in the diffusion of their findings through publications, conference presentations and website postings (Graham, 2010). These are the sources of information that decision makers from CEOs to frontline clinicians rely on (Dobbin et al., 2007). In order to promote the translation of their research findings into practice, researchers also have to engage themselves in fostering relationships with health care decision-makers, practitioners and policy makers, as well as in developing interactive and collaborative knowledge transfer strategies (Dobbins et
al., 2007). However, basic scientists have few incentives to do so because of complex regulations, patents and other issues (Butler, 2008).

One of the potential solutions to the knowledge and practice gap is “the expansion of practice-based research, which is grounded in, informed by, and intended to improve practice” (Westfall et al., 2007: 404). However, most researchers do not understand what happens in clinical settings, and they do not realize the difficulty of implementation or adoption of their findings in practice. In addition, doing clinical research poses a risk of career damage to research scientists (Butler, 2008). Some factors that may be critical to promote researchers’ engagement in knowledge transfer include: promotion and tenure, resources and funding, organization structure, knowledge transfer orientation and documentation (Jacobson et al., 2004).

**The importance of scientist-physician partnership:** A collaborative partnership between research scientists and health care practitioners could expand implementing the research efforts greatly (Kerner & Hall, 2009). Translating research into practice requires common understanding and languages among scientists and physicians. Partnerships between researchers and practitioners are the key for the creation of this common language as well as for other knowledge transfer processes such as knowledge generation, diffusion, dissemination and implementation. In addition, when comparing the physician-led or scientist-led research team models, the physician and researcher team model is the most successful model for sustaining the clinical researcher pipeline (Moskowitz & Thompson, 2001).

Taken together, SPP is essential in closing the chasm in the Valley of Death. SPP promotes the transfer of biomedical research into clinical practice by generating and
applying transferable medical knowledge and outcomes. Better SPP will likely improve healthcare management through increasing the quality of patient-care by making the research relevant and easy to transfer. Collaborations between physicians and scientists have generated many of the revolutionary advances in medicine (Goldstein & Brown, 1997). The power of physician and scientist interaction and collaboration is well demonstrated by the successful application of in vitro fertilization procedures to benefit a large sub-fertile population (Edwards, 2001). Consideration for collaborative investment in integrating the lessons from practice and research, as well as incorporation of partnership into publications and meetings, are proposed as ways to promote practice-research partnership and collaboration (Kerner & Hall, 2009).

Antecedents of Cross-Professional Collaboration

Definitions

Scientist-Physician Partnership (SPP) is expected to reduce physicians’ barriers in adopting the newest medical research and to help scientists discover new relevant research opportunities. Partnership or collaboration refers to the relationship between researchers and physicians who work together to create, and then transfer, medical knowledge into practice. Effectiveness is a measure of achieving expected and desired objectives and outcomes (Parkhe, 1993; Saxton, 1997). SPP effectiveness is defined in this study as the extent to which the partnership promotes such goals in terms of research and clinical outcomes, as well as collaboration satisfaction. Several sets of factors are known to influence collaboration and its outcomes and are reviewed next.
Individual Attributes and Collaboration

Personal attributes are important factors affecting collaboration. Individual characteristic, such as personality, is one of five main domains of a consolidated framework of implementation research (CFIR) (Damschroder et al., 2009). CFIR is a framework that “offers an overarching typology to promote implementation theory development and verification about what works where and why across multiple contexts” (Damschroder et al., 2009: 1).

**Personality:** Personality has been shown to be associated with performance. For example, “Conscientiousness has previously been shown to predict academic and job performance” (Higgins et al., 2007: 313). Higgins et al. (2007) also confirmed that conscientiousness has a positive relationship with job performance. In addition, the traits of agreeableness, patience and helpfulness have been related to cooperation (Goldberg, 1990). Another experimental empirical study shows a link between personality with collaboration-viability and communication in paired teams (Sfetsos et al., 2006). Personality of managers was also linked to service climate (Salvaggio et al., 2007).

**Professional identity:** Although the degree to which professionals identify themselves with profession and organization are different, professional identity significantly correlated with organizational identity, and both professional identity and organizational identity are positively related to job satisfaction (Russo, 1998; Johnson et al., 2006); and job satisfaction is positively related to business unit outcome including productivity (Harter et al., 2002). Another study among five big auditors also found that professional identity is positively associated with organizational identity (Bamber & Iyer, 2002). An empirical quantitative study reveals positive links between attractiveness of
perceived organizational identity, strength of organizational identity, and cooperative
behaviors among physicians (Dukerich, Golden, & Shortell, 2002).

**Motivation:** Motivation is defined as “individuals' desire to act or behave in a
particular manner” (Weiner, 1992 as cited by Buehl & Alexander, 2005). Researchers in
academia have no incentive to conduct clinical research. Physicians in practice—faced
with large debt burdens, lack of time, insufficient resources, and academic isolation—
may lack skills and personal motivation to engage in research (Bakken, 2006; Cabana et
al., 1999; Ley & Rosenberg, 2005; Scott et al., 2008). However, scientists or physicians
can be motivated by non-organizational factors, such as the factors in Herzberg’s (1959,
1964) two-factor theory of motivation: achievement orientation and recognition.
Achievement and recognition belong to motivator needs and they are two determinants of
employees’ job satisfaction (Judge et al, 2001).

**Institutional Factors and Collaboration**

Institutional forces and structures such as institutional arrangements, rewarding
systems and academic culture play important roles in SPP effectiveness. For example,
academic appointment and promotion standards often discourage scientists to collaborate
with physicians (Butler, 2008; Israel et al., 2001; Pober et al., 2001). In addition to
physicians’ lacking of skills and motivation to engage themselves in research (Bakken et
al., 2006; Lay & Rosenberg, 2005), lack of time and funding due to inadequate
organizational support is often the reason that many physicians fail to engage in
collaborative research. Knowledge transfer is a time and resource-intensive activity with
few incentives or rewards (Graham, 2010). Lack of reward and recognition from
universities, as well as lack of time and funding, prevent research scientists from actively
involving themselves in the dissemination of knowledge, including collaboration with physicians (Butler, 2008; Jacobson, 2004; Manske & Leithwood, 2002).

**Socio-Cultural Factors and Collaboration**

Social influence is “the perceived expectation from family, relatives, friends, and peers for an individual to perform the behavior of interest” (Hsieh, Rai & Keil, 2008 2008: 102). Culture is an “integrated pattern of human knowledge, belief, and behavior that is both a result of and integral to the human capacity for learning and transmitting knowledge to succeeding generations. Culture thus consists of language, ideas, beliefs, customs, taboos, codes, institutions, tools, techniques, and works of art, rituals, ceremonies, and symbols” (Merriam-Webster, 2014).

Socio-cultural factors play a critical role in collaboration (Unhelkar et al., 2010). ‘The social context of interpersonal relations, socialized professional roles and asserted privilege of certain knowledge” is a strong element in multidisciplinary teams, including experts of surgery, radiotherapy, oncology, pathology, nursing and radiology (Oborn & Dawson 2010: 1854). In scientist physician partnership, the physician’s power and social influence in society, the asymmetry in socio-economic status between physicians and scientists, as well as professional language difference are the socio-cultural factors that could influence SPP.

**Collaboration Process Factors**

*Communication:* Communication plays a central role in collaboration. The effect of communication on collaboration and partnership has been well documented. For example, communication strategy influences financial performance (Koza & Dant, 2007). Inter-organizational communication has been shown to impact the performance outcomes
in collaborative buyer-supplier relationships (Hunter & Perreault, 2007; Paulrajia, Lado, & Chen, 2007). Clinicians’ communication behavior has been shown to predict healthcare use and perceptions of quality of care (Clark et al., 2008). More frequent and higher caliber inter-professional communication and collaboration are also associated with positive experiences of all healthcare providers in a care unit (Conn et al., 2012). A study by Kraut and colleagues (1988) also demonstrates the importance of the frequency and quality of communications in scientific collaboration.

**Shared vision/goals (SVG):** This is the common view shared between collaborative partners relating to goals, objectives, future plans and strategic directions of the collaborative projects. An extensive literature review by Choi and Pak (2007) identifies a common goal and shared vision as one that promotes success in multidisciplinary, interdisciplinary and trans-disciplinary teams in the literature of health research, services, education and policy.

**Mutuality:** Thomson et al. (2007), who conducted an empirical study using interview, survey and field research to conceptualize and measure collaboration, conclude that mutuality, norm, governance, administration, and organizational autonomy are five key dimensions of collaboration. They point out that reciprocity, trust and reputation are three core relationships in norm; and commitment to collaboration is unlikely without norms of trust and reciprocity (Thomson et al., 2007). The level of commitment to collaboration is a critical variable in explaining success or failure of collaboration, and commitment requires mutual recognition or joint recognition (Ansell & Gash, 2008).

Mutuality—including equality in decision making, reciprocity, and resources exchange—is used to assess the degree of partnership (Brinkerhoff, 2002: 225). Mutual
trust and respect is identified as one of seven essential elements, including communication and co-ordination for successful collaboration in healthcare settings between physicians and nurses, and it is “common to and binds all of the other elements together. Each provider must be able to depend upon the integrity of the other as the foundation for their professional relationship” (Way et al., 2000: 6). Honesty, trust and respect are essential to the interdisciplinary structure (Satin, 1987 as cited by Freeth, 2001: 39).

**Barriers and Enablers of Cross-Professional Collaboration**

**Barriers**

As Butler (2008: 840) points, “the clinical and basic scientists do not really communicate”. Barriers to cross-boundary, cross-professional collaboration success include language problem, unequal power, institutional constrains, lack of communication, lack of guidelines for multiple authorship of research publications, and lack of resources such as funding and time (Choi & Park, 2007; Choi, 2008).

Scientist-physician collaboration faces challenges similar to other interprofessional collaboration such as differences in structure, professional agendas, project aim, career progression and institutional pressure (Freeth, 2001: 44; Harris et al., 2008). “The structures of research institutions and career pathways within academia are a limiting factor for interdisciplinary research” (Harris et al., 2008). Researchers often actively engage themselves in knowledge generation and diffusion (Graham, 2010). However, lack of time and funding, as well as lack of reward and recognition, are institutional barriers preventing researchers from actively involving themselves in the dissemination of knowledge, including collaborative activities with physicians (Butler,
In addition, engaging in clinical research imposes the risk of career damage to basic research scientists. Due to the nature of clinical research, it is hard for scientists to get clinical research published in top journals. Publishing in top journals is the main determining factor for scientists to be funded and promoted (Butler, 2008).

The need for advocating and championing the value and merits of the clinical researchers at local and national levels by respective stakeholders has been proposed (Murillo et al., 2006). However, as noted by Pober et al. (2001: 2308, 2311), “clinical investigators, like other medical practitioners, are pressured to see more patients and spend less time in the laboratory. At the same time, laboratory investigators who obtain salary support from National Institute of Health or other grants are pressed to pursue a more traditional, basic science career that is better suited to earning grant support, which minimizes their clinical time. Thus, the need to cover one’s salary promotes polarizing career choices that limit efforts in ‘bridge’ research”. Organizational support, by making treatment development as a research priority and by helping researchers with networking opportunity and seed funding, are ways proposed for the academic organization to foster the development of treatment ideas by academic investigators (Brewer, 2006). Brewer also discussed how other organizations such as the National Institute of Health (NIH), Food and Drug Administration (FDA) and legislation could facilitate the drug discovery process through the involvement of researchers.

“Mutual respect is a key component of mutuality in partnership. Mutual respect rests on an explicit recognition of the indispensability of each partner and its contribution. Partners are aware of each of their partner’s unique strengths and seek to effectively
incorporate these into the partnership work” (Brinkerhoff, 2002: 225). However, Pober et al. (2001: 2309) notes that “clinicians and basic science researchers have a fundamental difficulty in recognizing the merits of research from the other sphere…. This existing academic culture will have to change if collaborations between clinicians and laboratory-based investigators are to be successful”. This is because “without trust and respect, co-operation cannot exist. Assertiveness becomes threatening, responsibility is avoided, communication is hampered, autonomy is suppressed and co-operation is haphazard (Norsen, 1995 as cited by Way et al., 2000: 6).

**Enablers**

After conducting a systemic literature review process, San Martin-Rodriguez et al. (2005) summarize the determinants of successful cross-professional collaboration at organizational and systemic levels. The organizational determinants are: administrative support including leadership; realistic objectives; administrative leadership; coordination mechanism including standardization (work and skills); group discussions; formalization (rules and protocols); division of work and common rules; resources, including physical proximity, space and time; and organization’s philosophy of "climate of openness and positive conflict management" and an approving atmosphere. The systemic determinants include collegiality; a non-demanding approach and a non-abusive approach by the partners; understanding the practice of other professionals; awareness of other professionals’ contribution; awareness of other professionals contribution; and adhesion to collaboration instead of profession logics.

Management support can contribute to partnership effectiveness directly through resource commitments, such as available financing and personnel (Brinkerhoff, 2002).
The importance of supportive leadership was a finding in a study of collaboration between acute care hospitals and community-based primary healthcare agencies (van Eyk & Baum, 2002). In addition to providing funding and personnel support, organizational support can include providing collaboration contexts such as supportive leadership, a collaboration office and organizing networking events. These contexts are critical in initiating and facilitating SPP. Other analysis and studies have revealed the promoting role of: incentives, institutional support, providing communication platforms, and senior management (Brinkerhoff, 2002; Choi & Pak, 2007).

The inhibitors of cross-professional collaboration at organizational and socio-cultural levels are summarized in Table 1.
### TABLE 1
Barriers and Enablers of Cross-Professional Collaboration

<table>
<thead>
<tr>
<th>Citation</th>
<th>Organizational/Institutional level</th>
<th>Systemic (socio-cultural) level</th>
</tr>
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<tbody>
<tr>
<td>Freeth 2001, P44, Harris et al, 2008</td>
<td>Institutional pressure, career damage to basic research scientists, (Butler 2008); lack of reward and recognition; structural differences between organizations; conflicting organizational and professional agendas; resource requirements.</td>
<td>Difference in structure.</td>
</tr>
<tr>
<td>Fickel et al 2007</td>
<td>Understaffed/insufficient resources; Physical distance.</td>
<td></td>
</tr>
<tr>
<td>Bartunek 2007; San Martin-Rodriguez et al 2005</td>
<td>Different opinion on relevant and rigorous research; difference in practice and research.</td>
<td>Power differences.</td>
</tr>
<tr>
<td>Choi &amp; Pak 2007, 2008</td>
<td>Lack of guidelines for multiple authorship in research publications; insufficient time for the project; insufficient funding for the project; institutional constraints.</td>
<td>Language problems; discipline conflicts; unequal power among disciplines.</td>
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</tbody>
</table>

### Enablers of Cross-Professional Collaboration

<table>
<thead>
<tr>
<th>Organizational/Institutional level</th>
<th>Systemic (socio-cultural) level</th>
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<tbody>
<tr>
<td>San Martin-Rodriguez et al 2005</td>
<td>An approving atmosphere; leadership; realistic objectives; administrative leadership; coordination mechanism including standardization (work and skills); formalization (rules and protocols); division of work and common rules; resource including physical proximity, space and time.</td>
</tr>
<tr>
<td>Brinkerhoff 2002</td>
<td>Senior management support.</td>
</tr>
<tr>
<td>Choi and Pak 2007</td>
<td>Communication supporting platform; incentives; institutional support.</td>
</tr>
<tr>
<td>Austin 2000; Brewer 2006; Freeth 2001</td>
<td>Organizational systems; the role of organizations such as the NIH, FDA and legislation</td>
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SECTION III: THEORETICAL PERSPECTIVES

“Complex systems arise whenever there are populations of interacting agents (persons, organizations, or communities) that act on their limited and local information” (Amaral & Uzzi, 2007). Physician and scientist partnership (SPP) occurs in a system involving many organizations and agents. There are many factors at personal, organizational and social-cultural levels that influence collaboration. The environment and interactive nature of SPP at multiple levels reflect the characteristics of a complex system. Therefore, it is necessary to take a multi-perspective lens to study SPP. This section examines theoretical perspectives informing this research, including: structuration theory, institutional theory, motivation and reward system, and social network theory.

Structuration Theory

Giddens’s Theory of Structuration (1984) is a powerful lens to analyze SPP given that SPP involves the interactions between actors within the contexts of institutional and social structures. The key concepts of structuration include: (1) agent and agency; (2) agency and power; (3) structure, structuration; (4) the duality of structure; (5) forms of institution; (6) time, the body, encounters. This theory offers a way to analyze how a system is produced and reproduced through the interactions of situated actors (agents) and structures (rules and resources). Giddens (1984: 25) points out “structure is not to be equated with constraint but is always both constraining and enabling,” and “to be an agent is to be able to deploy a range of causal powers, including that of influencing those deployed by others.” This reflects the structure and agency feedback loop Giddens (1984: 14) writes about; i.e. agency and structure enable and constrain each other. According to Giddens, structures are translated into interactions through the modalities of power and
sanction. For Giddens, SPP is a recursively-organized practice that is found in the interactions between agencies and structures. For example, the academic culture of “publish or perish,” and academic promotion practices may discourage collaboration and translational research; however, institutional funding pressure and the difficulty of getting research published may force collaboration and translational research to a certain degree.

Giddens’ model provides a helpful way to guide and explain this study. From the perspective of the signification dimension (production of meaning or sense-making), the Valley of Death can be and has been interpreted as a lack of common language in science and practice. Therefore, many efforts have been placed on the promotion of translational research and the translators (i.e. physician-scientists) (Crist et al., 2004; Ley & Rosenberg, 2005; Zerhouni, 2007). The importance of recognizing the role of the domination (convey message on power) and legitimation (social norms, values and standards) dimensions were explored in this study.

**Institutional Theory**

Institutional fields provide the resource and rules upon which collaboration is embedded, and institution influence behaviors (Phillips et al., 2000, 2004). Therefore, it is appropriate to scan the SPP by using an institutional theoretical lens. Institutions are “conventions that are self-policing”. Specifically, they are “historical accretions of past practices and understandings that set conditions on action” through the way in which they "gradually acquire the moral and ontological status of taken-for-granted facts which, in turn, shape future interactions and negotiations" (Phillips et al., 2004: 637). Institutional theory has been used as a useful theory to explain the actions and behaviors of both individuals and organizations. Actor’s behaviors are results of and guided by social and
institutional structures. “Institutional features of organizational environments shape both the goals and means of actors” (Scott, 1987).

According to Scott (2000, 2005), institutions are composed of three important components: institutional logic, institutional actors and governance systems. Institutional logics are sets of cognitive maps, belief systems and organizing principles that guide and give meaning to participants’ activities. Institutional actors, either individuals or organizations, are both carriers and creators of institutional logics. They participate in both the institutional environment possessing institutionally-defined identities, capacities, rights, and responsibilities as well as material-resource environments as consumers or suppliers of a service. Governance systems are arrangements that support realized control. In the healthcare field, there are three distinctive institutional eras reflecting different institutional logics, actors and governance systems: the area of professional dominance; federal involvement; and managerial control and market mechanisms.

Institutional environment consists of three pillars: cognitive, nominative and regulative structures and activities. These three pillars provide stability and meanings to social behaviors. Institutions are transported by various carriers including cultures, structures and routines. Institutions operate at multiple levels; i.e. the levels of word system, societal, organizational field, organizational population, organization and organization subsystem. Social actors, individual or organization both create and modify institutional environments. Institutional features have profound influence on social structures and processes (Scott, 2000).

Institutional forces influence behaviors, and it is well documented that individuals accept and conform to institutionalized norms (Pfeffer, 1992). The positive links between
academic culture as a form of institutional structure and many other factors including communication, collaboration process effectiveness, academic outcome, and clinical outcome support these arguments and Barnard’s belief that “behaviors can be controlled and predicted if people are rewarded by incentives to perform specific tasks required by the organizations to be efficient” (Barnard, 1968, cited in Boulier, 2010).

Institutional theory provides a theoretical foundation for examining the scientist-physician collaboration. For example, the barriers to scientist-physician collaboration and clinical research at both individual and organizational levels illustrate the inhibitory role of organizational and institutional structure in medical discoveries and applications. The institutional barriers in scientist-physician collaboration reflect the influence of current institutional structures on physicians and scientists. For instance, part of the socio-cultural difference between physicians and scientists are results of institutional arrangements in education and compensation. The trend of physicians’ research interests and activities over the last five decades roughly resembles the trending focus of science logic of medicine in medical education (Dunn & Jones, 2010; Rosenberg, 1999), which supports the institutional theory. However, the ineffectiveness of institutional promotion for physicians’ participation in research suggests the importance of non-institutional elements, including socio-cultural factors in physician and scientist collaboration.

Motivation Theory and Reward System

Motivation was defined as “a process governing choice made by persons” by Vroom (1964), and is an important topic of the management field (Steers, Mowday, & Shapiro, 2004). Many motivation theories have been developed to explain and predict behaviors. For example: Maslow’s (1943) hierarchy of need theory; McClelland’s (1976)
(and Murray) theory of achievement, affiliation, power and autonomy; Herzberg’s (1964) motivation-hygiene theory, expectancy-valence theory, and goal-setting theory, to name a few. The goal setting theory has been widely applied in the industry in the forms of both individuals and teams. The recent motivation theory focuses on work force motivation (Steers & Shapiro, 2004). Maslow’s (1943) need based motivational theory explains the incentive of the collaborators: the conative need, the desire to know and to understand, is the motivation that drives physicians or scientists to participate in collaboration.

According to Vroom (1964):

Motivation is a function of three main factors: the subjective value placed on the reward by the individual (termed ‘valence’); the perceived likelihood that effort will produce an appropriate level of performance (‘expectancy’); and the perceived likelihood that this performance will be converted into an appropriate level of reward (‘instrumentality’) (as cited by Bresnen & Marshall, 2000: 589).

Motivation and commitment may be the results of both intrinsic (a sense of achievement, interest in the work itself) and extrinsic (financial) rewards. Agents motivated by extrinsic rewards tend to have low emotional commitment (Bresnen & Marshall, 2000). “Behavior modification… emphasizes the use of rewards and punishments as incentives and reinforces to influence behavior (Luthans & Kreitner, 1975 cited in Bresnen & Marshall, 2000: 589).”

The organizational rewarding structure is critical to promote researchers’ engagement in knowledge transfer (Jacobson, 2004), because “behaviors can be controlled and predicted if people are rewarded by incentives to perform specific tasks required by the organizations to be efficient” (Barnard, 1968 as cited by Bouchlier, 2010: 7). It has been long argued that academic culture inhibits scientists to engage in clinical
research with clinicians, because the standards set by appointment and promotion committees often discourage it (Butler, 2008; Pober et al., 2001). Failure of the academic reward system to encourage dissemination of research findings is one of three major factors explaining the disconnection between researchers and practitioners (Manske, 2010).

Academic culture that lacks a reward and recognition system for researchers’ involvement in clinical investigation is one of many findings of an empirical study on Canadian researchers (Graham, 2010). Not surprisingly, having a system that rewards collaborative effort and behavior is one example of collaboration enablers identified in case studies (Austin, 2000). However, “one of the most frequently mentioned institutional barriers for faculty … are the risks associated with trying to achieve tenure and promotion … Policies and mechanisms need to be established in universities to ensure that faculty members receive credit” (Israel et al., 2001: 191).

Social Network Theory

Social network theory provides a different theoretical perspective on SPP. Because we live in an interconnected and interdependent “small world,” social networks play an important role in fostering self-organized collaboration like SPP. As Ball (2012: 42) notes, “There is already a sound foundation on which to build a deeper understanding of how societies succeed or fail in developing a cohesive and collaborative community.” Social networks, information, and communication technology are the foundation of establishing successful collaborative community between researchers and physicians.

Social network theory emphasizes the influence of social relationships on the collaboration. From this perspective, physicians or scientists who are determined to
collaborate are most likely to collaborate with people within their social network already. They will collaborate with someone they have already known, or heard of, or was recommended by their colleagues or friends; i.e. with someone with a known reputation and trust.

Studies found that both informal and formal relationships are associated with greater and more cross-business-unit collaboration, and strong social relationships enhance knowledge transfer (KT) and shorten the completion times of KT (Gupta & Govinrajian, 2000; Hansen, 2002, as cited by Martin & Eisenhardt, 2010; Tsai, 2002). The data by Martin and Eisenhardt (2010) agrees with these earlier studies that positive social relationships facilitate collaborations. They argue that positive social ties improve the opportunity of finding collaborations and makes collaboration go smoothly and effectively, while poor or non-existing ties are the barriers to collaboration. Interestingly, Keating and Ayanian (2007) found that physicians in primary care practice obtained information from colleagues who have greater experience and expertise and who are accessible based on location and schedule. This proves the important role of social networks in healthcare.
SECTION IV: RESEARCH DESIGN AND METHODOLOGY

I present the research methodology in this section in the following order: I first explain why an exploratory sequential mixed method design was applied for this research. I then outline the three research phases, and the four individual and two integrated studies conducted. I conclude this section with a description of research samples, data collection, and data analysis methods employed in this research.

An Exploratory Mixed Method Approach

Research questions dictate research methodology (Tashakkori & Teddlie, 2008). The objective of this research is to identify factors influencing SPP in knowledge generation and application. The specific research questions are: what factors are involved in SPP? What are the relationships between the identified factors? What is the prevalence of these factors in SPP? How do these factors affect SPP? What factors predict SPP? I have designed an exploratory mixed-method approach to answer these questions.

Why Mixed Method?

Given the literature on SPP is inadequate, and an understanding of the challenges and opportunities in SPP is lacking, a mixed-method approach is beneficial and appropriate for my study.

With qualitative method’s emphasis on process and meanings and the social aspect of a phenomenon, I first conducted a qualitative investigation to gain understanding on the dynamic and social aspects of SPP (study 1). I interviewed both parties involved in SPP to identify the enablers and inhibitors of SPP by asking about their lived experience. After identifying factors that are important in SPP, I then developed a psychometric instrument to test the hypotheses developed from interview
findings. I hoped to validate the qualitative findings on a larger population. The subsequent quantitative data provided estimates for the prevalence of the factors emerged from the prior qualitative analysis. This enabled an exploration of the links between these factors and SPP. The quantitative component assisted in the interpretation and generalization of qualitative findings. Applying a mixed-method (quantitative and qualitative) approach in research can improve the validity and reliability of research findings (Silverman, 2011).

**Why Exploratory Mixed Method?**

The limited existing literature identifies the academic culture of independent work and a lack of organizational support as the main barriers in SPP. However, I did not know if these factors are true barriers that inhibit SPP or if they are only perceived barriers. The previous studies were conducted only on the physicians’ side; therefore, investigating both actors (physicians and scientists) in the same study is warranted. In addition, the existing literature may not capture all the elements involved in SPP. Furthermore, the literature may not reflect the impact of recent regulatory changes, especially the NIH’s attention to translational research and related new funding policies, regarding SPP. Whether additional factors contribute to SPP, and the logical relationships of these factors in SPP were unknown. Therefore, an exploratory mixed-method approach starting with interviewing physicians and scientists was necessary. This exploratory approach both confirmed and contradicted factors in the existing literature. It also identified factors not previously documented. The findings of the qualitative study guided the hypotheses and survey instrument development in the quantitative studies that followed.
Why Sequential?

I started with an exploratory qualitative inquiry and followed with three confirmatory studies. A sequential exploratory approach (QUAL to QUAN) was proven necessary and beneficial. It was important to identify the factors in SPP first, before investigating the impacts of these identified factors on SPP. The qualitative findings were used to guide the development of hypotheses as well as formulating a psychometric instrument that was used to collect the data for testing the hypotheses. It is critical to have a well-developed and well-informed survey instrument before launching a large-scale survey investigation to validate and link the factors identified (Tashakkori & Teddlie, 2008).

Limitation of Alternative Methods

Both qualitative and quantitative methods have their own advantages and limitations. For example, the generalizability of a qualitative study is a concern for researchers. Not all people agree that this method alone has the scientific vigor that a good research methodology should possess. Employing quantitative methodology alone was not desirable in this study either because I did not know where to start or focus due to the lack of literature on SPP. Concurrent data collection approach was not used because of its inability to adjust the data collection strategy once data was collected.

In summation, the exploratory sequential mixed-method design allowed me to achieve a comprehensive, elaborated and validated view of scientist-physician collaboration.
Research Phases and Studies

This research consists of one qualitative and two quantitative phases totaling four major studies (Figure 3) as described below.

FIGURE 3
Outline of Research Phases and Studies

Phase 1: Qualitative
(Semi-structured interviews with 10 PhDs, 8 MDs and 8 MD-PhDs)
RQ1: What are the factors influencing scientists and physicians collaboration? (Study 1)

Phase II: Quantitative (survey n=440)
(Structural Equation Model)

RQ2: To what extent do personal attributes impact SPP? (Study 2)
RQ3: To what extent institutional factors affect SPP? (Study 3)
RQ4: How do social and cultural factors influence SPP? (Study 4)

Phase III: Integration of Three Quantitative Studies
RQ3: Which factors are the most important influencing factors?
RQ4: Does organization collaboration mechanism have a moderating effect?

Phase 1: Qualitative Research (Study 1)

The purpose of this phase was to explore and uncover the factors involved in scientist-physician partnership (SPP). I utilized a qualitative approach based on grounded theory principles to understand how scientists and physicians experience their collaboration. This phase was carried out by semi-structured interviews that lasted 45-120 minutes with a mean of 70 minutes. Ten PhDs, eight MDs and eight MD-PhDs were interviewed guided loosely by an interview protocol developed based on pilot interview and literature. The findings of this qualitative study served as the foundation of three
quantitative studies in phase 2. Primarily based on the results of this study, together with the literature, a theoretical model of SPP is proposed for empirical quantitative studies in phase 2. The full paper of the study is attached as appendix A.

**Phase 2: Quantitative Phase (Studies 2, 3, 4)**

The purpose of this phase was to validate, extend and complement the qualitative findings of phase one. Phase 1 of the study identified many factors at personal, institutional and socio-cultural levels that hinder SPP and slow down knowledge transfer in medicine. However, the relationships among the identified factors, as well as the prevalence of their impacts on SPP and medical knowledge transfer, were unclear. I hence designed and conducted a survey employing a quantitative psychometric instrument among 440 research scientists and physicians who had cross-professional collaborations.

This phase consists of three quantitative studies to investigate the influence of personal, institutional, and socio-cultural factors on SPP. Specifically, to address the question: to what extent do personal attributes, organizational factors, and social and cultural forces influence SPP?

**Phase 2a: The role of personal attributes in SPP (Study 2)**

Phase 1 of the study revealed the importance of personal interests, individual effort, personal motivation, and personality in SPP. Therefore, I hypothesized that individual attributes such as professional identity, personal motivations and personality influence outcomes of SPP including academic outcome and clinical outcome. Phase 2a of the study (study 2) was carried out to test these hypotheses and to answer this specific research question: To what extent do personal attributes affect the effectiveness of SPP?
In addition, this study also explored the influence of professional degrees (MD or PhD) on the relationships between personal factors and collaboration outcomes. The full paper of the study is attached as appendix B.

**Phase 2b: The role of institutional factors in SPP (Study 3)**

Phase 2b (study 3) was carried out to answer the following research question: To what extent do organizational factors influence the effectiveness of SPP? Hypotheses were developed primarily based on the findings of phase 1. Data was obtained from same respondents at the same time as Phase 2a. The full paper of the study is attached as appendix C.

**Phase 2c: The role of social-cultural factors in SPP (Study 4)**

Despite the lack of research on socio-cultural differences between physicians and scientists in the literature, phase 1 data on the experiences of both scientists and physicians during SPP, guided me to focus the quantitative investigation on specific issues of socio-cultural influence such as: the influence of professional language differences, social-cultural differences between physicians and scientists, mutuality and social support. Phase 2c (study 4) was conducted to address this research question: to what extent do social-cultural factors affect the outcome of SPP? The full report of this study is attached as appendix D.

**Phase 3: Integration of Quantitative Studies**

Phase 1 and phase 2 studies identified factors that have significant influence on collaboration outcomes and collaboration facilitators including communication effectiveness, mutuality and satisfaction on process effectiveness of collaboration at three different levels. Phase 3 was then conducted to answer the following two questions:
• **Which factors are the most important influencing factors?**

This question was addressed by comparing the regression weights of influencing factors and their impact on the change of R square values of latent factors. Results are presented in Section V.

• **Does the organizational collaboration mechanism have a moderating effect on the influence of personal attributes and socio-cultural factors on the outcomes of SPP?**

This question was addressed by first dividing the organizational collaboration mechanism (OCM) data into OCM-low and OCM-high groups, then conducting a group analysis using OCM as the moderator using SEM to investigate the influence of OCM on the relationships between individual and socio-cultural factors with SPP outcomes in phase 2. Critical ratio analysis was applied for statistical analysis. Results are presented in Section V, indicating that OCM moderates many relationships in SPP.

**Sample and Data Collection**

Data was collected sequentially: qualitative data was collected first, followed by quantitative data collection through an online survey. The survey items were either derived from literature when available and appropriate, or developed in this study according to the information obtained from the qualitative study.

**Qualitative Phase Study**

Qualitative data was generated from semi-structured interviews with open-ended questions. A total of 26 physicians (MDs), scientists (PhDs, or MDs) and physician-scientists (MDs, or MD-PhDs) were interviewed. There were eight physicians, ten
scientists and eight physician-scientists. The interview protocol can be found in Appendix E.

**Quantitative Phase Studies**

Quantitative data was obtained through an online survey using a psychometric instrument (see Appendix F) developed based on the qualitative findings and literature. Due to the extremely time-sensitive nature of the unit of my inquiry (i.e. physicians and scientists), I anticipated a low response rate; therefore, the survey invitation was emailed to roughly 7,000 physicians and scientists at top medical schools and hospitals in the USA, as well as to members of several Clinical and Translational Science Award (CTSA) centers in the country. I obtained about 600 full responses from physicians, scientists and physician-scientists. Only 440 were analyzed after excluding non-cross-professional collaborations and non-collaborator responses.

**Data Analysis**

**Qualitative Data Analysis**

Data analysis began immediately after the collection of the first interview and lasted throughout the entire study. Simultaneous involvement in data collection and analysis helped to keep pursuing emphases as we shape our data collections to inform emerging analysis. Qualitative study software MaxQDA 10 was used to help manage the database. Analysis was conducted in three stages: open-coding, axial coding and focused coding (Corbin & Strauss, 2008). Constant comparisons of data and integrative diagrams were used to assist in data analysis.
Quantitative Data Analysis

SPSS and AMOS (version 20) were used for all data analysis, including: pre-analysis data screening (missing data, outliers, normality, linearity, homoscedasticity, multicolinearity), exploratory factor analysis (EFA), confirmatory factor analysis (CFA), various validity tests, common method bias tests, invariance tests, and structural equation model (SEM) analysis.

Addressing Issues of Validity and Reliability in a Mixed-Method Setting

Issues of validity and reliability in a mixed method setting were addressed using the methods listed in Table 2.

<table>
<thead>
<tr>
<th>TABLE 2</th>
<th>Addressing Credibility Issues</th>
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</thead>
<tbody>
<tr>
<td>Reliability</td>
<td><strong>Qualitative</strong></td>
</tr>
<tr>
<td></td>
<td>• Pre-tested the interview protocol.</td>
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<tr>
<td></td>
<td>• Interviews were tape recorded, and tapes were carefully transcribed.</td>
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<tr>
<td></td>
<td>• Interviews were conducted face-to-face.</td>
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<tr>
<td></td>
<td>• Inter-rater reliability checks on codlings.</td>
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<tr>
<td></td>
<td>• Data reporting including verbatim accounts of what people said.</td>
</tr>
<tr>
<td></td>
<td>• Attach interview protocol.</td>
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<tr>
<td>Validity</td>
<td><strong>Qualitative</strong></td>
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<tr>
<td></td>
<td>• Analytic induction.</td>
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<td></td>
<td>• Constant comparative method.</td>
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<td></td>
<td>• Deviant-case analysis.</td>
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<td></td>
<td>• Comprehensive data treatment.</td>
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<tr>
<td></td>
<td>• Appropriate tabulations.</td>
</tr>
<tr>
<td></td>
<td>• Use quantity measurements when possible and appropriate.</td>
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</table>
SECTION V: OVERVIEW OF MAIN FINDINGS OF FOUR INDIVIDUAL STUDIES AND INTEGRATED RESULTS

In this section, I provide an overview the main findings of the four individual studies first, and then present the findings of the integrated study. Finally, I end this section with an emerging model of SPP.

Key Findings of Phase 1 Study--Qualitative Inquiry (Paper 1)

As noted, literature on SPP in knowledge generation and transfer in biomedical research is sparse. In order to understand the underlying mechanism of SPP, I conducted a qualitative study first to generate a grounded theory about SPP. This study aimed to answer the research question: what are the factors involved in scientist-physician partnership in knowledge generation and application to practice? I conducted semi-structured interviews with physicians and scientists guided by open ended questions. I asked scientists (n=8) and physicians (n=8) as well as physician scientists (n=8) what their lived experiences are like in research, translational research, application of science into practice, and physician-scientist partnership.

This study uncovered many facilitating and inhibitory factors of SPP (Figure 4). Barriers to scientist physician partnership identified include learned beliefs on the randomness of discovery and prejudice on the necessity of translational research, lacking of funding and access to collaborating partners. In addition, the grant review process discourages translational research projects especially physician initiated projects, since they were viewed as descriptive and lack mechanism details. The barriers for scientists include: academic culture, lack of credit and respect from clinical partners, lack of funding, lack of opportunity and access to physicians and human tissues. The barriers for
physician’s participation in research are: funding, time, personal financial loss and skills.

This study reveals that individuals are the driving force of medical discovery and application. Personal interests, motivation and individual effort, and organizational and social support facilitate translational research and SPP. In addition, communication, shared goals and vision, mutuality, personality and proper recognition are factors enabling the success of SPP.

**FIGURE 4**

*Findings of Qualitative Study—Barriers and Enablers of SPP*

---

**Learned Barriers**
- Innovation happens randomly
- Hard to predict what knowledge is useful

**Actor’s Belief**
- Is translational research necessary?

**Barriers to Translational Research**
- Funding
- Access to tissues, partners
- Academic culture

**Barriers to Collaboration**
- For Researchers:
  - Lack of credit and respect
  - Academic culture
  - Lack of funding
  - No access to human tissues
  - Lack of understanding of diseases
- For Practitioners:
  - Time
  - Funding
  - Financial reduction
  - Interests
  - Skills

**Bridge: Personal Motivation + Organizational and Social Support**

**Starting Conditions**
- ForResearchers:
  - Survive: Publication + grant
  - Access to clinical partners
  - Translation research
  - Apply research into practice
- Practitioners:
  - Personal motivation
  - Funding
  - Time

**Collaboration Process**
- Success Factors
  - Communication
  - Mutuality
  - Shared goals
  - Personality
  - Proper credit

**Outcomes of Collaboration**
- Publications
- Grant
- Patents
- Products
- Clinical applications

---

I found that: (1) at personal levels, individuals’ interest, personal motivation and individual effort, as well as personality, contribute to the success and failure of SPP. (2) At organizational levels, institutional forces have widened the split between physicians
and scientists. SPP is hindered by lack of organizational support and infrastructure; Institutional structure inhibits SPP. Academic culture inhibits scientists’ participation in SPP and translational research. Medical centers discourage physicians’ participation in research. Institutional structure such as funding and promotion structures governs translational research and SPP. (3) At social and cultural levels, there is a “day and night” culture difference between physicians and scientists. Lack of mutual respect and understanding, a caste system and lack of recognition discourage scientists to work with physicians.

This study suggests The Valley of Death is a result of socio-cultural and institutional problems, in addition to the knowledge translation problem. Biomedical knowledge and practice gap is not only a knowledge translation problem, but also a collaboration problem between science and clinical practice. There are many cultural, social and institutional barriers at both personal and organizational levels that hinder SPP and translational research. The data of this study offers a new way to view and think about the challenges in knowledge production and application. A full paper generated from this study is listed in appendix A. Based on the findings of this study, a model (Figure 5) was generated to guide the subsequent quantitative investigations in phase 2 (studies 2, 3 and 4).

**Key Findings of Phase 2 Studies--Quantitative Investigations**

Based on the findings of study 1, I hypothesized that organizational factors, social and cultural forces, and individual attributes influence the process and outcomes of academia and practice partnership between scientists and physicians; collaboration process factors such as communication and mutuality mediate the effects of personal,
institutional and socio-cultural factors on performance outcomes of SPP. Partnership satisfaction on process effectiveness has a positive relationship with SPP outcomes.

**FIGURE 5**
A Conceptual Model of Scientist-Physician Partnership

To test these hypotheses, psychometric data was collected from 440 physicians and scientists at top U.S. hospitals and medical schools, or from the members of several Clinical Translational Science Award (CTSA) centers through their local offices. I used existing (when available and appropriate) scales and scales I developed for this dissertation to measure the constructs hypothesized in the conceptual model. I also included gender, age, academic title and income as controls for all three quantitative studies to account for their potential influences. The data were collected through an
online instrument (Quadrics) and was subjected to analysis using a Structural Equation Model based program (AMOS). Three studies focused on the influence of personal attributes, organizational factors and social-cultural factors, respectively. The sections below summarize the key findings of these three studies.

**Phase 2a: The Influence of Individual Attributes (Paper 2)**

This study focuses on the influence of individual factors on SPP effectiveness. It was hypothesized that professional identity has a positive effect on both academic and clinical outcomes; personal motivations influence SPP effectiveness; and personality has an impact on clinical outcome and academic outcome. In addition, it was proposed that professional degree moderates the relationship between academic outcome and clinical outcome.

The final structural model resulted in an explanatory power of 15% for academic outcome and 15% for clinical outcome. Given that both clinical and academic outcomes are the results of many complicated processes involving many additional factors, the personal attributes with a explaining power of 15% of variance in both academic outcome and clinical outcome indicate the importance of the individual factors. The analysis of 440 responses reveals the following findings: (1) Professional identity has a positive effect on both academic outcome and clinical outcome through satisfaction on process effectiveness (SPE) of collaboration, and SPE fully mediates the role of professional identity on both academic outcome and clinical outcome. (2) Recognition motivation has a positive effect on academic outcome, but surprisingly both recognition motivation and challenge motivation have a negative effect on SPE, which has a positive impact on both academic outcome and clinical outcome. Compensation motivation is not associated with
SPE, academic outcome and clinical outcome. (3) Introversion has a negative direct
effect on academic outcome, but no relationship with clinical outcome; conscientiousness
has a positive effect on SPE. Neither agreeableness nor openness is associated with any
SPP outcomes in this model. (4) Contrary to traditional beliefs, analysis data shows that
professional degree does not moderate the relationship between academic outcome and
clinical outcome. However, a lot of relationships between personal attributes and SPP
outcomes are stronger in PhDs than in MDs. The results of this study are summarized in
Figure 6.

This study contributes to the literature regarding the roles of professional identity,
personality, motivation, and professional degree in cross-professional collaboration such
as SPP. It has several practical implications on how to identify the right collaborators and
how the traditional belief of the role of physician-scientist should be re-assessed. A full
report of this study is listed as appendix B.

**FIGURE 6**
The Influence of Personal Attributes on SPP Effectiveness

- Personal Attributes: Professional Identity, Recognition Motivation, Challenge Motivation, Conscientiousness, Introversion
- SPP Effectiveness: Academic Outcomes (papers, grants), Clinical Outcomes (clinical applications, patents)
- Direct effect: Professional Identity → Satisfaction on Process Effectiveness (R²=0.152)
- Moderating effect: Professional degree → Academic Outcomes (P<0.001)

ns: non significant; +: P<0.1*; P<0.05; **: P<0.01, ***: P<0.001;
Phase 2b: Influence of Organizational Factors (Paper 3)

The research question I asked for this study was: to what extent does existing organizational infrastructure, levels of organizational support and incentive systems affect SPP effectiveness? I hypothesized that institutional forces and arrangements such as academic promotion criteria and organizational infrastructure are related to partnership satisfaction and performance outcomes including academic and clinical related outcomes. I posited that communication effectiveness mediates the effect of institutional forces on the partnership satisfaction and outcomes.

Consistent with the qualitative study, organizational collaboration mechanism positively influences communication effectiveness, and access difficulty has a negative relationship with communication and academic outcome. Communication plays a central role in SPP by partially or fully mediating the effects of academic promotion criteria, level of access difficulty, and the organizational collaboration mechanism on academic outcome. The data also reveals that contrary to past literature and the qualitative phase study, academic standards of appointment and promotion serve as an incentive and have a positive effect on communication, perceived satisfaction on process effectiveness (SPE) of SPP, and both academic outcomes directly and clinical outcomes indirectly. SPE has a directly positive impact on both academic outcome and clinical outcome. It fully mediates the effect of communication effectiveness on both academic outcomes and clinical outcomes. In addition, satisfaction on process effectiveness also partially mediates the effect of academic incentive on academic outcome. This model has a slightly improved explanatory power of 18% for academic outcomes and 16% for clinical outcomes. Strikingly, the combination of academic promotion criteria and
communication effectiveness explains 60.4% of variance in SPE. The results of this study are summarized in Figure 7. A full report of this study is listed as appendix C.

**FIGURE 7**
The Effect of Organizational Factors on SPP Effectiveness

Phase 2c: The Influence of Social-Cultural Factors (Paper 4)

This study aimed to investigate the influence of socio-cultural factors on scientist-physician partnership (SPP) outcomes. It was proposed that the perception of socio-cultural difference and professional language difference between scientists and physicians have a negative effect on SPP outcomes including both academic outcome and clinical related outcome; and social support and shared vision/goals positively influence the outcomes of SPP.

As predicted, shared vision/goals has a positive effect on communication effectiveness, mutuality and satisfaction on process effectiveness of collaboration. These
factors in turn positively influence both academic outcome and clinical outcomes.

Strikingly, shared vision/goals also has a direct effect on clinical outcome. Social support influences academic outcome and clinical outcome through its direct impact on mutuality.

Surprisingly, both professional language differences and perceived socio-cultural differences do not have a negative, but instead have a positive influence, on SPP outcomes directly or indirectly through their positive effects on communication effectiveness and mutuality as well as satisfaction on collaboration process effectiveness. Communication effectiveness fully mediates the effects of professional language difference and shared vision and goals on academic outcome. It partially mediates the effect of shared vision/goals on clinical outcome. Satisfaction on process effectiveness of collaboration partially mediates the role of perceived socio-cultural difference and shared vision/goals on academic outcome. It also mediates the effect of shared vision and goals on academic outcome. While the $R^2$ for SPE ($R^2 = 0.590$) in this model focusing on socio-cultural factors is similar to the $R^2$ ($R^2 = 0.604$) in another model focusing on institutional factors, this model has high explanatory power for communication effectiveness ($R^2 = 0.694$), indicating the importance of socio-cultural factors on communication effectiveness. These factors also result in a high explanatory power for mutuality ($R^2 = 0.715$). This model has an explanatory power of 14% for academic outcome and 16% for clinical outcome. The results of this study are summarized in Figure 8. A full report of this study is listed as appendix C.
FIGURE 8
The Impact of Socio-Cultural Factors on SPP Effectiveness

Findings of Phase 3-- Integrated Study

The three quantitative studies uncovered the causal links and the prevalence of the influencing factors in SPP. Next, I conducted two studies to answer two further questions: (1) which factors are the most influential in influencing SPP? (2) How does the organizational collaboration mechanism affect the influence of key factors on SPP outcomes? An answer to the first question helps to focus attention and efforts on the key factors of cross-professional collaboration. An answer to the second question provides empirical evidence and practical implications on the role of the organizational collaboration mechanism.
Phase 3a: Which factors are the most important influencing factors of SPP?

The phase 2 quantitative studies identified a host of factors that have significant influence on collaboration outcomes and collaboration processors including communication effectiveness, mutuality and satisfaction on collaboration process in three different models representing the factors at three different (personal, organizational and socio-cultural) levels.

Given the fact that I used the same dependent variables in three quantitative studies in Phase 2, I could compare the regression weights of influencing factors and their impacts on the changes of $R^2$ of the latent variables to find out the prevalence of their impact. However, this method would lead to missing data on the influence of personal factors on communications due to the non-inclusion of communication in the study of the effect of personal factors. In addition, comparing all involved factors in one combined model in the presence of other influencing factors provides more accurate results. Therefore, unlike the studies (2, 3, and 4) in phase 2 where SEM models was built separately based on the antecedents of personal, organizational and social cultural influences; in phase 3 studies, I included all factors (excluding mediators communication effectiveness and SPP) as independent variables, and used different latent variables as dependent variables in different models to compare the prevalence of the impacts of the identified factors on latent variables in the same combined model. The influence of the individual factor was conducted by comparing the $R^2$ differences of the model with or without the factor. The following is the results of the analysis of the different models (Model 1: academic and clinical outcomes as dependent variables (DV); Model 2:
Satisfaction on process effectiveness of collaboration (SPE) as DV; Model 3: communication effectiveness as DV; Model 4: mutuality as DV).

**Factors affecting clinical outcome (CO).** Clinical outcome is the ultimate goal of scientist physician partnership. One of the main goals of this research therefore was to identify the factors that influence clinical outcomes of SPP. Among all the factors investigated, only academic outcome ($\beta=0.154$, $p=0.001$), shared vision/goals ($\beta=0.121$, $p=0.008$) and satisfaction on process effectiveness of collaboration ($\beta=0.180$, $p=0.005$) have a direct influence on CO (Figure 9A). The $R^2$ of CO comparison between the model with and without each of these three factors individually showed that academic outcome caused 2.1% of change of $R^2$ of CO meaning that academic outcome is responsible for 2.1% of CO, or in other words academic outcome explains 2.1% of variance in CO. Satisfaction on process effectiveness of collaboration and shared vision/goals caused 1.6% and 0.8% of $R^2$ changes of CO respectively (Figure 9B).

**FIGURE 9**
**Influencing Factors of Clinical Outcome**

<table>
<thead>
<tr>
<th>A. Regression Weight of Influencing Factors</th>
<th>B. % Change of $R^2$ of Clinical Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPE</td>
<td>SVG</td>
</tr>
<tr>
<td>Academic Outcome</td>
<td>Academic Outcome</td>
</tr>
<tr>
<td>SVG</td>
<td>SPE</td>
</tr>
</tbody>
</table>

$0 \quad 0.05 \quad 0.1 \quad 0.15 \quad 0.2$

$0.0\% \quad 0.5\% \quad 1.0\% \quad 1.5\% \quad 2.0\% \quad 2.5\%$

SVG Academic Outcome SPE
Factors affecting academic outcome (AO). Academic activities and outcomes are the foundation of clinical outcomes. Given the effect of academic outcomes on clinical outcomes, I next investigated the factors that are responsible for academic outcome. Analysis of a SEM model including all factors identified in study 2, 3 and 4, but no mediators (to avoid confounding effect), showed that academic promotion criteria ($\beta = 0.215$, $p < 0.001$), mutuality ($\beta = 0.172$, $p < 0.001$), compensation motivation ($\beta = 0.088$, $p = 0.05$), and perceived socio-cultural difference ($\beta = 0.083$, $p = 0.072$) all have a directly positive effect on academic outcome, while level of access difficulty ($\beta = -0.139$, $p = 0.004$) and introversion ($\beta = -0.145$, $p = 0.001$) have directly negative effects on academic outcome (Figure 10A). The $R^2$ change of academic outcome by these factors ranged between 1.1% for perceived socio-cultural difference and 3.8% for academic promotion criteria (Figure 10B).

FIGURE 10
Influencing Factors of Academic Outcome

A. Regression Weight of Influencing Factors  
B. % Change of $R^2$ of Academic Outcomes

Next, I investigated the effect of collaboration facilitators (i.e. satisfaction on process effectiveness (SPE), communication effectiveness and mutuality) on academic
outcome. The analysis showed that SPE ($\beta=0.379$, $p<0.001$) has a strong direct influence on academic outcome explaining 6% of $R^2$ change of academic outcome, and communication effectiveness ($\beta=0.118$) also has a positive direct influence on academic outcome. Interestingly, mutuality ($\beta=-0.167$, $p=0.045$) has a negative effect on academic outcome in this model when other independent variables were not included (Figure 11).

**FIGURE 11**
The Effect of Collaboration Facilitators on Academic Outcome

A. Regression Weight of Influencing Factors  
B. % Change of $R^2$ of Academic Outcome

**Factors affecting communication effectiveness (CE).** Communication effectiveness plays a crucial role in SPP. It mediates the effect of many factors on satisfaction, collaboration, and SPP outcomes. In order to find out what factors affect CE most, I combined all factors together as independent variables while using CE as the dependent variable in a SEM model. Analysis of the combined model showed that mutuality and shared vision/goals have a strong influence on CE; professional language difference also has an effect on CE; openness and academic promotion criteria have modest but significant influence on CE (Figure 12). It is interesting to notice that agreeableness have a negative effect on CE, indicating the importance of encouraging
different opinions in effective communication. To see how much each factor is responsible for CE, I compared the $R^2$ of the models with and without the individual influencing factor included. Mutuality, shared vision/goals, and professional language difference are found to explain 6.5%, 3.3%, and 2.9% of variance in CE, respectively. The effects of openness, agreeableness and academic promotion criteria on $R^2$ of CE are all below 0.5%.

**FIGURE 12**

Influencing Factors of Communication Effectiveness

A. Regression Weight Influencing Factors of Communication Effectiveness

- Mut: $P<0.001$
- SVG: $P<0.001$
- PLD: $P<0.001$
- Openess: $P=0.043$
- AcadInctv: $P=0.044$
- Agreeableness: $P=0.012$

B. % $R^2$ Changes of Communication Effectiveness
Factors affecting satisfaction on process effectiveness (SPE) of collaboration.

Satisfaction on process effectiveness is an important factor in SPP. It mediates the effect of many factors including communication effectiveness on SPP outcomes. In order to find out the prevalence of the factors affecting SPE, I included all factors as the independent variables and used SPE as the dependent variable in a SEM model. The analysis showed that mutuality ($\beta=0.51$, $p<0.001$) has the strongest influence on SPE; shared vision/goals ($\beta=0.213$, $p<0.001$) and academic promotion criteria ($\beta=0.172$, $p<0.001$) also influence SPE positively; and conscientiousness ($\beta=0.067$, $p=0.037$) has a weak but significant effect on SEP (Figure 13). Analysis of $R^2$ changes showed that mutuality explains 7.4% of $R^2$ changes of SPE, and shared vision/goals and academic promotion criteria explain 1.3% and 2.8% respectively. The effect of conscientiousness on $R^2$ of SPE is only 0.4%.

FIGURE 13
Factors Affecting Satisfaction on Process Effectiveness (SPE)

A. Regression Weight

<table>
<thead>
<tr>
<th>Factor</th>
<th>Regression Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mutuality</td>
<td>0.51</td>
</tr>
<tr>
<td>SVG</td>
<td>0.213</td>
</tr>
<tr>
<td>APC</td>
<td>0.172</td>
</tr>
<tr>
<td>Conscientiousness</td>
<td>0.067</td>
</tr>
</tbody>
</table>

B. % Change of $R^2$ of SPE

<table>
<thead>
<tr>
<th>Factor</th>
<th>% Change of $R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mutuality</td>
<td>7.4%</td>
</tr>
<tr>
<td>SVG</td>
<td>1.3%</td>
</tr>
<tr>
<td>APC</td>
<td>2.8%</td>
</tr>
<tr>
<td>Conscientiousness</td>
<td>0.4%</td>
</tr>
</tbody>
</table>

Factors affecting mutuality. Given the important role of mutuality on communication effectiveness and satisfaction on process effectiveness of collaboration, I
next investigated the factors influencing mutuality. The analysis of a SEM model using mutuality as the dependent variable identified shared vision/goals (SVG) as an important factor that influences mutuality. Shared vision/goals ($\beta=0.825$, $p<0.001$) has a very strong effect on mutuality. It explains 54.9% of $R^2$ changes of mutuality. Other factors influencing mutuality weakly include professional identity ($\beta=0.065$, $p=0.015$), professional language difference ($\beta=0.045$, $p=0.088$) and academic promotion criteria ($\beta=-0.077$, $p=0.003$). The effects of these factors on the $R^2$ changes of mutuality are below 0.5% or no effect (Figure 14 A, B).

**FIGURE 14**
Factors Affecting Mutuality

![A. Regression Weight](image)

![B. % Change of $R^2$ of Mutuality](image)

**Phase 3b: The Moderating Effect of Organizational Collaboration Mechanism (OCM)**

The studies in phase 1, 2 and 3a identify many factors affecting SPP and its outcomes. They represent factors at individual, institutional and socio-cultural levels. While there is not too much organizations can do to change or influence the individual (introversion, share vision/goals, professional identity) or social-cultural factors
(professional language difference etc), organizations perhaps can influence the negative effects of some personal factors and social-cultural factors on SPP outcomes through organization structures and mechanisms such as incentive structure and organizational supporting mechanism for collaborations. To test this hypothesis, I divided the data of organization collaboration mechanism (OCM) into OCM-low and OCM-high groups, and then investigated the influence of OCM on the relationships between personal attributes and social factors with SPP by using OCM as a moderator. Critical ratio analysis was applied for statistical analysis. Tables 3 and 4 list the results of group analysis.

**Relationships stronger in OCM-high group.** Group analysis shows that the positive effect of academic promotion criteria on communication effectiveness is significant only when OCM is high. It is worth noting that, although the z score does not reveal a significant difference between high and low OCM groups on the relationship between perceived socio-cultural difference (PSCD) and communication effectiveness, PSCD has a positive effect on communication effectiveness when OCM is high (p=0.072), but has no effect when OCM is low (p=0.932). Similarly, shared vision/goals almost has a positive effect on clinical outcome when OCM is high (p=0.100), but has no effect when OCM is low (p=0.683). These data (Table 3) indicate the importance of providing a high OCM.

**TABLE 3**

**Relationships Stronger in High Organizational Collaboration Mechanism**

<table>
<thead>
<tr>
<th>Relationship</th>
<th>OCM-Low</th>
<th>OCM-High</th>
<th>z-score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic promotion criteria on CE</td>
<td>0.024</td>
<td>0.157</td>
<td>1.66*</td>
</tr>
<tr>
<td>Perceived socio-cultural difference on CE</td>
<td>0.005</td>
<td>0.097</td>
<td>1.168</td>
</tr>
<tr>
<td>Shared vision/goals on clinical outcome</td>
<td>0.307</td>
<td>1.384</td>
<td>0.956</td>
</tr>
</tbody>
</table>
**Relationships stronger in OCM-low group.** Group analysis showed a negative influence of recognition motivation on satisfaction on process effectiveness (SPE) of collaboration, and a negative influence of perceived social cultural difference on clinical outcomes when OCM is low, but there are no significant relationships when OCM is high. This suggests that organizations should provide high OCM to mitigate the negative influence of these factors.

It is worth noticing that although the z-score \( z = 1.623 \) does not reveal a significant difference between high and low OCM groups for the effect of challenge motivation on satisfaction on process effectiveness of collaboration, the negative effect of challenge motivation on SPE is significant only when OCM is low \( (p < 0.0001) \), but has no negative effect when OCM is higher \( (p = 0.195) \). In addition, although the z-score \( z = 0.718 \) does not reach significant level, the negative effect of introversion on academic outcome is stronger when OCM is low \( (\beta = -0.627, p = 0.006) \) than when OCM is high \( (\beta = -0.391, p = 0.096) \). The findings further support the importance of high OCM.

It appeared that the following relationships are stronger when OCM is low: the positive effect of professional language difference on communication effectiveness; the positive effect of shared vision/goals on mutuality; the positive effect of communication effectiveness on SPE; the positive effect of recognition motivation on academic outcome. Additionally, although z scores do not reach the significant levels, there are differences between high OCM and low OCM based on regression weights and p values in the following relationships: perceived socio-cultural difference on SPE, shared vision/goals on SPE, professional identity on SPE, and professional language difference on mutuality. These data suggest that when the OCM is low, intrinsic factors such as shared
vision/goals, professional identity, motivation and other factors are critical. Further investigation is needed to provide better understanding on why the positive effects of professional language difference on communication effectiveness, communication effectiveness on SPE, recognition motivation on academic outcome and shared vision/goals on mutuality are stronger in OCM-low group.

**TABLE 4**

<table>
<thead>
<tr>
<th>Relationship</th>
<th>OCM-Low</th>
<th></th>
<th>OCM-High</th>
<th></th>
<th>z-score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>p</td>
<td>Estimate</td>
<td>p</td>
<td></td>
</tr>
<tr>
<td>Recognition Motivation on SPE</td>
<td>-0.205</td>
<td>0.003</td>
<td>-0.032</td>
<td>0.572</td>
<td>1.91*</td>
</tr>
<tr>
<td>PSCD on clinical outcome</td>
<td>-1.303</td>
<td>0.060</td>
<td>0.610</td>
<td>0.448</td>
<td>1.802*</td>
</tr>
<tr>
<td>Challenge Motivation on SPE</td>
<td>-0.481</td>
<td>0.000</td>
<td>-0.168</td>
<td>0.195</td>
<td>1.623</td>
</tr>
<tr>
<td>Introversion on academic outcome</td>
<td>-0.627</td>
<td>0.006</td>
<td>-0.391</td>
<td>0.096</td>
<td>0.718</td>
</tr>
<tr>
<td>Professional language difference on CE</td>
<td>0.453</td>
<td>0.000</td>
<td>0.277</td>
<td>0.000</td>
<td>-1.694*</td>
</tr>
<tr>
<td>Shared vision/goals on mutuality</td>
<td>0.792</td>
<td>0.000</td>
<td>0.698</td>
<td>0.000</td>
<td>-1.891*</td>
</tr>
<tr>
<td>Communication effectiveness on SPE</td>
<td>0.598</td>
<td>0.000</td>
<td>0.492</td>
<td>0.000</td>
<td>-2.221**</td>
</tr>
<tr>
<td>Recognition Motivation on AO</td>
<td>0.600</td>
<td>0.010</td>
<td>-0.053</td>
<td>0.819</td>
<td>-1.991**</td>
</tr>
<tr>
<td>Perceived socio-cultural difference on SPE</td>
<td>0.154</td>
<td>0.001</td>
<td>0.046</td>
<td>0.318</td>
<td>-1.634</td>
</tr>
<tr>
<td>Professional identity on SPE</td>
<td>0.768</td>
<td>0.000</td>
<td>0.459</td>
<td>0.002</td>
<td>-1.434</td>
</tr>
<tr>
<td>Shared vision/goals on SPE</td>
<td>0.161</td>
<td>0.020</td>
<td>0.076</td>
<td>0.309</td>
<td>-0.843</td>
</tr>
<tr>
<td>PLD on mutuality</td>
<td>0.111</td>
<td>0.059</td>
<td>0.022</td>
<td>0.627</td>
<td>-1.196</td>
</tr>
</tbody>
</table>

*The relationship similar in high and low OCM groups.* Interestingly, the relationship between academic outcome and clinical outcome is not affected by the status of OCM (β = 0.279, p = 0.064 for OCM low group; β = 0.332, p = 0.066 for OCM-high group, z = 0.225). This finding is consistent with the observation of the qualitative study.
that individuals are the driving force of medical innovation. It also reflects the complicated nature of clinical outcomes.

Summary of the Findings—an Emergent Model of Scientist Physician Partnership

In summary, this dissertation research identified the factors involved in scientist physician partnership (SPP), uncovered the relationships of these factors, and investigated the prevalence of the impacts of these factors on outcomes of SPP. A model of SPP in biomedical knowledge generation and translation has emerged (Figure 15) based on the results of four individual and two integrated studies.

This model proposes that clinical outcome is influenced directly by academic outcomes and shared vision/goals between scientists and physicians as well as by their satisfaction on the process effectiveness of collaboration. Collaboration process factors such as communication effectiveness play an important role mediating the effects of personal, organizational and socio-cultural factors on the effectiveness of SPP. Among all the influencing factors, shared vision and goals, mutuality, academic promotion criteria and professional language difference are the main facilitators of SPP, and lack of organization support as indicated by the level of access difficulty to collaborators and introversion personality are the main barriers to the effectiveness of SPP.

Organization collaboration mechanism moderates many relationships in SPP. For example, high OCM abolishes the negative influence of perceived socio-cultural difference on clinical outcome and recognition motivation on SPE. In addition, OCM mitigates the negative influences of introversion on academic outcome dramatically ($\beta = -0.627$, $p = 0.006$ in OCM-low; vs $\beta = -0.391$, $p = 0.096$ in OCM-high). Furthermore, the positive effect of APC on communication effectiveness ($\beta = 0.157$, $p = 0.002$) is present
only in the high OCM context. When OCM is low, this positive effect disappeared (β = 0.024, p = 0.701). These data demonstrate the importance of providing organizational collaboration contexts. Interestingly, professional degree (MD, PhD or MD/PhD) does not moderate the relationship between academic outcome and clinical outcome.

FIGURE 15
An Emergent Model of SPP
SECTION VI: DISCUSSION AND CONCLUSION

This section begins with a discussion of framing issues with The Valley of Death, followed by my unexpected findings and their implications, and then followed by the role of organizations. The conclusion section starts with the influencing factors of SPP, including antecedents of SPP and facilitators and inhibitors of SPP, and concludes with a brief summary of this research.

Discussion

The Medical Science and Practice Gap: beyond the Knowledge Translation Problem

The failure to apply research findings to clinical practice has been framed as a problem of knowledge translation (Graham et al., 2006; Lenfant, 2003; Sung et al., 2003). The majority of efforts to reduce the research and practice gap has been focused on increasing translation by promoting translational research (TR) (Crist et al., 2004; Zerhouni, 2007) and emphasizing the important role of the translators (physician-scientists) (Ley & Rosenberg, 2005). Many efforts and initiatives, including research funding and educational programs, have been made to promote physicians’ participation in research, especially translational research (Crist et al., 2004; Goldstein & Brown, 1997; Harrington, 2006; Rosenberg, 1999; Zerhouni, 2007).

However, none of my respondents in the first study reported language being an obstacle for translational research focused SPP, which suggests that “translation” or lack of common language is not the problem scientists and physicians experienced. This observation was confirmed in the phase 2 quantitative studies. In responding to a question asking the influence of professional language difference on their collaboration, less than 4% of respondents agreed with this statement: “The professional language difference
between physicians and scientists prevented me from collaborating with PhDs /MDs.” As a matter of fact, professional language difference may not inhibit, but under some conditions, may promote collaboration between scientists and physicians as data in study 4 suggests.

A few of the respondents mentioned the important role physician-scientists play in translational research, but none of them stated that physician-scientists are the only individuals who can narrow the gap between practice and science. However, quantitative data analysis using professional language as a moderator did not reveal a relationship between clinical outcome and professional degree.

The fact that “collaborations between physicians and scientists have generated many of the revolutionary advances in medicine” (Goldesnstein & Brown, 1997: 2808) supports my finding that a lack of common language is not a main issue in applying medical research to practice. This study suggests that the science-practice gap is a problem in which language is only a small part of the difficulty.

Giddens’ (1984) structuration model provides a helpful way to describe the findings of this research and to analyze the process. As illustrated in Figure 16, from the perspective of the signification dimension (production of meaning or sense-making), the Valley of Death has been interpreted as a lack of common language in science and practice; therefore, many efforts have been placed on the promotion of translational research and physician-scientists. My findings reveal that in addition to the signification dimension, it is also important to recognize the role of domination (convey message on power) and legitimation (social norms, values and standards) dimensions. According to the model, facility and norm behavior affect the power of agents and impose sanctions
(positive and negative) through reward systems, grants, a caste system, and promotions. These systems all contribute to the participation of scientists and physicians in translational research and SPP.

**FIGURE 16**

**Structuration Theory and Factors in Scientist-Physician Partnership**

<table>
<thead>
<tr>
<th>Structure</th>
<th>Signification</th>
<th>Domination</th>
<th>Legitimation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rules</td>
<td>Interpretive Scheme</td>
<td>Facility</td>
<td>Norm</td>
</tr>
<tr>
<td>Resources</td>
<td>Languages of science and practice</td>
<td>Government Funding agencies</td>
<td>Socio-economic status</td>
</tr>
<tr>
<td>Modality</td>
<td></td>
<td>Academic Medial Centers</td>
<td>Cultural difference</td>
</tr>
<tr>
<td>Means</td>
<td></td>
<td></td>
<td>Grant review mechanism</td>
</tr>
<tr>
<td>Tools</td>
<td></td>
<td></td>
<td>Physician authority</td>
</tr>
<tr>
<td>Interaction</td>
<td>Communication</td>
<td>Power</td>
<td>Sanction</td>
</tr>
<tr>
<td>Agencies</td>
<td>Physicians scientists Translational research</td>
<td>NIH University/Hospital Physicians Scientists</td>
<td>Grant award</td>
</tr>
<tr>
<td>Actions</td>
<td>Language and sense making</td>
<td></td>
<td>Reward and recognition</td>
</tr>
<tr>
<td></td>
<td>Many efforts</td>
<td>Institutional arrangements</td>
<td>Caste system</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Academic Promotion</td>
</tr>
<tr>
<td>Current strategy</td>
<td></td>
<td></td>
<td>Socio-cultural barriers</td>
</tr>
<tr>
<td>to address the structuration problems in the Valley of Death</td>
<td></td>
<td></td>
<td>Inadequacy</td>
</tr>
</tbody>
</table>

The focus on the translation issue has emphasized cognitive and knowledge related barriers. My study reveals that social, cultural and institutional factors are at work for translational research and SPP. This supports Carlile’s (2004: 559) argument that “under some circumstances, however, it is not just a matter of translating different meanings, but of negotiating interests and making trade-offs between actors.” The data on physician’s interest in participating in research and applying innovation, as well as scientist’s interests in clinical related research, is consistent with Carlile’s notion.
Framing the clinical-related research, as translational research alone, is not enough. A more integrative approach is needed.

Carlile (2004: 558) discusses many approaches to move knowledge across different domains including, “focused on the role of particular individuals as brokers and translators who enable the flow of knowledge.” The medical community has emphasized the role of physician-scientists, evidenced by numerous financial and educational programs. However, the physician-scientist is a vanishing species (Schafer, 2010). As Nobel Laureates Goldstein and Brown (1997: 2808) point out, “It is increasingly difficult for a single individual simultaneously to fill the roles of physician and scientist.”

Emphasizing the knowledge translation problem and the role of physician-scientists has not produced desired knowledge or outcomes to narrow the Valley of Death. These unsuccessful efforts suggest that knowledge translation is not a major problem in applying medical science into practice. The problem of the research and practice gap could be, and should be, formed differently. Proper formation of a problem is essential to the solution, because whether a certain result is true or not is relative to the methodological approaches used at the time (Knorr-Celina, 1999).

**The Relationship between Academic Outcome (AO) and Clinical Outcome (CO) is not Stronger in MDs than in PhDs**

Clinical outcome depends on the results of academic outcomes. Given the importance of physician-scientists in producing a good clinical outcome and the different training background and focus of PhDs and MDs, I expected a stronger relationship between AO and CO in MDs than PhDs. Surprisingly, the critical ratio analysis using
professional degree as a moderator did not uncover a difference between MDs and PhDs (z score = -0.084; p > 0.10).

However, this finding was consistent with what I found in the qualitative phase study. As the interviewees stated, physician-scientists are forced to focus on basic science in order to compete with basic scientists for grants and for publishing research papers. Clinical research is considered as descriptive, lacking mechanism, due to the availability of human research models and human samples. In addition, this finding agrees with the result of a survey question asking about the purpose of their collaborations. Almost identical percentages of MDs, PhDs, and MD-PhDs (83.2% for PhDs, 83.5% for MDs and 83.9% for MD-PhDs) engaged in SPP to get papers published, and slightly more MDs than PhDs or MD-PhDs used it to transfer research into clinical practice (68.5% for MD, 76.6% for MD, and 67.7% for MD-PhDs).

One possible explanation for this unexpected finding may lie in the measurement of clinical outcomes. I included patents generated from collaboration as a CO outcome for its potential clinical application. Some patents may only have research applications but no clinical applications. Future study, using only applied clinical applications or licensed patents for clinical applications as a clinical outcome, may provide a more accurate picture on the role of PhDs and MDs in transferring research into practice.

III. Structure and Behavior: The Impact of Academic Promotion Criteria

Literature suggests that academic culture such as appointment and promotion discourages the collaborative effort (Israel et al., 2001; Jacobson et al. 2004; Pober et al., 2001). However, obtaining funding as a principal investigator and publishing as a primary (first or last author) author have a positive, not a negative effect on
communication effectiveness, partnership satisfaction on collaboration process effectiveness and academic rewards directly, and on clinical outcomes indirectly. This is in line with Giddens’s (1984: 25) Structuration Theory where he points out, “Structure is not to be equated with constraint but is always both constraining and enabling.”

My findings suggest that organizational structure, such as promotion standards created by institutional forces, serves as an incentive for the actors to adjust their actions in order to pursue the reward. In my study context, the academic incentive of publications and grants is a result of academic structure of appointment and promotion and the academic culture of publish or perish (Pfeffer, 2007). Academic incentives drive the collaboration between physicians and scientists to pursue primarily the academic reward and clinical reward to a certain degree. For instance, more collaboration has been seen in response to policy and funding changes. “The increasing number of authors per article in academic journals is the consequence of a changing scientific culture”, and this may be shaping a new paradigm of “publish together or perish” (Baethge, 2008).

“Institutional features of the organizational environments shape both the goals and means of actors” (Scott, 1987: 493). Institutional forces influence behaviors, and it is well documented that individuals accept and conform to institutionalized norms (Pfeffer, 1992). The positive links between academic culture as a form of institutional structure and many other factors including communication, collaboration process effectiveness, academic outcome, and clinical outcome support these arguments and Barnard’s belief that “behaviors can be controlled and predicted if people are rewarded by incentives to perform specific tasks required by the organizations to be efficient” (Barnard, 1968 cited in Bouclier, 2010: 7).
The unexpected positive links between perceived social cultural differences with academic outcomes and satisfaction on collaboration, between professional language differences with communication effectiveness, and mutuality may also be results of institutional structures, the structures encouraging or forcing actors to overcome the difference for the rewards institutions provide such as grants, promotion, and recognition.

IV. The Role of Organizations

Lack of organizational support and organizational collaboration mechanisms (OCM) to foster and support physician and scientist collaboration were identified in the qualitative study. While some collaboration practices, such as seminars and supportive leaders, exist to a certain degree in a few organizations, most interview participants mentioned the inadequacy or dearth of organizational collaboration mechanisms, such as: senior management support, a Technology Transfer Office-like Collaboration Office, and collaboration oriented meetings or networking events. As participants clearly confirmed, individuals are far more helpful than organizations in their collaborations.

The quantitative study confirmed that the organizational collaboration mechanism—including the existence of supportive leadership, collaboration office, seminars and meetings, as well as social events for networking in organizations—are important facilitators of SPP. OCM has a positive influence on communication effectiveness, a key factor in SPP that mediates many effects of collaboration antecedents on SPP outcomes. In addition, the Phase 2 study shows that access difficulty to collaborators as an indication of lack of organizational support has a direct negative impact on SPP effectiveness. Favorable institutional structures, such as promotion and collaboration supporting practices, play a prominent role in the effectiveness of SPP.
The important function of OCM is also reflected in the group analysis data. When OCM is low, recognition motivation and challenge motivation have negative effects on satisfaction on process effectiveness of collaboration, perceived socio-cultural difference (PSCD) has a negative effect on clinical outcome, and introversion has a negative effect on academic outcome. Remarkably, when OCM is high, these factors do not have (recognition motivation, challenge motivation and perceived socio-cultural difference), or have a much decreased (introversion: $\beta = -0.627/==0.006$ in OCM-low vs $\beta = -0.391/==0.096$ in OCM-high), negative effects. In addition, the positive effects of academic promotion criteria and PSCD on CE, and shared vision/goals on clinical outcome are only present when OCM is high. High OCM mitigates the negative influence of inhibitory factors, or promotes the positive roles of academic promotion criteria and shared vision/goals, demonstrating the importance of providing OCM.

Furthermore, group analysis data suggests that when the OCM is low, intrinsic factors such as SVG, professional identity, motivation and other factors are critical. In order to encourage the participation and outcomes of SPP of all, not only the ones with high intrinsic motivations, it is critical to provide a high collaborative context.

Conclusion

This research identified many personal, organizational and socio-cultural factors that affect the outcomes of scientist-physician partnership (SPP).

Factors Influencing Scientist-Physician Partnership

**Antecedents:**

**Antecedents for clinical outcome (CO) and academic outcome (AO):** The direct antecedents for clinical outcome (CO) are satisfaction on process effectiveness of
collaboration (SPE), academic outcome (AO), and shared vision/goals. All of them have
direct positive influence on CO. The direct antecedents for academic outcome include
SPE, communication effectiveness (CE), academic promotion criteria (APC), mutuality,
compensation motivation, perceived socio-cultural difference, introversion, lack of
organizational support and recognition motivation. Introversion and lack of
organizational support have negative effect on AO, and the rest all have positive effect on
AO.

**Antecedents for communication effectiveness (CE):** When taking all factors into
consideration using only communication effectiveness as the dependent variable,
mutuality and shared vision/goals have strong positive impacts on CE. Professional
language difference also has an influence on CE. In addition, academic promotion criteria
(APC) and openness have weak positive influence on CE. Surprisingly, agreeableness
has a weak negative impact on CE.

**Antecedents for satisfaction on process effectiveness of collaboration (SPE):**
When taking all factors into consideration using only SPE as the dependent variable,
mutuality and CE have strong influence on SPP, followed by shared vision/goals and
academic promotion criteria. In addition, conscientiousness has a week but significant
positive influence on SPE. Furthermore, when SPE is analyzed as part of three separate
models (studies 2, 3, and 4), professional identity has a strong effect on SPE, and
perceived socio-cultural difference influences SPE positively, but recognition motivation
and challenge motivation influence SPE negatively.

**Antecedents for mutuality:** are shared vision/goals (very strong positive),
professional identity and professional language difference (weak positive), and academic
promotion criteria (weak negative). In addition, social support is a weak positive antecedent of mutuality in a model in which only social and cultural factors are included.

**Facilitators:**

Both the qualitative and quantitative inquires identified communication effectiveness, shared vision/goals, and mutuality as important enablers in SPP. Shared vision/goals have significant direct influence on clinical outcome. In addition, it has direct influence on SPE, CE and mutuality—the important antecedents of AO and CO. Mutuality has direct impact on CE, SPE and AO. CE in turn has direct influence on SPE and AO. SPE has a direct impact on both AO and CO. Furthermore, CE and SPE mediate the effects of many other factors on AO or CO, proving their critical roles in SPP. In addition to these facilitating factors in SPP, the quantitative data also reveals significant positive influence of other factors in SPP. For example, academic promotion criteria, perceived socio-cultural difference, compensation motivation and recognition motivation have positive effects on AO; conscientiousness, academic promotion criteria, perceived socio-cultural difference, and professional identity positively influence SPE; openness, professional language difference and academic promotion criteria are facilitators of CE; professional identity and professional language difference are positive antecedents of mutuality.

**Inhibitors:**

Consistent with the qualitative findings, a lack of organizational support is an inhibitory factor in academic outcome of SPP. In addition, academic promotion criteria have a small negative influence on mutuality. Recognition motivation and challenge motivation both have a negative influence on SPE. The quantitative data reveals that
introversion has a negative impact on academic outcome, and agreeableness surprisingly negatively influences communication effectiveness. The qualitative study suggests that personality played a big role in a lot of failed collaborations.

The qualitative study identified both promotional and inhibitory factors in SPP (see study 1 in appendix A). However, to my surprise, the quantitative study did not confirm the negative roles of several factors. Perhaps, this was due to the fact that the quantitative studies were based on the responses from participants who collaborated. The distributions of some response data indicate that more successful collaborators participated in the survey. This may explain the reason why the number of inhibitors identified in this research is smaller than the number of facilitators in the quantitative studies.

Summary

This dissertation research utilized a mixed multiple-phase method to investigate the mechanism of SPP in biomedical knowledge generation and transfer by engaging the participation of both scientists and physicians in one study. This research identified the factors involved in SPP at individual, organizational and social-cultural levels. It uncovered the relationships between these factors, as well as the prevalence of their impacts on the outcomes of SPP. This research uncovered the enablers and constrainers of SPP. The unexpected findings of the roles of academic incentive/culture, professional language differences and perceived social-cultural differences between physicians and scientists in SPP provide new insights on how to promote cross-professional collaborations. These findings should provoke further research. In addition, this research provides new insights on the long-believed translational problem in the research and
practice gap in medicine, as well as on the roles of scientists, physicians and physician-scientists in biomedical knowledge generation and transfer. I will discuss the contributions and its implications in depth in the next section.
SECTION VII: CONTRIBUTIONS AND IMPLICATIONS

This research utilized a methodology of mixed methods, a multiple phases and multiple studies approach, to investigate the mechanism of SPP in biomedical knowledge generation and transfer by engaging the participation of both scientists and physicians for the first time in one study. It has important contributions to the literature and provides many practical implications.

Theoretical Contributions

This research makes several important contributions to the literature. First, this research identified many influencing factors in SPP, and quantified the influence of some facilitators and inhibitors on the outcomes of SPP. Four reflective and three informative new scales were developed in this study. The findings and scales developed contribute to the missing literature regarding physician-scientist collaboration—an essential function in medical knowledge discovery and application.

Second, it adds knowledge to the literature of cross-boundary, cross-professional partnership. For example, the findings on the influence of a lack of common language and the effect of socio-cultural differences between different professions may provide insights on other similar cross-professional, cross-boundary collaborations.

Third, contrary to the literature, this research reveals that academic promotion criteria do not inhibit, but instead promotes SPP. This contributes to theories of incentive systems, motivation and institutional theories.

Forth, the unexpected findings of this research challenge many assumptions on inter-professional collaboration. This research should provoke further research in these areas.
Finally, the data of this research suggests that the long-believed “translation” might not be the main problem in the Valley of Death. It provides novel insights on how to tackle the knowledge transfer problem differently. Perhaps it requires a paradigm shift in thinking—a shifting from a common language centered translation issue approach to a collaborative approach that takes personal, organizational and socio-cultural perspectives into consideration.

**Practical Implications**

In addition to its theoretical contributions, this research provides many practical insights for SPP and for other cross-professional collaborations. The findings of this research offer many implications and action recommendations for policy makers, organization decision makers, funding agencies and individual collaboration participants.

**What Can Organization Decision Makers and Institutional Policy Makers Do?**

**At design levels:** Institutions/organizations should design an infrastructure to decrease the negative influence of SPP inhibitors and to enable and foster the positive influence of SPP facilitators. They should design a system with fewer barriers to promote and to sustain SPP and design a proper reward mechanism for the participation of SPP. Institutions/organizations should design a collaborative infrastructure system that takes the influence of socio-cultural differences between physicians and scientists and personal attributes into consideration.

- **At national levels:** Establishments of collaboration offices, national human tissue consortium and national core facilities would be very beneficial for scientist-physician collaboration and translational research.
• **Organizational collaboration mechanism (OCM):** Institutions/organizations should establish supportive organizational collaboration practices such as a collaboration office, supportive leadership, and social networking opportunities. A good OCM can mitigate the negative influence of constrainers of SPP and can foster the positive effects of many facilitators.

• **Funding agencies:** Funding agencies should decrease the tensions between SPP activities and the rules and regulations. For example, at the national funding level, the current sole “Principal Investigator” structure of the National Institute of Health grant application discourages collaboration. In addition, it creates unequal power for the participating investigators. Without access to, and control of, funds and without a pre-existing structure governing collaboration, the motivation of non-Principal Investigators is limited and sometimes it is frustrating for them when the collaborative relationship is not satisfying. It is necessary to improve the current funding system by encouraging co-applicants. In addition, guidelines on how to allocate the grants to collaborators should be in place to ensure that partners get their fair shares. Regulatory barriers to SPP should be decreased and eliminated if possible. For example, partnership outside of the small local environment is penalized financially due to some rules of funding agencies such as the National Institute of Health (NIH).

• **A system recognizing everyone’s contribution correctly:** The current system focusing on only primary authorship and grant-awards to “Principal Investigators” discourages collaboration, as indicated in the qualitative study. Each collaborating
partner’s contribution should be correctly reflected and awarded in tenure and other promotion processes.

- **Who to support:** The lack of links between professional degrees and clinical outcomes that this study found suggests that the approach and practice of focusing on physician-scientists is not necessarily the only, or the best solution in medical knowledge transfer. While it is important to encourage physicians’ participation in research, it is important to support and sponsor the research activities of both scientists and physicians. Given the random nature of medical discovery, it is necessary to support basic research projects as well while focus on clinical oriented projects.

- **Publishers (Publishing Agencies):** Journal editors and reviewers of scientific publications have powerful positions to shape the research and SPP because the ability to publish one’s research in peer-reviewed journals determines future funding opportunities and the survival of research scientists. The publishers should have a policy to take both clinical relevance and scientific vigor of research into consideration when deciding what to publish and what to reject. In addition, an elaborated discussion of clinical relevance, implication and application of research should be required.

- **Education system and other regulatory agencies:** Systemic considerations and modification of practices and policies in the educational system (on the functions of medical school and PhD programs), and on regulatory agencies such as the Food and Drug Administration (FDA) and Internal Review Boards should be in place as well.
What Can Individuals Do?

This research provides implications for individuals on deciding who to collaborate with, and what to do in SPP. To ensure successful and productive inter-professional collaboration, it is important to identify potential collaborators who share the same vision and goals. It is important to communicate the plans, roles of individuals involved and objectives effectively among collaborators, and to show mutual respect and understanding to each other.

The qualitative phase study reveals that most of the collaborations that fail are because of personality conflicts. Quantitative data suggests that introversion is not a good character for SPP, and conscientiousness and extroversion characteristics are good for collaboration. However, a person’s intellectual ability as measured by the openness construct is irrelevant to SPP effectiveness, and agreeableness has nothing to do with effectiveness of SPP. In addition, it may be wise to avoid collaborating with people who are motivated primarily by recognition and/or challenge motivation since these two motivations are associated with dissatisfaction on process effectiveness of collaboration. Given the important role of professional identity in SPP, it is desirable to collaborate with those who identify highly with their profession. Lastly, it is important to be aware of the differences between physicians and scientists.

In summary, the facilitators and inhibitors, as well as the prevalence of the impacts of these factors on SPP outcomes, provide insights on: what organizations should do to promote and foster SPP, with whom individuals should collaborate, and what individuals can do to generate desired SPP outcomes.
SECTION VIII: LIMITATIONS AND FUTURE RESEARCH

Although carefully designed and controlled as much as possible, this research still has several limitations. Some of the limitations of this research, the findings of this research and the remaining research gap provide many new research opportunities.

Limitations

Qualitative Strand

Theoretically uninformed sample selection and the researcher’s experience could have led to a biased data interpretation. These are common limitations of similar qualitative studies. To overcome these limitations of qualitative research, quantitative studies were designed to validate, extend and complement the qualitative findings to a larger extent and context.

Quantitative Strand

The quantitative studies had several limitations: (1) this study is based on single resource and single method obtained self-reported data. Nevertheless, one social desirability item included did not reveal any concern. In addition, CMB checks did not uncover any threats. In addition, I designed both subjective (satisfaction on process effectiveness of partnership and on collaborative relationship) and objective outcomes (abstracts, papers, grants, clinical applications and patents) as dependent variables. (2) The data is from voluntary participants who have collaborated. I noticed that many respondents who started the survey stopped at the question asking, “Have you collaborated with a physician or a scientist?” These partial responses were excluded from the study. The completed non-collaborator responses consisted of less than 10% of total responses, and therefore were excluded from data analysis. This may have biased
findings to a certain degree. (3) Some of the scales used may not fully capture the complex nature of SPP. For example, the finding of the influence of professional language differences may be related to the under-specification of this construct. The influence of perceived social-cultural difference may be another example. (4) The findings on the relationships between individual attributes, organizational and socio-cultural factors with the outcomes of partnership may be specific to the research field. Its generalizability to other cross-boundary and cross-professional collaborations may need to be validated in other contexts.

**Future Research**

There are many lines of research that warrant future research and include but are not limited to the following:

(1) While the data obtained from respondents who had cross-professional collaborations provides insights on institutional enablers in SPP and clinical outcomes, it is necessary to obtain data from non-collaborators. Non-collaborator data would generate insights on the constrainers of SPP and clinical outcomes.

(2) Further investigate the links between professional degrees (PhD, MD or MD-PhD), job categories (scientist, physician, and physician-scientist) and employment affiliation (academia, hospital, or dual appointment) with clinical application of research to provide more insights on the “translation” issue of the Valley of Death using these factors as control and/or moderators. The data would be extremely helpful for policy and decision makers.

(3) Investigate the links between the purpose of SPP (clinical-oriented or academic-oriented) and outcomes of SPP. This could be conducted by studying if
clinically-oriented collaboration leads to clinical outcomes. This info is relevant to the view that translational research and SPP are not really necessary due to the randomness of medical discoveries.

(4) Investigate the interaction effects of several factors on SPP as well as their impacts on clinical outcome.

(5) Study what combinations of collaborator personalities are the best personality matches for SPP. This information would be helpful on how to build successful and effective SPP teams.

(6) Investigate which collaboration mechanism (access to collaborators, supportive leadership, collaboration office, networking events, seminars and meetings, etc.) is the most effective method in facilitating SPP and SPP outcomes. This information would provide guidance for organizations on how to promote SPP and where to focus on their efforts.

(7) Research the influence of other factors such as self-efficacy, conflict management, and social networking capacity on SPP and its outcomes.

(8) Future work can be conducted on the effects of other institutional arrangements, such as: government regulations, insurance policy, funding agencies and regulation, and hospital operations.

(9) This model could also be extended to other cross-professional, cross-boundary and cross-cultural collaborations and partnerships in health and other industries.
APPENDIX A
The Valley of Death—a Result of Knowledge Translation, Socio-Cultural and Institutional Problem in Medicine

ABSTRACT

Substantial resources invested in medical research have generated revolutionary discoveries in medical science. However, it takes 17 years to translate 14% of research findings into clinical practice. The gap between medical science and practice is labeled as “the Valley of Death” and has been framed as a “lost in translation” problem, therefore the effort has focused on the promotion of translational research and translators—physician scientists who understand both science and practice language. Despite many educational and funding programs, physician’s research interest has declined and the gap has not been narrowed. To understand the underlying mechanism, we conducted a qualitative study involving for the first time scientists and physicians as well as physician scientists in the same study. Without presupposing the research and practice gap to be a translation problem, we asked what their lived experience is like in research, application of science into practice, translational research and physician-scientist partnership. Our data reveals that the gap is not only a knowledge translation problem but also a collaboration problem between science and clinical practice. There are many cultural, social and institutional barriers at both personal and organizational levels that hinder physician-scientist partnership and translational research. Our data also uncovers many facilitating factors, and reveals a critical and essential role of individuals in medical discovery and application. Our study suggests that the Valley of Death is a result of socio-cultural and institutional problems in addition to the knowledge translation problem. Our study offers a new way to view and think the challenges in knowledge production and application.

Key words: healthcare; knowledge to practice; collaboration; socio-cultural barriers; institutional structure; physician-scientist partnership.
INTRODUCTION

Substantial resources are invested in U.S. biomedical research (Kerner 2006). The National Institutes of Health (NIH) alone earmarked $31.3 billion for research in 2011, for example, yielding vast knowledge as evidenced by the number of publications generated from sponsored research projects (Grol & Grimshaw, 2003; Kerner, 2008). However, the contribution of research to the improvement of human life is limited, largely because of the slow adoption of research findings by the medical profession (Berwick, 2003; Glasgow et al., 2003; Lenfant, 2003). On average, it takes an estimated 17 years to turn 14% of research findings into changes that benefit patients (Balas & Boren, 2000 cited in Westfall et al., 2007). This demonstrates there is a “very real gulf separating cutting edge laboratory discoveries from their transformation into effective treatments” (Nabel, 2010).

The failure to apply research findings to clinical practice has been framed as a problem of knowledge translation (Graham et al., 2006; Sung et al., 2003). As Lenfant (2003: 869) writes, “moving this knowledge off the shelves and into practice, making it relevant and accessible to practitioners and patients, achieving a true marriage of knowledge with intuition and judgment—all this requires translation” and “the output of biomedical science is getting lost in translation”. The majority of the efforts to reduce this research and practice gap has been focused on increasing translation. This is done by promoting translational research (TR) (Crist et al., 2004; Zerhouni, 2007) and emphasizing the importance of the translators—physician scientists (Ley & Rosenberg, 2005).
Many initiatives and funding and educational programs have been used to promote TR and to encourage the involvement of physician scientists in research (Harrington, 2006; Varki & Rosenberg, 2002; Zerhouni, 2007). Despite many warnings (Goldstein & Brown, 1997; Wyngaarden, 1979) and efforts such as loan payment program, training grants, and fellowships (Ley & Rosenberg, 2005; Varki & Rosenberg, 2002), the physician-scientist has been repeatedly described as a fragile, endangered and vanishing species for more than 3 decades (Rosenberg, 1999; Schafer, 2010; Weatherall, 1991; Zemlo et al., 2000).

"Unless we understand how actors socially construct their accounts of action and how actors constitute the character of their actions..., we will continue to fail ... to furnish satisfactory answers to the long-standing questions" (Mulkay et al., cited by Boland & Tankasi, 1995: 355). However, only a few empirical studies have addressed adoption and implementation of medical knowledge from the individual perspectives of physicians (Scott et al., 2008), funding agencies (Tetroe et al., 2008), and decision makers (Dobbin et al., 2007).

The engagement of both academics and practitioners is essential in the transformation of research findings into clinical practice (Pettigrew, cited by Van De Ven 2007: 262). As primary care practice-based research networks found, “less translation is required to apply research to practice when clinicians are involved in deciding what to study, how to study, and how to evaluate and present the results” (Mold & Peterson 2005: s12). “There is very little rigorous research that considers knowledge translation, continuing education, or research utilization in the inter-professional context”
(Zwarenstein & Reeves 2006: 52). Empirical studies on the actors (scientist, physician, physician scientist) as well as their interactions are incomplete or missing.

We therefore conducted a qualitative study that for the first time involved scientists in academia, physicians in clinical practice and physician scientists who reside in both worlds. Without presupposing a research and practice gap to be a translation problem, we asked what their lived experience is like in research, application of science into practice, translational research and scientist-physician partnership (SPP).

Semi-structured interviews were carried out with hospital-affiliated practicing physicians and university or hospital based research scientists.

Our research question is: what are the factors that facilitate or inhibit the scientist-physician partnership in knowledge generation and application to practice as well as translational research? Our study identifies many barriers to TR and SPP at both individual and organizational levels. It reveals the institutional and social forces that have deepened the profound cultural difference between scientists and physicians. Our data shows that the medical research and practice gap is more than a knowledge “translation” problem and there are many institutional, socio-cultural factors involved in the application of research to practice. In addition, our data reveals the critical role of individual agency in medical discovery and application.

LITERATURE REVIEW

This section examines literature that situates the theoretical framework of our study. It is organized as follows: 1) we review the gap between medical science and practice and the reasons as well as knowledge transfer theories; 2) we examine the literature in sociology and product innovation concerning cross boundary collaboration
and knowledge management; 3) we examine the roles of physicians and scientists in this process, and address the importance of physician-scientist partnership.

I. The Valley Of Death— A Medical Research and Practice Gap

**The gap:** One of the most persistent problems in healthcare management is that not all useful research findings are adopted or adopted promptly for the ultimate benefit of patients (Berwick et al., 2003; Glasgow et al., 2003; McGlynn et al., 2003). A “study examining articles published in several basic science journals from 1979 to 1983 found that only one in four promising technologies resulted in a published randomized trial and fewer than one in 10 entered clinical use within 20 years of the index basic science publication” (Crist et al., 2004: 477). The slow uptake of evidence-based medicine in primary care practice has resulted in the loss of potential benefits for patients (Amsterdam et al., 2002; Graham et al., 2006; Grol & Grimshaw, 2003; Lenfant, 2003) and the failure to fully leverage the investment of research and financial resources (Dougherty & Conway, 2008). “The gap between public health research and public health practice has been described repeatedly” (Colditz et al., 2008: 144), and it is labeled as the ‘Valley of Death”, a place where neither basic researchers, busy with discoveries, nor physicians, busy with patients, are keen to venture (Butler 2008: 840).

**The reasons:** there are many reasons for the medical research and practice gap (Glasgow & Emmons, 2007; Rye & Kimbley, 2007; Scott, 2007). For example, “policy-makers and practitioners lack the skills and incentives to access and apply evidence” (Maynard, 2007: 251). The adoption of innovative research findings by the provider organizations presents managerial and financial challenges for the adopting organizations (Rye & Kimbley, 2007). However, the extremely slow adoption of aspirin and beta-
blockers in the management of myocardial infarction patients by physicians has nothing to do with financial factors (Lenfant, 2003). Physician’s skills and attitudes and the attributes of innovative research are important factors in the adoption of the innovation (Cabana et al., 1999; Scott et al., 2008; Titler, 2007). Other barriers include group psychology, peer influence, social marketing, as well as organizational characteristics (Cabana et al., 1999; Colditz et al., 2008; Titler, 2007; Young et al., 2003). The invisible influence of opinion leaders as both facilitators and inhibitors in the acceptance of an innovation is another factor (Fitzgerald et al., 2003).

**Stakeholders:** Knowledge transfer occurs in a complex system of interactions among researchers, patients, physicians and other decision makers, such as hospital administrators and insurance companies (Dobbins et al., 2007; Estabrooks et al., 2006; Ploeg et al., 2007; Sinuff et al., 2007; Zwarenstein & Reeves, 2006). The blocks between medical research and clinical practice can be overcome only by the collaborative efforts of these multiple system stakeholders (Sung et al., 2003: 1278). Studies have been conducted to address the issues of application of medical research knowledge into practice from the perspectives of physicians (Cabana et al., 1999; Scott et al., 2008), directors of applied research organizations (Lavis et al., 2003), funding agencies (Tetroe et al., 2008), clinical professionals (Fitzgerald et al. 2003), and hospital decision makers (Dobbin et al., 2007). Studies on other stakeholders include administrators, nursing staff and project leaders (Ploeg et al., 2007), senior management (Bradley et al. 2004) and leaders (Edmondson, 2003; Gifford et al., 2008).

Adoption of knowledge also involves diverse parties such as politicians, policy makers, the public, the media, educators, insurers and other consumers. Many
organizations are part of this process as well. This includes hospitals, research institutes, professional organizations, consumer groups, public media, industry, insurance companies, funding agencies, and advocacy groups (Dougherty & Conway, 2008; Estabrooks et al., 2006; Lavis et al., 2003; Sung et al., 2003; Titler, 2007). Dopson and Fitzgerald (2006) note the complicated and contextual interactions between different professional groups in knowledge transfer. They propose to design diffusion and implementation strategies that acknowledge this complexity in organizational change process. Given the complexity, Best and others (2003 and 2008) propose to use a system thinking model in translation of theory into effective health promotion strategy.

**Knowledge transfer (KT)** theory: There are many KT models and frameworks with the purpose to guide practice, research and theory (Dobbins, 2010; Fitzgerald et al., 2003; Graham & Tetroe, 2009; Graham et al., 2006; Lang et al., 2007; Mitton et al., 2007; Sudsawad, 2007; Sussman et al., 2006; Wandersman et al., 2008). Graham and Tetroe (2007) identified 31 models from papers published between 1983 and 2006 on KT. The similarities and differences of various theoretical models are illustrated from organizational innovation, health, and social sciences perspectives (Estabrooks et al., 2006: 25). In addition, the following factors also have to be considered in the implementation of adopting the knowledge of research into practice: organizational context and culture, organizational resources and support, attributes of change or innovation, nature of the evidence or knowledge, the audience, and implementation-related factors (Graham & Tetroe, 2007).

**Translational research (TR):** Among many identified barriers and proposed KT models, TR has been the buzzword and main focus in the medical research community to
move discovery into practice (Woolf, 2008; Zerhouni, 2007). Translational research is “the application of basic scientific discoveries into clinically germane findings and, simultaneously, the generation of scientific questions based on clinical observations” (Rustigi 1999). It “occurs at the interface of basic and clinical research” (Crist et al., 2004). Many efforts and initiatives including research funding and educational programs have been devised to enhance and improve TR (Crist et al., 2004; Harrington, 2006; Zerhouni, 2007). It has been believed TR requires the participation of physician scientist--the translator for the languages of science and clinical care.

**Physician scientist:** Physician scientists are individuals who have an MD degree or combined MD-PhD degree. They participate in both scientific research and clinical endeavors as a career role. Because they are trained in both medicine and research, they are the natural translational researchers. They are “essential to the orderly introduction of scientific advance into clinical practice” (Wyngaarden, 1981: 416). The critical role of physician scientist in bringing science to medicine has been emphasized since 1960s when the MD-PhD program was created (Goldstein & Brown, 1997; Rosenberg, 1999). However, the declining interest in research and TR among physicians including the ones with MD-PhD degrees (Moskowitz, 2001; Zemlo et al., 2000) suggests different approaches should be considered.

**II. The frame of the problem: knowledge translation or cross boundary collaboration?**

The unsuccessful effort on only one “community of knowledge” (physician–scientist) suggests that the problem of the research-practice gap could be and should be formed differently.
Proper formation of problems is essential to the solution, because whether a certain result is true or not is relative to the methodological approaches used at the time (Knorr-Celina, 1999). Knorr-Cetina argues that reality including scientific facts is not a given, and it is constructed through interpretation, accidental events and negotiation. Through her study on how the science of high-energy physics and molecular biology makes knowledge, she argues that experimental strategies and procedures are cultural preferences. Emphasizing on knowledge translation problems and the role of the physician scientist have not produced desired knowledge and outcome on the narrowing the Valley of Death. This indicates that different strategies should be explored.

Medical knowledge that is not applied into clinical practice can be seen as an unfinished or unmarketable product in the industry. Medical society can learn insights from production innovation to narrow the gap between research and practice. Dougherty (1992: 179) points out that the commercial success of a new product depends on how well the product's design meets customers' needs and on the collaboration among the technical, marketing, manufacturing, and sales departments. Her study revealed that product innovators often do not link technological and market issues, and often do not collaborate across departments.

Collaboration across boundaries is essential given the shortage of physician scientist and has been proven successful. As Nobel Laureates Goldstein and Brown (1997: 2808) write, “it is increasingly difficult for a single individual simultaneously to fill the roles of physician and scientist. There is one sure way to cover this spectrum: collaboration. Perhaps more powerful is a collaboration in which one partner permanently plays the role of physician and the other is the scientist. Such collaborations work best
when each of the partners has some training and experience in the discipline of the other so that they can readily exchange ideas and insights”.

“The complexity of the challenges of translating lessons learned from science to public health, primary care, or disease specialty service settings requires a multifaceted partnership approach to accelerate the translation of research into practice” (Kerner, 2006: 72). Colon-Emeric et al. (2006) addresses the need to develop interventions to improve interdisciplinary collaboration. Based on aspects of the research-to-practice model and the community-centered model, Wandersman et al. (2008) presents a framework consisting of three systems, including funders, practitioners and researchers. Soklaridis and colleagues (2007: 1199), who conducted a qualitative study on health care professionals including nurses, pharmacists, speech language pathologists, occupational and physical therapists, social workers, and family medicine practitioners, points out that: unless academic settings are developed to provide the necessary training for primary health care professionals to work in teams, the new generation of health care professionals will continue to work in status quo environments, and reform initiatives are unlikely to become sustainable over time.

III. Physician-Scientist Partnership

Zwarenstein and Reeves argue that “improved inter-professional collaboration may facilitate evidence-based care” (2006: 52). Indeed, the U.S. Veterans Health Administration has made considerable advances in systematically implementing evidence into practice through a system-level program focused on collaboration and partnerships among policy makers, clinicians and researchers (Stetler et al., 2008: 1&9). A long-term researcher-practitioner “partnership may help to more quickly translate research findings
into practice settings and help ensure that health care organizations sustain the intervention program beyond the end of the funded project” (Sussman et al., 2006: 30).

**Physician’s role in KT:** The physician, as the main intended adopter of research knowledge for the benefit of patients, plays a critical and essential role in the adoption and implementation of research findings into practice. The rapid adoption of low molecular weight heparin in the management of cardiovascular diseases demonstrated the impact and importance of clinicians on the translation of research into practice (Denis et al., 2002). However, physicians also can hinder the translation process (Lenfant, 2003). Among the many barriers to a physician’s success with translation are lack of awareness, lack of familiarity, lack of agreement, lack of self-efficacy, and lack of outcome expectancy (Graham & Tetroe, 2007).

A lack of organizational support and guidelines also reduce translation by physicians. Although leadership plays an important role in the implementation of guidelines (Gifford et al., 2008), general managers in hospitals have relatively little influence when compared with clinicians, especially doctors (Dopson & Fitzgerald, 2006). Young’s survey (2003) of Australian surgeons revealed that peer opinion leaders were rated as being more influential than clinical audits in influencing them to change their practice. In short, physicians can serve as both facilitators and inhibitors of implementing research findings in practice (Dopson et al., 2010).

**Scientist’s role in KT:** Being recognized as knowledge generators, scientists actively engaging themselves in the diffusion of their findings through publications, conference presentations and website postings (Graham, 2010), the sources of information transfer that decision makers from CEOs to frontline clinicians rely on
(Dobbin et al., 2007). In order to promote the translation of their research findings into practice, researchers also have to engage themselves in fostering relationships with health care decision-makers, practitioners and policy makers, as well as in developing interactive and collaborative knowledge transfer strategies (Dobbins et al., 2007). However, basic scientists have few incentives to do this because of complex regulatory and patent issues (Butler, 2008).

One of the potential solutions to the knowledge and practice gap is “the expansion of practice-based research, which is grounded in, informed by, and intended to improve practice” (Westfall et al., 2007: 404). However, researchers do not understand what happens in clinical settings, and they do not realize the difficulty of implementation or adoption of their findings in practice. In addition, doing clinical research poses a risk of career damage to research scientists. Due to the nature of clinical research, it is hard for scientists to get clinical research published in top journals, but, publications in top journals is the determining factor for choosing which scientists are to be funded and promoted (Butler 2008). Some factors that may be critical to promote researcher’s engagement in KT include: promotion and tenure, resources and funding, organization structure, KT orientation and documentation (Jacobson et al., 2004).

The importance of physician-researcher partnership: A collaborative partnership between research scientists and health care practitioners could expand the research implementation efforts greatly (Kerner & Hall, 2009). Translating research into practice requires common understanding and languages among scientists and physicians. Partnerships between researchers and practitioners is the key for the creation of this common language as well as for the rest of the KT process—knowledge generation,
diffusion, dissemination and implementation. In addition, comparing the physician-led or scientist-led research team models, the physician and researcher team model is the most successful for sustaining the clinical researcher pipeline (Moskowitz & Thompson, 2001).

Taken together, the physician-scientist partnership will improve healthcare management through increasing the quality of patient-care by making the research relevant and easy to transfer. Collaborations between physicians and scientists have generated many of the revolutionary advances in medicine (Goldstein & Brown, 1997). The power of physician and scientist interaction and collaboration is well demonstrated by the successful application of in vitro fertilization procedures to benefit a large sub-fertile population (Edwards, 2001). However, “The clinical and basic scientists do not really communicate” (Butler, 2008: 840). Consideration for collaborative investment in integrating the lessons from practice and research as well as incorporation of partnership into publications and meetings are proposed as ways to promote practice-research partnership and collaboration (Kerner & Hall, 2009).

**RESEARCH METHOD**

**Methodological Approach**

We conducted an exploratory, qualitative study based on semi-structured interviews of physicians, scientists and physician-scientists. We analyzed interview transcripts with a grounded theory based method to develop a richer understanding of the translation phenomena in health care. This methodology is appropriate for our study because translation research is a poorly understood, under-theorized phenomenon. Interviews are “one of the most important data gathering techniques for qualitative
researchers in business and management… interviews allow us to gather rich data from people in various roles and situations” (Myers, 2009: 121). A grounded theory approach provides guidelines for collecting and analyzing qualitative data in order to construct theories grounded in the data themselves, “rather than deducing testable hypothesis from existing theories” (Charmaz, 2006: 2 &4). Glaser and Strauss noted that a systematic qualitative analysis can generate theory (Charmaz, 2006: 6). “Qualitative research allows researchers to get at the inner experience of participants, to determine how meanings are formed through and in culture, and to discover rather than test variables” (Corbin & Strauss, 2008: 14).

**Sample**

Sampling was “on the basis of emerging concepts, with the aim being to explore the dimensional range or varied conditions along which the properties of concepts vary” (Corbin & Strauss, 2008: 16). Consistent with grounded theory practice, the sampling and the interview protocol were redefined based on the data collected and analyzed. A total of 26 pure research scientists, practicing physicians and physician scientists were interviewed. The distribution of participants is listed in the Table A1.
Data Collection

Data was collected through intensive interviews conducted between May and November of 2011. The interviews averaged about 60 minutes. Participants were informed of the nature of the interview and data analysis. All 26 interviews were recorded and transcribed verbatim by a professional service. Both Critical Incident Inquiry and Appreciative Inquire methods were used to elicit the account of interviewees’ rich and specific experiences. The participants were asked to describe a successful, an unsuccessful and a significant collaboration experience. Memos were written immediately after the interview to help capture and analyze data.

Data Analysis

Data analysis was begun immediately after the collection of the first interview (Corbin & Strauss, 2008) and lasted throughout the study. Simultaneous involvement in data collection and analysis helps to “keep pursuing these emphases as we shape our data collections to inform our emerging analysis” (Charmaz, 2006: 20). Analysis was
conducted in three stages (Corbin & Strauss, 2008). First, open-coding was performed to capture and label the fragments/words with potential interests, and then to categorize and compare them with similar content from other interviews. Second, axial coding was used to define the patterns that were emerging from the interviews. Axial coding was used to systematically develop and relate categories to their subcategories and to reassemble data that were fractured during open-coding. Third, focused coding was employed to prioritize main themes that yielded key findings of proposed research. Maxqda software was used to manage the open coding process. Techniques such as the use of mini-framework, constant comparisons of data and integrative diagrams were used to assist in data analysis. Memo-writing was applied to “elaborate categories, specify their properties, define relationships between categories, and identify gaps” (Charmaz, 2006: 6). Data and literature interaction was carried out constantly throughout the entire study.

**FINDINGS**

The respondents’ rich narratives of their lived experiences revealed cultural, social, economic and institutional barriers to the application of science to clinical practice, translational research, and scientist-physician partnership. In addition, our data uncovered the factors that lead to a successful scientist-physician partnership (SPP) and translational research (TR).

**Finding 1. Socio-Cultural Forces Have Deepened Physician and Scientist Differences**

**1.1 A “Day and night” culture difference exists between physicians and scientists**

*Culturally they're incredibly different, incredibly different. --a MD*
They're definitely different cultures...Night and day...They look at the problem with different eyes” --a MD

I had previous experience working with MDs, and I always found that they approached problems very differently from how I approached problems --a PhD

There is a significant cultural difference between researchers and physicians. All respondents acknowledged the “day and night” cultural difference between physicians and scientists. They recounted how physicians and scientists view the world and approach problems differently, how their work styles, value systems and learning styles and working languages are different. These differences originate in their training, the nature of their jobs and their different foci. A physician articulated that “it’s because they’ve separated along the track”, which was echoed by a PhD researcher who described how physicians learned through lecturing, but scientists learned “by trial and error and empirically”. Physicians were described by researchers as non-linear thinkers, jumping around fast and randomly. This is echoed by physicians’ own descriptions of their ability to make decisions fast and to multi-task. In addition, in their patient-care focused real world, physicians have limited ability to administer things logically and control does not exist or is very limited.

Scientists, on the other hand, are viewed by physicians as having delayed gratification, and being slow in their response, action and decision making process. Physicians also perceived scientists as being logical, linear thinkers who focus on scientific method of perfect control and logic in an ideal world. Many researchers were proud of their interests in answering basic scientific questions, and in focusing on process rather than the end use of their research. However, interestingly, many physicians who had certain research training mentioned that they wish medical school had taught them
critical thinking skills and the scientific method possessed by scientists. Several physicians mentioned that “most clinical practitioners have very limited critical thinking skills”.

**FIGURE A1**

**Difference between Scientists and Physicians**

A “day and night” cultural difference exists between physicians and scientists

<table>
<thead>
<tr>
<th>Scientists</th>
<th>Physicians</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research is all about ethnicity. You know, does something work in the ideal world? (a MD)</td>
<td>Practitioners are much more interested in effectiveness. Does this work in my world? (a MD)</td>
</tr>
<tr>
<td>Researchers …are more cognitive and their sense of delayed gratification is even greater than the physicians that are non-surgeons. (a MD)</td>
<td>“Clinically we run by opinion. For whatever we think in our head, we make a decision.”(a MD).</td>
</tr>
<tr>
<td>they (researchers) are very slow and linear thinkers. (a MD)</td>
<td>Physicians are always like I need answers now”(a PhD), “…my world, where everything is immediate, and you expect answers immediately …we do cases in a room, everything is now, now, now”(a MD)</td>
</tr>
<tr>
<td>a PhD scientist tends to be a little bit more focused on defining basic mechanisms. (a MD)</td>
<td>they are not necessarily thinking about it from the beginning. (a PhD) “I said, but that just isn’t what happens. We could just do A to F.”(a MD)</td>
</tr>
<tr>
<td>I am interested in the process.’ (a PhD)</td>
<td>They cannot think outside of the box in this regard. in research they are just absolutely single-minded.” (a PhD)</td>
</tr>
</tbody>
</table>

"Physicians are much more willing, however much they have difficulty with it, accepting a greater degree of uncertainty than researchers.” (a MD)

**1.2 Lack of mutual respect and understanding**

There’s a lot of name calling …Physicians should not regard PhD’s with arrogance and PhD’s should not regard physicians as idiots …Many times physicians feel like PhDs don’t understand their world. A lot of times there will be a disconnect and sometimes PhDs think physicians don’t understand their world. A physician will say you haven’t figured that out yet, and the PhD will say, what, are you nuts? You have absolutely no idea how hard that is. --a MD

It’s like, what are all these PhDs doing? Why can’t they figure it out? And it’s just a naïve of how the laboratory works. --a PhD
Too much arrogance on both sides. Cause “I certainly know better than this person does.” There’s a lot of that... the basic science guys would sit there and complain about the clinical guys being dishonest and just trying to get an extra dollar, and I was like, “Look, you guys are the worst. You don’t even know it”. -a MD-PhD

Given the huge cultural difference, it is not surprising that many of our respondents reported a lack of mutual respect and understanding between physicians and scientists. They described how physicians and scientist do not value each other’s opinion and do not have an open mind to appreciate each other’s view of world. The importance of mutual respect and understanding is reflected in the following account by a scientist when he described his successful partnership with a physician:

"It’s the realization of what each person brings and the appreciation of that. … even though he does his things differently, I don’t always agree with it, but I can see where he’s coming from. And that helps me – it makes me question my own thing and think about my own things that way. And I think the other way around, he appreciates my perspective and that it’s unique from his. And rather than saying, Vincent, do what I do, I think we have a give and take, and we both appreciate what the other has to bring."

1.3 Caste system and lack of recognition discourages scientists to work with physicians

While emphasizing their strong interest in answering basic scientific questions, the majority of scientists also expressed their desire to have their research findings translated into clinical practice. This requires them to work with physicians. Our data revealed many factors that prevent scientists from working with physicians and at clinical departments.

Caste system: A physician respondent who is also a healthcare service researcher with an administrative responsibility argued that “basic scientists who want to be in a medical school should be people who want to collaborate with clinical departments; and they should be part of clinical departments”. All PhD scientists (~70% of total PhDs
interviewed) work at clinical departments, except one, expressed to a certain degree that they have been treated differently and feel they are second class citizens in clinical departments. However, the majority of them still want to continue to work at clinical departments because this offers them an easy access to clinicians, opportunities to target clinical problems, and involvement in “useful” projects with potential clinical application. Interestingly but not surprisingly, none of the scientists who work in basic science departments mentioned the feeling of being a second-class citizen. In addition, job insecurity also was a factor in some scientists’ mind as they “would be the one to go” first in clinical department budget cuts.

**FIGURE A2**
Socio-Cultural Difference Between Scientists and Physicians

**Lack of recognition and visibility:** Many scientists expressed their dismay about working with some physicians. For various reasons including physician’s time, training, skills and attitude, some scientists who collaborated with physicians ended up doing most
of the work, because their collaborating partners did not “pull their own weight”.

However, this contribution was not credited and reflected properly on the paper or grant applications or in other forms, because “MDs are not willing to give credit to the PhDs”. Lack of recognition and respect from clinical partners affected how the researchers think about their next collaboration with certain physicians, and made them shy away from working with physicians in general.

**Asymmetry in social status and income:** In addition to the recognition and being treated as second-class citizen issues, the inequality some researchers felt came from compensation. The huge income difference discouraged many physician scientists’ engagement in research, due to their reduced personal income from doing research instead of seeing patients. Furthermore, the high social status and influence physicians enjoy in American culture make this asymmetry more apparent.

1.4 Randomness of medical discovery

*Last year there were three Nobel Prize winners in medicine... One of them said, you know what, I'm against all this business of money has to go for translation. When I was working on this, it was very basic science. How the heck does a chromosome maintain stability? A simple question. I don't know what disease, what cancer -- I didn't know anything but I figured out how that works, and I'm sitting here with my Nobel Price. -- a MD/PhD*

Nobody knows where the discovery is gonna come from or nobody would have predicted RNA interference ten years ago. And if that research hadn’t been funded, we wouldn’t have RNA interference; and that’s thought to be a huge therapeutic potential. Well, you can make the same argument about surprise stem cells and a lot of other things. You can’t really predict where the great basic discovery is gonna come that lead to the translational. -- a MD

*These bisphosphonates are now used by women to inhibit osteoporosis, and also, it's become a very effective drug. Secondarily, in the cancer field, where cancer patients suffer huge bone loss because of chemotherapy and radiation, but now they have a drug actually that they take to inhibit the bone loss... who could have imagined it -- a PhD*
I can think of some examples where we’ve done translational research without – I mean, I guess what I would consider translational research without a basic science partner. --an MD

As demonstrated in the above quotes, many medical innovations and discoveries did not result from Translational research (TR) or scientist-physician partnership. They occurred randomly as a result of basic research. It is hard to predict what knowledge is or will be important. Therefore, researchers who are interested in answering basic questions should be allowed to pursue their creativity. Although very helpful, SPP is not essential for TR. Several examples exist where TR was conducted without the participation of the basic scientists.

Although many of our respondents agreed that TR, which aims at making research findings applicable to the human population, is important, they also warned that TR should not be forced and that forced TR could be “a bigger waste of money”, because TR is very hard to do. It requires research scientists who can speak the different languages of both practitioners and scientists. Our data noted that scientist-physician collaboration must be authentic in order to be successful. As reported by many scientists, “it’s up to the people that are doing the research or it’s up to the clinicians, if they wanna collaborate”, and “an organizational level by putting those different groups together doesn't work ”. Many study participants described how they chose their collaboration partners carefully based on prior experiences or the reputation and expertise of the potential partners. Most respondents expressed their unwillingness to collaborate with a partner with whom she/he have had bad experiences. Only two of them said that
although not pleasant, they would still collaborate with those individuals because “personal ego should not get into the way of discovery”.

**Finding 2. Institutional Forces Have Widened the Split between Physicians and Scientists**

*People are more helpful than the organizations; I mean they’re not that helpful* --an MD

When asked what organizations did to promote scientist-physician partnership and to encourage physicians’ interest in research and scientists’ interest in clinical issues, both scientists and physicians overwhelmingly reported a lack of organizational support and infrastructure at multiple levels, including funding agency, school, hospital, institute and department. In addition, academic culture and some funding regulatory issues inhibit scientist-physician partnership. As reported by a physician with research activities, “sometimes, creativity and innovation is difficult in certain kinds of environments”.

### 2.1 Partnership is hindered by lack of organizational support and infrastructure

Our data revealed the lack of organizational support and infrastructure in SPP and TR. The majority of the respondents recounted their frustrating experiences trying to obtain institutional support. Many respondents expressed the need for an infrastructure to facilitate collaboration, a sort of office where interested partners can go to seek help. Additionally, as articulated by a MD-PhD physician, a baseline policy laying out who gets what for doing which job in a collaborative effort would be very helpful, especially for physicians who are too busy to talk or “not trained to negotiate”. Lack of support and infrastructure is at multiple levels including departmental, institutional, school, hospital and funding agency, although at a very limited scale, some departments do better than others. Respondents were in agreement that “things could be better if there was some sort
of vision for how people can work together and facilitate collaboration”, as articulated by a MD-PhD physician scientist. Three forms of support are needed for physicians: infrastructure, financial resources and time.

**FIGURE A3**

Institutional Factors and SPP

**Academic Culture**

I will be very focused on not extending myself collaboratively any longer…. The system doesn’t value collaborative productivity as much as they value first and last author productivity. And there’s only two positions or first and last, even middle is almost discounted for not having had important role, which I think is unfair. --a MD-PhD

If you’re not writing papers, or you’re not publishing results, then you’re not doing anything as far as the world is concerned, and if you don’t have money to do it, and if you don’t get grants, you won’t be able to do investigations. --a MD

I’m reviewed for tenure. I’m reviewed because of the grants I have or because of the papers I have, not because of the patents or commercial products I have. --a PhD.

**Medical Centers**

The pressure on physicians is to see patients, not to translate. And so it took three years to finally enroll a first patient. Because the pressures on physicians, they don’t have enough time to do all the things that are necessary for example start clinical trials. --a PhD

I wouldn’t mind doing more. The environment I’m in right now, it’s hard because having funding to separately do things like that is very difficult to come by. And then there’s time. I still generate my entire salary from my clinical work so I have no – if I were to get research support, then I can do that -- a MD-PhD

A person (physician) said could I collect tissue for her and store it, and I said yes. And then I collect it, and store it, and this is about ten years ago, and it’s still sitting there. --a PhD

Having funding for the time is the key issue. --a MD, chairman of a clinic department. --a PhD

**Lack of infrastructure**

We went through all this and then the NIH wanted some cost sharing. They wanted a division where the hospital would put up at least a little bit of infrastructure. And despite having world-class investigators, all the faculty that would use us, the hospital said, no, we don’t have the resources. We’re not going to do that. So the grant was good marked unacceptable, lack of institutional support for it. So building an infrastructure that can foster collaboration is important. --a MD-PhD physician scientist.

Most of my colleagues, except a few areas, they get into such collaboration by chance, by meeting somebody or hearing about something – which is not good. --a PhD

We are the worker bees. We’re the ones who get the jobs done. --a PhD

2.2 Institutional structure inhibits scientist-physician partnership

The NIH doesn’t encourage collaboration within different institutes financially – I can tell you that much – ’cause it’s extremely expensive. Really to pay him (from another institute) $30,000.00 salary is gonna cost me $50,000.00 out of my directs --a PhD.

Many physician respondents described the impact of government’s funding policy and medical center policy on physician’s attitude and ability to participate in research and to collaborate with scientists. In order to access to human tissues and complementary skills, or to work with people with compatible personalities and shared vision, partnership outside of the small local environment is necessary. However, this effort is

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penalized financially due to the regulations of funding agencies. In addition, the current pay scale system makes it extremely expensive for scientists to collaborate with physicians. Physician’s compensation scales impose several challenges: (1) due to the high salary of physicians, not many physicians are interested in taking a lower paying job to do highly competitive research, because, “where people wanna go is the highest paying private jobs because, of course, the money will make you happy” as reported by a physician; (2) researchers are shy to collaborate with physicians due to the high and expensive cost of physicians to their limited financial resources; and (3) the inequality scientists feel when working with physicians.

2.3 Academic culture inhibits scientists’ participation in SPP and TR

The negative impact of the current reward system in academia on collaboration was mentioned multiple times by both pure basic scientists and physician scientist. All respondents expressed their desire to collaborate, but a collaborative role has no place in the academic promotion process, because university promotions committees stress independence as an essential criterion.

2.4 Medical centers discourage physician’s participation in research

Our data revealed that many physicians, though very interested and motivated to do research, would not commit to it. Funding, time and personal income reduction are three reasons given by physicians. One physician said, “a lot of physicians are caring less and less about research because they’re having pressures of seeing more patients”. A chairman of a clinical department confirmed this by stating: “physicians generally do not have any time to talk to anybody”. It is not surprising that scientists complained that “it’s difficult to get hold of some of these people”, and complained “it’s very frustrating”.

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Funding is another big issue as articulated by a clinical chairman and echoed by all physicians: “the main issues for them are how hard it is to get funded, how much time it takes to be an expert in science and still maintain clinical expertise.” Several physician respondents’ many failed grant application experiences supported this statement.

Finding 3. Institutional Structure Governs Translational Research and Scientist-Physician Partnership

It’s money. For any good thing to happen, money involved seems to help. --a PhD

“Grant”, “funding” and “money” are the most frequent words used by all the respondents through this entire study. Research scientists have to fund themselves “because research is not supported by the university; it’s supported by the money that you bring in” as reported by a PhD scientist. Physicians with research interests cannot conduct any research investigation without money paying for the time that they were away from their clinical responsibilities. In other words, money is what drives SPP and TR.

3.1 Money facilitates SPP and TR projects

Grant money drives research activity and projects. A very prominent scientist recounted how he got involved with certain research projects because of funding and how he would start a new line of investigation if he were asked by a sponsor to study a specific research topic. This is consistent with other investigators’ reports when they said that they have to write and do the projects that interest the grant reviewers so that they can get funding. In addition, money facilitates TR as reported by a PhD basic scientist: “so in some ways, I think a lot of people are switching to become a little bit more
Money being the driver of TR is well echoed by many physicians. Many practitioners talked about how valuable pilot money was and would be for high risk but potentially innovative translational projects. They reported how difficult it is to obtain NIH funding for translational projects because of the rigor of the grant review process as well as physician’s lack of robust research training and experience. Given the essential role of money, it is not surprising that forced collaboration and SPP are “becoming more common” as acknowledged by a PhD respondent. Therefore, money plays a critical role in facilitating scientist-physician partnership.

**FIGURE A4**
Institutional Structures and SPP

The most persuasive reason for clinicians and basic scientists to talk to each other is getting the grant. — a PhD

What I’ve learned .. is putting an MD on your grant is a good thing. They want to see that you’ve got clinicians engaged, that there’s someone with expertise. -- a PhD

He helped me with writing the data analysis sections for my merit review grant... I was able to get funded in part because of his assistance in writing the grant and helping with the data analysis for the paper. -- a MD

The potential collaboration (get human tissue from physician for research) was ended with that telephone call. But again, his pressure is at the academic place is to have his faculty published as well as see patients. ... So when I suggested that there was no intellectual contribution, his comment is those are the conditions by which we are willing to interact with you. -- a PhD

In order to be successfully funded, you have to play the game. -- a PhD

I’m not very well funded .. I could be if I was willing to play the game. But I’m not willing to play the game... I have the luxury of not having to play the game. But the people who work for me don’t have that luxury. -- a MD

When we’ve been successful in writing grants it’s been because we’ve targeted them to an audience that wants to embrace that work. They think that way. It’s a game. It’s knowing the rules, it’s knowing you can look at the study section and tailor things. It’s knowing that, okay, this guy doesn’t believe in this experiment, so if he’s on my study section I shouldn’t say that. That’s the game. ..It is an art and it is a game, so you need to know how to play that game. --a PhD

For the researcher, it is publishing. They talk about how they want to improve healthcare, all that kind of stuff, but that is a lot of crap. You can quote me and identify me, I have no problem, and The practitioners talk about how wonderful research is but, only in the abstract, it got nothing with their life. --a MD

Sometimes, you have to force your collaboration in order for you to make money, just like in business. --a PhD

If somebody gave me a large amount of money, and he was in what I told him, he was interested in rheumatological arthritis (RA), I didn’t know anything about it, except I assumed MSCs could function as therapeutic agents... but he gave me a ton of money to study RA. And now I’m an expert on RA. This financial support for disease-focused activities is motivating and requires...people who are conscientious and responsive. --a PhD

Once he had this program project grant it was very easy for us to continue to meet regularly and justify it. -- a PhD
3.2 The main goal of collaboration is to obtain grants and publish papers

Papers and grants are key components of being a scientist. Therefore, generating papers and obtaining grants were the most frequent purpose and outcome of scientist-physician partnership. In fact, one of the main goals of publishing papers is to obtain grants. As reported by a PhD scientist, “the publication is related to whether I will get future grant-funding”. It is worth to note that in a couple of cases, doing TR was indeed the purpose and outcomes of SPP as a few respondents described. However, the current funding mechanism discourages TR. The following excerpt from a physician scientist respondent illustrates the institutional barriers to TR:

The majority of people who are reviewing the grants are basic scientists, so your grant has to read as basic science to compete with grants that it’s next to. If it’s too translational, it comes off kind of fuzzy and descriptive. It’ll be described as speculative and descriptive, and not mechanistic. So the translational physician is forced into a mechanistic paradigm, which only works in mouse models and cell lines. So it’s very difficult to explore the translational way, with human samples and human interventions.

3.3 Game-playing is one of the institutional orders

All respondents talked about the role of playing games in obtaining research funding, in getting papers published, and in getting promoted. A few people detested it, but a few said that knowing how to play and convincing people is part of the fun. Most respondents consider playing the game as part of the normal institutional order. They think game-playing is necessary for achieving goals, and it is no different from any other industry and business.

Finding 4. Individuals Are the Driving Force of Medical Discovery and Application.

A significant finding of this research is the important role that individuals played in medical discovery. The respondents’ description of the role of organizational and
personal effort in SPP, TR and medical discovery revealed that personal motivation serves as the bridge to cultural difference separating physicians and scientists, and individuals, not organizations, are the driving force of medical innovation. In the end, it appears that medical discoveries are driven by individuals’ (physicians and scientists) interests and motivations.

**Personal interests:** Scientists can do research without collaborating with physicians and physicians can make more money without doing research. However, some of them did cross the boundaries and overcame many of the difficulties in working with each other. This was driven by their personal interests and motivation. For scientist, it is to apply their findings to patient care. For physicians it is the challenge, creativity, discovery and excitement of scientific investigation. In addition, our data revealed that personal interests were formed from their earlier exposure to the research environment and from social and other influence including family influence.

**Personal Motivation:** The motivation of physicians’ involvement in science includes leaving a legacy behind, helping answering clinical questions, satisfying professional interest and bridging the research and practice gap. The motivation of scientists’ interests in clinical investigation is to make a “positive contribution” and to help “improve the delivery of care” to patients. Scientist’s passion for medical research and discovery is well reflected in the following account of an action of a highly motivated “mad” scientist:

“We formulated our own creams. My colleague actually injected himself with some extract of a bacteria that he grew from a patient, and he got a cellulitis and fever and chills, because it was probably contaminated – it probably wasn’t contaminated, it probably was Staph superantigen. They had purified this protein, and it did nothing in rabbits and mice. They put it into themselves and “voomp!” So that was translation, back in the day.”
Medical innovation comes from a collective effort of individuals. As summed up well by an internationally famous innovative physician respondent, “innovation occurs when you're bringing people from very, very different skill sets and very, very different backgrounds together, then we come up with something new”. Given the very limited sometimes even negative role of organizations in facilitating partnership, our data clearly showed that individual effort plays an essential role in creating collaboration and medical innovation.

**FIGURE A5**
The Role of Individuals in Medical Discovery

### Individuals are the Driving Force of Medical Discovery and Application

<table>
<thead>
<tr>
<th>Personal interests</th>
<th>Personal Motivation</th>
<th>Individual efforts</th>
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<tbody>
<tr>
<td>I like the challenge and the discovery, the excitement of discovery. Every few years you, actually, discover something. I like the lifestyle. And I’m happy. -- a MD.</td>
<td>I want to leave the legacy of something that really made a difference and I think invention, innovation, applied innovation, discovery, those are things that you can leave behind after you leave this earth and I think that last many, many generations. -- a MD</td>
<td>They want everybody here to fund their own stuff. … they know people will work hard trying to get stuff on their own. -- a MD-PhD</td>
</tr>
<tr>
<td>For me, human skin disease, human diseases were always more interesting than an animal system. So, chose to seek out clinical work where I could do basic investigations using those samples if possible. -- a PhD</td>
<td>For basic scientists, the joy is to see your bench work get to the bedside. -- a PhD</td>
<td>For funding, you've got to go out and find it yourself. You've got to write your own grant. And a lot of this stuff, like almost everything I do, is unfunded research. It's just stuff you do, like I said, in your spare time… but really, it's all on your own. -- a MD</td>
</tr>
<tr>
<td>Research is much, much more interesting...so I take a financial cut, or risk, or reduction to be able to do a more interesting job, more challenged. It's less money than I make clinically, but I'm okay with that because I like my job and it's all right. -- a MD-PhD</td>
<td>To me, you can't get a better high than finding something new that nobody else knew. -- a MD</td>
<td>For funding, you've got to go out and find it yourself. You've got to write your own grant. And a lot of this stuff, like almost everything I do, is unfunded research. It's just stuff you do, like I said, in your spare time… but really, it's all on your own. -- a MD</td>
</tr>
<tr>
<td>I like doing research, I like being able to get to be a little creative …it makes life more interesting to be able to answer these kind of research questions and being creative. -- a MD.</td>
<td>When I went to Ecuador as a PhD and people with that disease would hear that there were doctors in the country, they would line up around the block and wait for days to see us, to give us samples, so I've always been very attuned to trying to develop things that actually help people. My work as a PhD was translated into an ELISA kit that diagnoses the parasite. -- a PhD</td>
<td>You kind of just have to figure it out on your own in your local environment... Again just individuals just trying to sort out --a MD-PhD</td>
</tr>
</tbody>
</table>

I like the challenge and the discovery, the excitement of discovery. Every few years you, actually, discover something. I like the lifestyle. And I’m happy. -- a MD.

For me, human skin disease, human diseases were always more interesting than an animal system. So, chose to seek out clinical work where I could do basic investigations using those samples if possible. -- a PhD.

Research is much, much more interesting...so I take a financial cut, or risk, or reduction to be able to do a more interesting job, more challenged. It's less money than I make clinically, but I'm okay with that because I like my job and it's all right. -- a MD-PhD.

I like doing research, I like being able to get to be a little creative …it makes life more interesting to be able to answer these kind of research questions and being creative. -- a MD.
DISCUSSION

I. Is Knowledge Translation a Major Problem in Applying Medical Science into Practice?

Overall, the extant literature is not helpful in explaining the “valley of death” from the aspect of phenomenal experiences. Without presupposing a knowledge translation problem, this study investigated the lived experience of key individual actors in medical discovery and application including scientists, physicians and physician scientist. None of our respondents reported language being an obstacle for TR focused scientist-physician partnership, which suggests that translation or lack of common language is not the problem they experienced. A few of our respondents mentioned the important role physician scientists play in TR, but none of them stated that physician scientists are the only individuals who can narrow the gap of practice and science. The fact that “collaborations between physicians and scientists have generated many of the revolutionary advances in medicine” (Goldesnstei & Brown, 1997: 2808) supports our finding that lack of common languages is not a main issue in applying research to practice. Our study suggests that the science-practice gap is a collaboration problem in which language is just one part of the difficulty.

The focus on translation has emphasized cognitive and knowledge related barriers. Our study reveals that social, cultural and institutional forces are at work for TR and SPP. This supports Carlile’s argument (2004: 559) that “under some circumstances, however, it is not just a matter of translating different meanings, but of negotiating interests and making trade-offs between actors”. Our data on physician’s interest in participating research and applying innovation, as well as scientist’s interests in clinical
related research is consistent with Carlile’s notion. Carlile notes that knowledge management cross boundary involves four processes: transfer, translation, transformation and iteration. Framing the clinical related research as translational research alone is not enough. A more integrative approach is needed.

Carlile discusses many approaches to move knowledge across different domains including “focused on the role of particular individuals as brokers and translators who enable the flow of knowledge” (2004: 558). The medical community has emphasized the role of physician scientists as evidenced by numerous financial and educational programs. However, the physician scientist is vanishing species (Schafer, 2010). This is very troubling considering that a half of century ago, Pickering (1964: 1618), a physician scientist himself, holds an optimistic view on the following question: “are the attitudes of mind of the physician and the scientist irreconcilable or many there be a synthesis”. Nobel Laureates Goldstein and Brown (1997: 2808) point out that “it is increasingly difficult for a single individual simultaneously to fill the roles of physician and scientist. There is one sure way to cover this spectrum: collaboration”.

Instead of focusing on one small “knowledge community” – the physician scientist, successful medical innovation and application rely on the collaboration of multiple communities of knowing. Like product innovations in other industries and “in knowledge-intensive firms, competitive advantage and product success are a result of collaboration in which diverse individuals are able to appreciate and synergistically utilize their distinctive knowledge through a process of perspective taking (Boland & Tenkasi, 1995: 358). Given the profound difference between practitioners and researchers, perspective taking is crucial.
II. The Socio-Cultural Barriers

Caste system and mutual understanding

Our data revealed the roles of cultural differences and a caste system in SPP. Lack of recognition and respect from clinical collaborators prevents scientists from working with physicians and at clinical departments. The asymmetry of social statue and income and competition in science discourages physician’s participation in science. Our finding on lack of understanding and mutual respect echoes what Snow (1961: 4) described as a “gulf of mutual incomprehension” and “distorted image of each other” between the two cultures of the arts and the sciences. Churchman and Schainblast (1965) emphasize the importance of mutual understanding in partnership. “Understanding” is the word several scientists used when they described their successful partnerships with physician collaborators, suggesting that mutual understanding is one of the crucial factors in the collaboration of two cultures. However, given the profound split between physicians and scientists, as well as the social and institutional forces that reinforce the split, it is not surprising that mutual understanding occurs only sporadically.

Two cultures

The “incredibly different” physician and scientist cultures our data revealed are an underlying condition explaining many factors that affect the partnership between them. Our data supports the notion of two cultures proposed by Snow a half century ago (1961). Snow attributes the two cultures of arts and sciences as due to their different social idiosyncrasies and to their “specialized” education, which is consistent with our findings. Many respondents pointed out that the current education system separates the biomedical scientists and physicians early in their education. As a result, physicians are not taught
about scientific method or critical thinking skills and biomedical scientists are not trained to have knowledge of disease processes. Snow notes that “once anything like a cultural divide gets established, all the social forces operate to make it not less rigid, but more so”. Only a very small percentage of the MD-PhD program participants become clinical investigator (Moskowits & Thompson, 2001; Zemlo, 2000). The social and institutional forces including academic culture, arrangement of medical centers, funding mechanisms, and the different social status of physicians and scientists, as well as the tough competition in medical science have contributed to making this gulf even bigger.

III. The Institutional Orders and Problems

The barriers to scientist-physician partnership and TR at both individual and organizational levels that our study identified illustrate the inhibitory role of organizational structure in medical discoveries and applications.

**Institutionalized order of funding**

Realizing the disconnection between science and human health, referred to as the “valley of death”, and being pressured by the Congress to show a positive return on research investment, funding agencies such as NIH have started to require a link between basic research and human disease on grant proposals. To encourage best science, a fundable research proposal must address research questions at mechanistic instead of descriptive levels. However, translational research especially those initiated by interested physicians is generally considered as descriptive because it is very hard and sometimes impossible to do human studies at mechanism levels. Therefore, those projects and physicians who are interested in answering clinical questions are forced to step away from “descriptive” human studies to more mechanistic basic science, using animal
models and cell lines. The majority of the partnerships that were formed had the purpose of generating papers and grants instead of doing translational research. Scientists, including physician scientists, are forced to avoid research projects that have the potential to be applied to humans. This institutional contradiction of the current funding structure in medicine is similar to what Galison (1997) describes in high particle physics. In his book *Image and Logic*, Galison reveals how the complexity and scale of apparatus in physics research distances physicists from the science that brought them to physics in the first place.

Our data reveals a relationship between game playing and successful funding. In addition, playing games is important in getting papers published, in promotion and in other scientific activities. Playing games seems to have become part of the institutional order, but it is a double-edged sword. It allows the individuals who know how to play the game to overcome many socio-cultural and institutional barriers. Meanwhile, game playing has created more institutional barriers for all actors to overcome.

Scientists have to publish in highly rated journals in order to obtain grants and survive. Unfortunately, the results of clinical and translational research are generally not something that can get published in high profile academic journals. Our findings on the role of academic culture in SPP and TR are consistent with previous literature (Israel et al. 2001; Pober et al. 2001; Jacobson 2004), and demonstrates that the academic culture of “publish or perish” is a universal academic phenomenon across disciplines (Pfeffer 2007).
Collaboration and coordination in Academic Medical Centers

Our study revealed that academic medical centers may make partnerships between physicians and scientists difficult. The barriers for researchers include lack of access to clinical partners, lack of access to human tissues and samples, and lack of recognition and respect from clinical collaborators. The barriers for physicians include lack of time and funding as well as the pressure from hospitals to see more patients. The problem of coordination between physicians and scientists is not unique in medicine. Galison (1997) mentions a similar scenario in high energy physics. He writes that “knowledge diffusion is going to depend crucially on the volatile intersection arenas of physics” – the intersections are “trading zones” where groups with different subcultures and technical traditions in physics meet. The incomplete coordination among academic medical centers reflects the misaligned incentives among its sub-institutes, and consequently, among its actors.

Institutional theory

The institutional barriers we identified reflect the influence of current institutional structures on physicians and scientists. Actor’s behaviors are results of and guided by social and institutional structures, because “institutional features of organizational environments shape both the goals and means of actors” (Scott, 1987). For instance, part of the socio-cultural difference between physician and scientist are results of institutional arrangements in education and compensation. The trend of physician’s research interests and activities over the last 5 decades roughly resembles the trend of the focus of science logic of medicine in medical education (Dunn & Jones, 2010; Rosenberg, 1999). However, the ineffectiveness of institutional promotion for physician scientist’s
participation in research suggests the importance of non-institutional elements including socio-cultural structure.

IV. The future: Individual agency and institutional structures

Structuration: Giddens’s Theory of Structuration (1984) offers a way to analyze how a system is produced and reproduced through the interactions of situated actors (agents) and structures (rules and resources). According to Giddens, structures are translated into interactions through the modalities of power and sanction. As illustrated in the figure below (Figure A6), Giddens’ model provides a helpful way to describe our findings. From the perspective of the signification dimension (production of meaning or sense-making), the Valley of Death is interpreted as a lack of common language in science and practice, therefore many efforts have been placed on the promotion of translational research and physician scientists. Our findings reveal the importance of recognizing the role of the domination (convey message on power) and legitimation (social norms, values and standards) dimensions. From their perspectives, facility and norm behavior are seen as negatively affecting the power of agents and imposing sanctions (positive and negative) through reward systems, grants, a caste system, promotions and participation in translational research and partnerships.
Despite the many barriers at different stages and different levels, SPP and TR do exist as the driving force of medical discovery. Despite the many constraints of institutional arrangements and social structures, the application of medical discoveries has undoubtedly improved human health (Lenfant, 2003). This is in line with Giddens’s Structuration Theory where he (1984: 25) points out “structure is not to be equated with constraint but is always both constraining and enabling”. Although our data revealed a doing nothing or “constrainer” role of organizations, organizations do serve as an “enabler” sometimes. For example, while regulations of NIH prohibit inter-institutional SPP and discourage TR projects, they also promote TR and encourage SPP in a certain way. While emphasizing that collaboration and TR cannot and should not be forced,
some respondents also reported the positive influence of funding requirement and tough competition in obtaining grants, as a scientist reported:

Forced collaboration, I think, is becoming more common because of the reality that there is less and less money. So sometimes, you have to force your collaboration in order for you to make money, just like in business, I feel, that’s what’s going on.

Our findings on the roles of organizations and individuals reflect the structure and agency feedback loop Giddens (1984: 14) writes about: “to be an agent is to be able to deploy a range of causal powers, including that of influencing those deployed by others”.

Our study identified many socio-cultural and structure forces that have reinforced the profound split between medical research and practice. Our data also uncovered the factors that enable individuals to overcome some of the barriers. These facilitating factors include self-identity, personal motivation, social relationships, personality, game playing, funding and communication. Because socio-cultural barriers are not easy to tackle, a funding driven approach might be a good strategy. Scientists have to obtain funding to survive. Their responses to the funding pressure and requirement indicate the feasibility of this strategy. For a small number of physicians, their personal motivation alone is enough to drive their participation in research. For many physicians with research interests, funding would encourage and make their participation in research possible. The hope therefore may lay in the combination of personal motivation of individuals and funding support from organizations.

Our data identifies the individual as the driver of medical innovation under the current institutional structure. However, “the individual does not think in isolation and is not an autonomous origin of knowledge. A community of knowing is a language game
and neither the language nor the knowledge created within it comes from the actor alone” (Boland & Tenkasi, 1995: 355). For working partnerships, it is essential to get actors to see how the other person's interest is in their interest, which Latour (2005) calls enrollment. The socio-cultural and institutional barriers identified in this study are forces that undermine the chances for enrollment to take place. However, enrollment does happen in spite of the forces individuals experienced and the importance of individual agency in achieving enrollment is evident in our study. This may provide insights on how to design a system with fewer barriers that recognizes and encourages the enrollment of individuals. The system should incorporate perspective making and perspective taking concerning socio-cultural and institutional forces to allow more individuals to become the heroes who cross the boundary barriers by enrolling themselves in a partnership process.

V. Implications

This study has several implications for practice. Our results on the role of individuals, organizations, funding, constrains and enablers of SPP and TR will be of interest to the academic community, medical centers, government and funding agency. Our study indicates that a better social and institutional structure is needed to cross the Valley of Death in medicine. This structure should take many issues in the current system into consideration including the reward system, asymmetry in social status, income inequality, appreciation of others, and misaligned incentives of organizations and individuals.
Changes Required

Instead of emphasizing only the role of physician scientists, changes should be made to promote cross-boundary collaboration, namely physician scientist partnership, because most innovation occurs at the boundaries between specialized domains. In addition, instead of focusing on the language barrier between science and practice, changes should be made to reflect the socio-cultural and institutional barriers separating scientists in science and physicians in practice.

When designing a system for improvement of the application of science to patient care, practical, socio-cultural, institutional and political challenges need to be recognized and appreciated. An effective system “requires an appreciation of how they can mediate the transformation and changing relationships among communities of knowing by affecting perspective making and perspective taking capabilities”, because “perspective making and perspective taking are the basis for transformations within and between communities of knowing and thereby the basis for open system control in knowledge work” (Boland & Tenkasi, 1995: 352). For example, the current recognition and reward systems need to be changed. The power of partnership should be recognized and rewarded at promotional and funding levels by academic community and funding agencies. It is necessary to “relentlessly advocate for the necessary changes by federal and private research funding agencies and by medical schools to secure a bright future for a robust physician-scientist workforce” (Schafer, 2010: 2).

VI. Limitations of this research and future research

Small sample size, theoretical based sample selection and perhaps experience influenced interpretation are the limitation of this research. Those are the limitations of
similar qualitative studies. Therefore validation of the findings with quantitative approach would make the study stronger. After identifying the barriers and facilitators of SPP and TR, a quantitative study on the factors identified would be needed to provide most useful information on where and how to focus the effort to improve SPP and TR aiming at improving the application of science to clinical practice.
APPENDIX B

Individual Attributes Affecting Physician-Scientist Collaboration in Biomedical Research and Knowledge Transfer

ABSTRACT

Substantial resources invested in biomedical research have generated revolutionary discoveries in medical science. However, it takes on average 17 years to turn about 14% of research findings into changes that benefit patients. Lack of scientist-physician partnership (SPP) is one main reason for the extremely slow translation of science into medical practice. My phase 1 qualitative study identified many factors that influence SPP in knowledge production and transfer in medicine at personal, institutional and socio-cultural levels. However, the relationships among the identified factors, as well as the prevalence of their impacts on scientist-physician partnership and transfer of knowledge are unknown. This study focuses on the influence of individual factors on SPP effectiveness. I hypothesize that professional identity has a positive effect on both academic and clinical outcomes; personal motivations influence SPP effectiveness; personality has an impact on clinical outcome and academic outcome. I posit that professional degree moderates the relationship between academic outcome and clinical outcome. I surveyed 440 scientists and physicians to test these hypotheses. My data reveals that: (1) professional identity has a positive effect on both academic outcome and clinical outcome, and satisfaction on process effectiveness (SPE) of collaboration fully mediates the role of professional identity on both academic outcome and clinical outcome; (2) both recognition motivation and challenge motivation have a negative effect on satisfaction on process effectiveness of collaboration; (3) Introversion personality has a negative direct effect on academic outcome; and conscientiousness has a positive effect on SPE; (4) Professional degree does not moderate the relationship between academic outcome and clinical outcome. However, several relationships between personal attributes and SPP outcomes are stronger in PhDs than MDs. This study contributes to the literature on the roles of professional identity, personality, motivation, and professional degree on cross-professional collaboration such as SPP. It has several practical implications on how to identify right collaborators and how the traditional belief on the role of physician scientist should be re-assessed.

Key words: Scientists-Physician Partnership, Collaboration, Individual Attributes, Professional Identity, Personality, Motivation, Satisfaction, Academic Outcome, Clinical Outcome
INTRODUCTION

1.1 Problem of Practice: the Knowledge and Practice Gap

Significant resources have been invested in U.S. biomedical research (Kerner, 2006). For example, the National Institutes of Health (NIH) alone has earmarked $30-$32 billion annually for research since 2008 yielding a vast amount of knowledge as evidenced by the number of publications generated from sponsored research projects (Grol & Grimshaw, 2003; Kerner, 2006). However, the contribution of research to the improvement of human life has lagged behind, largely because of no or very slow application and adoption of research findings by the medical profession (Berwick 2003; Lenfant, 2003; Glasgow, 2003; Kerner, 2006). It takes an estimated 17 years, on average, to turn 14% of research findings into clinical practice (Balas & Boren, 2000 cited in Westfall et al., 2007).

1.2 The Importance of Inter-Professional Collaboration-Scientist-Physician Partnership

There are many reasons for the gap between medical research and practice (Glasgow & Emmons, 2007; Rye & Kimbley, 2007; Colditz et al., 2008; Scott et al., 2008). The attributes of innovative research (Titler, 2007; Scott, 2007) and physician’s skills and attitudes (Cabana et al., 1999; Scott et al., 2008) are among the many barriers to knowledge transfer. Therefore, engagement of both academics and practitioners is essential in the translation of research findings into practice (Pettigrew, cited by Van De Ven, 2007: 262). Many have called for increased scientist-physician partnership (SPP) to produce knowledge that is worthy of transferring and easy to transfer (Moskowitz & Thompson, 2001; Kerner, 2006; Kerner & Hall, 2009).
Understanding factors that influence SPP effectiveness is important for improving knowledge generation, adoption and implementation outcomes in healthcare. However, literature and empirical studies on the interactions between research scientists and physicians are sparse. “There is very little rigorous research that considers knowledge translation, continuing education, or research utilization in the interprofessional context” (Zwarenstein et al., 2006: 52).

1.3 Individual Attributes and SPP

Medical innovation comes from a collective effort of individuals. As summed up well by an internationally famous innovative physician respondent, “innovation occurs when you're bringing people from very, very different skill sets and very, very different backgrounds together, and then they come up with something new”. Indeed, study 1 interviewing both scientists and physicians revealed an important role individual play in medical discovery. My data indicates individuals, not organizations, are the driving force of medical innovation and discoveries; the interests and motivations of individuals including both physicians and scientists serve as the bridge to the professional, social and cultural difference between physicians and scientists in medical knowledge generation and application.

Collaboration effectiveness is affected by many factors including member ability and personality (Barrick et al., 1998), autonomy, interdependency, team development (Janz et al 1997), management support (Sundstrom, 1999), and cultural values (Kirkman & Shapiro, 1997). Many barriers and enablers of cross professional teams have been identified and discussed (Austin, 2000; Brinkerhoff, 2002; San Martin-Rodriguez et al., 2005; Choi & Pak, 2007; Fickel et al., 2007; Dopson et al., 2010). The influencing
factors of collaboration effectiveness and their importance vary depending on the forms
and functions of a collaborative team. In a collaborative team composed of scientists and
physicians in biomedical research field, additional factors such as difference in
professional language, professional culture, social status and power are involved in the
effectiveness of team performance.

Investigation of traits and behaviors of both partners is essential to uncover the
underlying mechanism that influences SPP effectiveness. Phase 1 study found that
physician-scientist partnership effectiveness and outcomes of translational research are
influenced by many personal, institutional and socio-cultural factors. The role of several
organizational factors in scientist-physician team effectiveness has been investigated
quantitatively. However, the causal links among the other identified factors and the
degree of their impact on SPP effectiveness are unknown. In this study, I investigate the
individual attributes that affect SPP effectiveness. Specifically, I ask to what extent
professional identity, personal motivation and personality influence SPP effectiveness.
To address this question I conducted a quantitative research surveying research scientists
and physicians. I obtained 440 usable responses from research scientists and physicians
who collaborated with partners that have different skills (i.e. MD and PhD
collaborations).

The remainder of the paper is organized in the following sequence. First, I review
the literature background and present the development of my research hypotheses.
Second, I describe my research design and key measures of the study. Third, I report the
main findings. Next, I discuss the importance of my findings. I then conclude with
practical implications and limitations of this study. I finally end with an outline for future work.

**LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT**

### 2.1 Research Model

“Collaborative Practice is an inter-professional process for communication and decision making that enables the separate and shared knowledge and skills of care providers to synergistically influence the client/patient care provided” (Way et al., 2000: 3). Scientist and physician partnership or collaboration in this study is defined as the relation between research scientists and physicians who “work or act together” and “work with” each other to create and transfer biomedical research findings into practice. The definition is adopted from the following literature: “Partnership involves co-operation, i.e. “to work or act together” (Holland, 1984 cited in McQuaid, 2000: 2). In this study, I use collaboration and partnership interchangeably.

Scientist-physician partnership (SPP) is expected to promote the transfer of biomedical knowledge into clinical practice by generating transferable medical knowledge, and by making the application into practice process easier. The partnership is expected to help scientists identify new relevant research opportunities and to reduce physician’s barriers in adopting the newest medical research. **SPP effectiveness** is defined as the extent to which the partnership promotes such goals in terms of research (academic) and clinical outcomes, as well as satisfaction on collaboration process.

Personal attributes play a crucial role in inter-professional collaboration like SPP. For example, individual characteristic such as personality is one of 5 main domains of a consolidated framework of implementation research (CFIR) (Damschroder et al., 2009).
CFIR is a framework that “offers an overarching typology to promote implementation theory development and verification about what works where and why across multiple contexts” (Damschroder et al., 2009: 1). Although academic appointment and promotion standards often discourage scientists to collaborate with physicians (Pober et al., 2001; Israel et al., 2001; Butler, 2008), my qualitative study uncovers that the physicians and scientists who participate in SPP are motivated by non-organizational factors such as professional identity, achievement orientation and other intrinsic motivations. In addition, I found that personality can affect the success and the effectiveness of SPP. To capture the impacts of these factors, I designed a quantitative approach to investigate the causal links between collaboration effectiveness and personal attributes including professional identity, motivation and personality.

Informed by both literature and my earlier empirical study, Figure B1 depicts a conceptual model formulated to guide researchers. It consists of personal factors that influence SPP effectiveness. This model focuses on the role of individual attributes in the partnership between academic research and medical practice. I propose that individual attributes such as professional identity, motivation and personality influence the outcomes of academia and practice partnership between scientists and physicians including satisfaction, academic and clinical outcomes. Partnership satisfaction on process effectiveness of collaboration has a positive relationship with academic and clinical outcomes of SPP; it mediates the effect of individual attributes on academic outcome and clinical outcome. Gender, age, academic title and income are included as controls to account for their potential influence on SPP effectiveness. The sections below
review these factors in detail. In addition, these sections describe the development of the research hypotheses compromising my model.

**FIGURE B1**
Conceptual Model

**Scientist and physician partnership (SPP) effectiveness**: Effectiveness is a measure of achieving expected and desired objectives and outcomes (Parkhe, 1993; Saxton, 1997). My Phase I study suggests outcomes motivating researcher and physician collaboration include: obtaining clinical samples for research purposes; obtaining grants; applying research findings in clinical practice, and conducting clinical research with the aim of creating new treatments. I therefore use academic outcome (AO) and clinical outcome (CO) as key dimensions defining SPP effectiveness. **Academic outcome** refers to the generation of research abstracts and papers, as well as research grants generated and awarded. **Clinical outcome** is defined as the generation of patents and new clinical applications of research findings. Both dimensions measure collaboration outcomes objectively.
Satisfaction on process effectiveness (SPE): Collaboration research typically uses three types of measures to define the performance: financial, objective and subjective measures (Cooke-Lauder, 2006). Grants awarded measure financial performance. Publications, patents and clinical applications of translational outcomes are objective measures of SPP effectiveness. I use satisfaction on process effectiveness of SPP as a subjective measure in this study. Partnership satisfaction on collaboration process is related to partnership performance and has been used as a measure of partnership success in many studies (Geringer & Hebert, 1989; Hausman, 2001; Sriram & Stump, 2004). I define satisfaction on process effectiveness (SPE) as the performance of collaboration that partners perceived on whether the collaboration achieved desired objectives and whether they are satisfied with the collaboration process.

Professional identity: In this study, I consider career synonymous with professionalism, because scientists and physicians are professionally employed. I therefore adopt the definition of career identity to describe professional identity in this study. Career identity measures “the importance of the career role to a person’s self-identity”. Career identification is found to moderate the interpersonal relationships (Wilk & Moynihan, 2005). Career commitment has been associated with various work-related outcomes including skill development, job performance and turnover (Carson & Bedeian, 1994). In a self-reported survey of university faculty, identity was found to be related to altruism and generalizes compliance, and identity is positively associated with task performance (ven Knippenberg, 2000). I refer professional identity to the commitment, importance and identification of a person to his/her profession.
Motivation: Motivation is defined as “individuals' desire to act or behave in a particular manner” (Weiner, 1992 cited in Buehl & Alexander, 2005). Researchers in academia have no incentive to conduct clinical research. Physicians in practice, faced with the large debt burdens lack of time, insufficient resources and academic isolation, may lack skills and personal motivation to engage themselves in biomedical research (Cabana et al., 1999; Ley & Rosenberg, 2005; Bakken et al., 2006; Scott et al., 2008). I conjectured, based on the literature and findings of my qualitative study that personal motivation is the drive for physician’s participation in research. For example, leaving a legacy of beyond 2 to 3 generations has been the motivation for a highly accomplished physician’s active involvement in research as well as in transferring research into practice, which is in agreement with Herzberg’s (1959, 1964) two-factor theory of motivation. Achievement and recognition align with motivator needs and they are two determinants of employees’ job satisfaction.

Qualitative phase study identifies the important motivational roles of achievement, recognition, challenge, and compensation to a certain extent in SPP. I, therefore, use three scales to measure recognition motivation, challenge motivation and compensation motivation in this study. The recognition motivation scale reflects the desire to be recognized for achievement at organization. The challenge motivation scale measures the desire to solve new, difficult and complex problem. The compensation motivation scale measures the attitude of the respondents to the income one can earn through one’s profession.

Personality: Personality emerged as one of main factors that are critical to SPP success in my qualitative study which motivates me to measure the relationship between
SPP effectiveness and four important dimensions of personality that emerged in qualitative study. I adopt the dimensions and definitions of Big Five personality traits (Goldberg, 1990, 1999). Specifically, in this study, **Introversion** scale reflects the traits of being reserved, quiet, shy and inhibited; **Agreeableness** scale reflects the traits of being forgiving, trusting and considerate and kind; **Conscientiousness** scale reflects the traits of being reliable, persistent, efficient and executive at work and task; **Openness** scale reflects the traits of being ingenious, imaginative and inventive.

### 2.2 Hypothesis Development

One significant finding of my phase 1 qualitative study is that while organizations play very limited, sometimes even inhibitory roles in facilitating SPP, individuals play an essential role in creating scientist-physician collaboration for generating biomedical knowledge and for transferring scientific discoveries into clinical practice. Interprofessional SPP was driven by the personal interests and motivation of scientists and physicians. For scientists, it is application of their findings to patient care. For physicians, it is the challenge, creativity, discovery and excitement of scientific investigation. The motivation of physicians’ involvement in science includes leaving a legacy behind, helping answering clinical questions, satisfying professional interest and bridging the research and practice gap. The motivation of scientists’ interests in clinical investigation is to make a “positive contribution” and to help “improve the delivery of care” to patients.

The following hypotheses on the influence of the individual attributes on SPP effectiveness are developed based on my qualitative study and the literature.
2.2.1 The effect of professional identity

The literature on the direct link between professional identity and collaboration outcomes is sparse. However, there are many investigations on the association between organizational identity and performance. It was found that professional identity significantly correlated with organizational identity, and both professional identity and organizational identity are positively related to job satisfaction (Russo, 1998, Johnson et al., 2006). Job satisfaction is positively related to business unit outcome including productivity (Harter et al., 2002). Study among big five auditors also found that professional identity is positively associated with organizational identity (Bamber & Iyer, 2002). Empirical quantitative study reveals positive links between attractiveness of perceived organizational identity, strength of organizational identity and cooperative behaviors among physicians (Dukerich, Golden, & Shortell, 2002).

My qualitative inquiry suggests that scientists and physicians are highly identified with their profession, because they “get a lot of personal, professional satisfaction” from their career as explained by a MD physician scientist; and they like the life style and they are very happy with their choice of career as many physicians stated. Therefore, they care about the fate of their profession and they are willing to put forth a great deal of effort in order to be successful in this profession. For instance, scientist’s passion for medical research and discovery is well reflected in the following account of an action by a highly motivated “mad” scientist:

“We formulated our own creams. My colleague actually injected himself with some extract of bacteria that he grew from a patient, and he got a cellulitis and fever and chills, because it probably was Staph superantigen. They had purified this protein, and it did nothing in rabbits and mice. They put it into themselves and “voomp”!
The professional curiosity of physicians and scientists to a large extent drives medical discoveries as a MD-PhD physician scientist commented in my qualitative investigation. Drawing on the literature and my qualitative study, I reasoned that professional identity and professional interests and goals influence the level of professional effort, which is related to job performance, including collaboration performance. I propose:

**Hypothesis 1:** Professional identity has a positive effect on academic (H1a) and clinical (H1b) outcomes of scientist-physician partnership.

### 2.2.2 The effect of motivation

Literature indicates researchers in academia have no incentive to conduct clinical research. Physicians in practice, faced with the large debt burdens lack of time, insufficient resources and academic isolation, may lack skills and personal motivation to engage themselves in research (Cabana et al., 1999; Ley & Rosenberg, 2005; Bakken, 2006; Scott, 2007). My qualitative study revealed that personal motivation is the driving force for physicians’ participation in research and for scientists’ engagement in clinical research. Performance including collaboration performance is highly dependent on motivation.

Motivation is “individuals' desire to act or behave in a particular manner” (Weiner, 1992 cited in Buehl & Alexander, 2005). Maslow’s need based motivational theory explains the incentive of the collaborators in SPP. The conative need, the desire to know and to understand, is the motivation that drives physicians or scientist to participate in collaboration.
My qualitative study identifies the important motivational roles of achievement, recognition, challenge and income to a certain extent in scientist-physician collaboration. For example, in responding to questions on his motivation of participating in medical research, a highly successful physician, who performed the first special medical procedure in North American after many years of laboratory work he and his colleagues conducted answered: “I want to leave the legacy of something that really made a difference and I think invention, innovation, applied innovation, discovery, those are things that you can leave behind after you leave this earth and I think that last many, many generations”. Achievement and recognition belong to motivator needs of Herzberg’s (1959, 1964) two-factor theory of motivation. They are two determinants of employees’ job satisfaction, and satisfied employees perform better (Judge et al., 2001). According to Judge and colleagues (2001: 376), who conducted a meta-analysis on 312 samples with a combined N of 54,417, “the mean true correlation between overall job satisfaction and job performance to be 0.30”.

Challenge motivation is a strong theme I identified in my qualitative investigation of scientist-physician collaboration in biomedical knowledge production and application. Many physicians expressed their great interests in conducting research, because “seeing a new cardiology patient every 20 minutes, for eight hours a day, for five days a week, for the rest of my life is incredibly monotonous. Research is much, much more interesting” (a MD-PhD); “taking care of patients is enjoyable; but it lacks the challenges of excitement. It’s discovery… I’ve enjoyed it... I like the challenge and the discovery, the excitement of discovery. Every few years you, actually, discover something. I like the lifestyle. And I’m happy” (A MD physician scientist). Physicians participate in and
enjoy research, because they “like being able to get to be a little creative … it makes life more interesting to be able to answer these kind of research questions and being creative” (a MD physician scientist)” ; “What I like about research is I wake up every morning and you are just excited to just tackle the problems and make progress and answer questions (a MD-PhD physician scientist); “I am very happy to come to work and work hard and get excited about things” (a MD physician scientist). As a MD physician scientist summarized, “you can’t get a better high than finding something new that nobody else knew”

My qualitative study indicates that compensation is also a factor in some physicians’ consideration on whether to engage in research or not. Their decisions sometimes are influenced by their family. Physicians can choose between doing research and seeing patients. The compensation for seeing patients is much higher than that of doing research. For example, A MD-PhD scientists reported that he “takes a financial cut, or risk, or reduction to be able to do a more interesting job (research)”, and a MD noted that “people go to where money is”. Although successful grant application will lead to some financial rewards at a certain degree, the compensation as a scientist is much lower than as a physician. Another potential way to make more money is through licensed patents. Licensed patents as a form of clinical application of research will lead to financial reward.

I reasoned that individuals motivated by various reasons will make all sorts of efforts including engaging in SPP to reach their goals and objectives such as getting research papers published, obtaining research grants, and applying research findings into medical practice. Because performance is highly dependent on motivation, it is likely that
the level of motivation correlated with the level of collaboration performance outcomes. Drawing on literature and the findings of my qualitative study, I hypothesized that:

**Hypothesis 2:** Recognition motivation has a positive effect on academic (H2a) and clinical (H2b) outcome of scientist-physician partnership.

**Hypothesis 3:** Challenge motivation has a positive influence on academic (H3a) and clinical (H3b) outcome of partnership.

**Hypothesis 4:** Compensation motivation has a positive impact on clinical outcome.

### 2.2.3 The effect of personality

An experimental empirical study shows a link between personality with collaboration-viability and communication in paired teams (Sfetsos et al., 2006). Personality of managers also links to service climate (Salvaggio et al., 2007). For instance, the traits of agreeableness, patience and helpfulness are related to cooperation (Goldberg, 1990). “Conscientiousness has previously been shown to predict academic and job performance” (Higgins et al., 2007: 313), and Higgins et al. (2007) confirmed that conscientiousness has a positive relationships with job performance.

Personality was identified as one of the main factors that are critical to the success of scientist-physician team in qualitative study. For example, an MD scientist commented that successful inter-professional collaboration is “more personality driven, and almost social networking driven…it is really driven by personality, and you can always find one or two personalities that are focused on a particular problem or particular innovation” (a MD). A successful clinical application of a research finding “came about because of the determination and patience of Dr. SG, who if it had just been me, I would've abandoned
because the IRB (Internal Review Board) took one year to get permission to do this through the IRB, maybe 20 separate meetings... And Dr. SG was enormously patient, 
"(noted by a PhD scientist). It takes "the resilience to keep going on". A lot of promising collaborative projects died because of personality clashes. As a PhD scientist admitted, "I have a way bigger ego than my nice collaborator".

I reasoned that if individuals are being shy and inhibited, they will not seek collaboration actively; if collaborative partners are agreeable, then collaboration projects may go smoothly; if collaborative partners are reliable and creative, then a high level of collaborative team performance is likely. Generally speaking, the performance and outcomes are associated with an individual’s level of openness (i.e. intellectual level as defined in Goldberg’s big 5 theory). Based on these reasons and the literature including my earlier study, I hypothesized:

**Hypothesis 5**: Introversion has a negative effect on academic (H5a) and clinical (H5b) outcomes

**Hypothesis 6**: Conscientiousness has a positive influence on academic (H6a) and clinical (H6b) outcomes of SPP.

**Hypothesis 7**: Agreeableness has a positive relationship with academic (H7a) and clinical (H7b) outcomes of SPP.

**Hypothesis 8**: Openness has a positive impact on academic (H8a) and clinical (H8b) outcomes.

2.2.4 The mediating role of satisfaction on process effectiveness (SPE) of collaboration
A study by Geringer and Hebert (1989) reveals a strong association between perceptual assessments of collaboration performance and satisfaction with objective measures. My interview findings also support a positive link between partnership satisfaction and performance outcomes of collaboration. If collaborators feel that the collaboration process is effective, and it has achieved the desired objectives, then most likely the collaboration will generate favorable outcomes. The positive relationship between satisfaction with the collaboration process and the effectiveness of SPP is confirmed in my previous quantitative study. I found that satisfaction on process effectiveness (SPE) of collaboration has a positive effect on both academic and clinical outcome.

Professional identity will motivate collaborators to work together effectively through various means in order to achieve their expected objectives of collaboration. I reasoned that a high level of professional identity will lead to a higher level of favorable collaboration activities resulting in a higher level of satisfaction on collaboration process effectiveness, which in turn will lead to a higher level of SPP effectiveness. I thus hypothesized:

Hypothesis 9: Satisfaction on process effectiveness mediates the effect of professional identity on academic (H9a) and clinical (H9b) outcomes.

Similarly, an individual who is highly motivated by recognition will make a great effort to make sure that the collaborative projects s/he participates in are successful through various means such as effective communication, and working hard on his or her own part. These behaviors and efforts will lead to satisfaction on process effectiveness of
collaboration. Together with the association between SPE and outcomes of SPP, I anticipated the following relationship:

**Hypothesis 10:** Satisfaction on process effectiveness mediates the effect of recognition motivation on academic (H9a) and clinical (H9b) outcomes.

### 2.2.5 The moderating role of professional degree

My qualitative study reveals a profound difference between physicians and scientists. As my respondents noted, “culturally they're incredibly different, incredibly different”; "there’s a big difference in how physicians and scientists look at world”; "the value system is very different." Research scientists are described as having delayed gratification, linear and logic thinkers who focus on process; and physicians are described as non-linear thinkers who focus on present and have the ability to do multiple tasks and “are willing to accept a greater degree of uncertainty than researchers”.

Given the significant difference in professional language and social-cultural and economic status between physicians and scientists, the different focus of their job and research interests and goals, I reasoned that the specific professional degree will make a difference in their research focus and objectives, as to how scientists and physicians process and experience the collaboration between themselves, and in their satisfaction with collaboration, and in their perception of their collaboration performance. For example, physicians may care more if their research projects solve clinical problems, and if their research findings can be applied to clinical practice than scientists would care. In addition, physicians have to work with many people including patients, nurses, and other support staff, while scientists in most situations work with non-human materials such as
cells and research animals, scientists might be more introvert than physicians. For these reasons, I hypothesized that professional degree moderates the following relationships:

Hypothesis 11: Professional degree moderates the positive effect of academic outcome on clinical outcome, in such the relationship is stronger for MDs than for PhDs.

Hypothesis 12: Professional degree moderates the negative relationship between introversion and academic outcome, in such the negative relationship is stronger for PhDs than for MDs.

RESEARCH DESIGN AND METHOD

3.1 Methodology and Study Context

I carried out a quantitative psychometric study to test my hypotheses and validate the proposed research model. A structured survey was designed to measure the factors influencing scientist-physician partnership effectiveness by collecting response data from physicians and scientists who have collaborated with one another. SPSS and AMOS (version 21.0) were utilized to conduct statistical analysis. SPSS was used to conduct basic statistical analysis (data screening), computing Cronbach’s alphas and exploratory factor analysis (EFA). I used AMOS to conduct covariance based structural equation model analysis (CBSEM) (Arbuckle & Wothke, 1999). Amos user’s guide. Structural equation model (SEM) was chosen, because it offers many advantages over linear regression analysis including integration of the measurements and the hypothesized causal paths into a simultaneous assessment (Bollen, 1989). In addition, “SEM allows the creation and estimation of models with multiple dependent variables and their interconnections at the same time” (Gefen, Rigdon, &
AMOS software (CBSEM) was chosen because it brings the error terms into one unified model, therefore providing better protection from measurement errors (Gefen et al., 2011). The following sections detail the methods used including the development of survey instruments, sampling, data collection and statistical analysis.

3.2 Construct Operationalization

Measurement items of constructs were either adapted from existing measures when available and appropriate, or developed for the study based on the literature and a prior qualitative study. Table 7B at Appendix A lists the multi-item scales for each construct that were used to collect the data. A 5-point Likert-type scale is used in this study for most of constructs, because it is believed to be easier for respondents to master (Arya & Lin, 2007).

3.2.1 Adapted scales

**Professional Identity (PI):** Measures for Professional Identity were adopted from the literature (Hudson, 2007; Mowday et al., 1982; Vandenberg & Scarpello, 1994) There are 4 items to measure PI in a 5-point Likert scale (1=strongly disagree and 5= strongly agree). This construct operationalized as a reflective construct, because the items reflect the construct they measured, and the causal directions are from construct to items and the items of each individual construct are interchangeable since they measure similar things that correlate with each other, and the items manifest instead of defining the construct they measure (Bollen, 1989; Jarvis et al., 2003). The Cronbach’s alpha for this construct is 0.850.

**Motivation:** I measured three dimensions of motivation including Challenge Motivation, Compensation Motivation and Recognition Motivation. Measures for all
three dimensions of motivation were adopted from the literature (Miao & Evens, 2007; Kumar, 2009). All items are in a 5-point Likert scale (1=strongly disagree and 5= strongly agree). All three constructs operationalized as reflective constructs according to the definition of reflective construct (Bollen, 1989; Jarvis et al., 2003). Challenge Motivation: There are 3 items to measure challenge motivation. The Cronbach’s alpha for this construct is 0.805; Compensation Motivation: 3 items, The Cronbach’s alpha is 0.773; Recognition Motivation: 3 items, The Cronbach’s alpha is 0.808.

Personality: I adopted Goldberg’s big 5 personality concept (1990), but only measured 4 of 5 dimensions that are relevant in my study context as my qualitative study suggested. They are Extraversion, Agreeableness, Conscientiousness and Openness. Measures for the four dimensions of personality were adopted from Pierce (2009) and Goldberg (1990). All four constructs of personality operationalized as reflective constructs for the same reason stated above for reflective construct. All items are in a 5-point Likert scale (1=strongly disagree and 5= strongly agree). Introversion: There are 4 items to measure introversion. The Cronbach’s alpha for this construct is 0.853; Agreeableness: 3 items, The Cronbach’s alpha: 0.721; Conscientiousness: 4 items, The Cronbach’s alpha: 0.820; Openness: 3 items, The Cronbach’s alpha: 0.863.

Satisfaction on process effectiveness (SPE): Items for satisfaction on process effectiveness of calibration were adapted from Cooke-Lauder (2006) who adapted it from the literature (Smith & Barclay, 1997; Saxton, 1997). There are 3 items measuring satisfaction on process effectiveness in a 5-point Likert scale (1=strongly disagree and 5= strongly agree). This construct operationalized as a reflective construct. The Cronbach’s alpha is 0.932.
3.2.2 Scale development

The measurements for academic outcome and clinical outcome were developed specifically for this study.

**Dependent variables (outcomes of partnership):** In addition to measuring the perceptual understanding of partnership quality including satisfaction on process effectiveness of collaboration, I also measured the factual outcomes of collaboration. To this end I developed several items that reflect the results of SPP including generation of research abstracts, papers, research grants, patents and clinical applications. The questions I asked were: (1) were paper(s)/meeting abstract(s) generated? (2) were grants generated? (3) were grants awarded? (4) did the collaboration lead to clinical application(s)? (5) did the collaboration generate patents (in preparation, pending or awarded)? The respondents were asked to choose between “Yes” or “No” to the above questions. A “no” answer was assigned as “0”, and a “yes” answer was assigned a numerical number based on the importance of the item in the outcomes of SPP as explained below. These constructs were operationalized as a formative construct.

**Academic outcome (AO):** the academic paradigm of “publish or perish” dictates the academic incentive and collaboration outcomes especially for research scientists. A “yes” answer to first (paper/meeting abstract), second (grant generated) or third (grant awarded) question was assigned as “2”, “2” or “3” respectively. The numerical numbers for all three items were added together to obtain the index of academic reward. Although items 2 (grant generated) and 3(grant awarded) loaded very well together as a factor in both EFA and CFA with high loadings, we did not use them as a separate construct in our analysis, because they are part of an index of academic outcome.
Clinical outcome (CO): Most research findings are supposed to contribute to general knowledge without clinical or practical applications. Although some patents filed and awarded are for research purposes only, a patent generated from research indicates the potential application of knowledge in practice. Clinical applications of research are the ultimate goal of a vast majority of biomedical research. Therefore, a “yes” answer to item 4 regarding patent was assigned as “5”, and to item 5 regarding clinical application as “10”. The index of academic reward was obtained by adding the numbers for these two items together.

3.2.3 Controls

I included income, age, academic title and gender as controls to account for their potential impact on collaboration and its outcomes. These variables reflect the demographic data of the respondents, and they were operationalized as categorical variables.

3.2.4 Pretesting of scales: After interviewing and discussing with several scientists and physicians, the initial survey was tested with two physicians and two research scientists for content and face validity and comprehensibility (Bolton, 1993). The pretest did not reveal any conceptual issues. I made a few questions clearer by adding “in above collaboration” to several questions. The refined survey was then distributed to the unit of my analysis—physicians, scientists and physician scientists with a MD, PhD or MD-PhD degree.

3.3 Data Collection

Data was collected using a carefully designed questionnaire and administered online using the assistance of survey software by Qualtrics (www.qualtrics.com/).
Because scientist and physician collaboration is the focus of this study, I excluded MD and MD or PhD and PhD collaborations, and only sampled the collaborative relationships based on respondent’s professional degrees: PhD and MD collaboration, PhD and MD-PhD collaboration, and MD and MD-PhD collaboration. Due to the small (13.9%) population of MD-PhDs in the respondents, the majority of the collaboration occurred between professionals who have a MD and a PhD.

**Sample population:** Informed by the findings of my previous qualitative study, the study population was practicing physicians, research scientists, and physician scientists in the United States of America. The data was collected by invitation primarily through two methods: (1) email listings including both physicians and research scientists were compiled based on the contact information of potential respondents whose information is available on the websites of the research departments and research centers of top US hospitals and medical schools. Invitation e-mails containing a brief description of research purpose and content, IRB information and the survey link were emailed to the individuals on the e-mail listings. (2) The survey link was distributed to members of several Clinical Translational Science Award (CTSA) centers through their local offices. In addition, three qualified (with MD-PhD collaboration) responses were received from people through personal connections whose names were not among the email listings mentioned above. The response rate is 8.2%, which is similar or higher than similar studies surveying physicians (Scott et al., 2008; Clark et al., 2008; Brewster, 2010). The low response rate probably reflects the highly time sensitive nature of my unique survey population (MDs, PhDs and MD-PhDs).
**Non-response bias:** The analysis of demographics and main constructs showed no significant difference (Armstrong & Overton, 1977; Pavlou & Sawy, 2006) between early and late responders or between completed or partial responders, suggesting non-response bias is not likely a threat in my study.

**Demographics of respondents:** A total of 440 responses that satisfy the analysis conditions (i.e. collaborated with physicians or scientists, and the collaboration partners are physicians and scientists with a MD or PhD) were obtained for further data analysis. Table B1 summarizes the demographics of respondents.

![Table B1](image)

**3.4. Data Screening**

**Missing values:** Among the 440 responses we analyzed, 4 values of income were missing in the data set, which accounted for less than 0.025% of the total values of data.
We replaced these 4 missing values with median, which is acceptable given the missing value is way below 5% as suggested by Tabachnick et al. (2001). There were not any other missing values for any of the other items measured.

**Outliers:** Extreme outliers did not exist, because values for all reflective variables were based on Likert-like scales with five intervals or categorical values for categorical variables.

**Normality:** At item level, only 7 items showed slight non-normal distribution with negative skewness values. Correspondingly, these items also have some minor kurtosis issues. However, visual inspection of the normality plots of items showed that the distributions are roughly normal. At variable levels, all the values for skewness (-1.217 to + 0.368) and kurtosis (- 0.707 to + 1.777) are within acceptable range with good variance (Hair et al., 2010). The items with negative skewness are the items measuring professional identity and challenge motivation. Given the unique sample population of my study (MDs, PhDs, MD-PhDs), the nature of their job and their social status, as well as the possibility that more successful collaborators participated and finished the survey, the negative skewness and leptokurtic curve of kurtosis are not surprising. Because the variables are based on Likert-type scales, and there are good variances in the items/constructs with Skewness and Kotosis issues, I did not exclude variables with minor distribution issues.

**Linearity:** Simple OLS regression test was conducted to check linearity for all direct relationships in the model. The majority of relationships are linear with significance values below 0.05, except for the following relationships: between recognition motivation, compensation recognition and endogenous variables, between
agreeableness with academic outcome and clinical outcome. Additional OLS analysis including more independent variables shows that relationship between recognition motivation and satisfaction of process effectiveness of collaboration is linear. The non-linear relationships are not included in the final model.

**Multicollinearity**: To check for multicollinearity, the Variable Inflation Factor (VIF) and tolerance tests were conducted for all eight exogenous variables simultaneously. The maximum tolerance value is 0.926; All VIF values are below 3 except for between professional identity and agreeableness (VIF=3.003), indicating that multicollinarity is not a significant concern (Stine. 1995).

3.5. **Statistical Analysis**

3.5.1 **Measurement model**

**Exploratory factor analysis (EFA)**

EFA was carried out using Principle Axing Factoring (PFA) and Promax rotation in SPSS (21). Pattern matrix (Appendix B) shows that all the items loaded as expected after the deletion of two items with unacceptable cross loadings (difference of loadings <0.2) or no loading in EFA. Eigen values for all nine factors extracted were above 1.0. The analyses for reliability, validity and data adequacy of EFA indicate a great factor solution (Hair et al 2010): KMO=0.849, Chi-square =4116, df=91, p=0.000). All communalities were above 0.6. Five factors explained 73% of variance, there were 1% non-redundant residuals with absolute values >0.05; no problematic cross loadings. The Cronbach's alphas for all factors were above 0.7 (Nunnally. 1978).
Confirmatory factor analysis (CFA):

Model fit: The obtained EFA solution was then analyzed in a CFA model. In order to achieve a good model fit, the following error terms were covaried within constructs: between PI2 and PI3 within professional identity, ChalM2 and ChalM3 within challenge motivation, Intra2 and intra4 within introversion and Con1 and Con2 within Conscientiousness. The final measurement model has a good fit as indicated by the following fit parameters: Chi-square=817, degrees of freedom=394, CMIN/DF=2.074, P value=0.00, PCLOSE=0.565; GFI=0.894, AGFI=0.866, NFI=0.89, TLI=0.928; CFI=0.939, RMSEA=0.049, SRMR= 0.056.

Reliability and validity: All loadings in the final CFA model are greater than 0.7 except for 5 items with values greater than 0.550(appendix A). As Table B2 shows, there are no convergent, discriminant or reliability concerns for all the factors except for agreeableness whose AVE is slightly lower (0.473) than desired 0.50.

### Table B2
Convergent and Discriminant Validity of the Construct

<table>
<thead>
<tr>
<th></th>
<th>CR</th>
<th>AVE</th>
<th>MSV</th>
<th>ASV</th>
<th>Consciousness (CON)</th>
<th>Professional identity (PI)</th>
<th>Challenge Motivation (ChalM)</th>
<th>Compensation Motivation (CompM)</th>
<th>Recognition Motivation (RM)</th>
<th>Extraversion (Extra)</th>
<th>Agreeableness (AGR)</th>
<th>Openness (OPE)</th>
<th>Satisfaction on Process effectiveness (SPE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CON</td>
<td>0.820</td>
<td>0.537</td>
<td>0.206</td>
<td>0.071</td>
<td>0.733</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PI</td>
<td>0.833</td>
<td>0.556</td>
<td>0.461</td>
<td>0.103</td>
<td>0.357</td>
<td>0.746</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>ChalM</td>
<td>0.802</td>
<td>0.585</td>
<td>0.461</td>
<td>0.096</td>
<td>0.309</td>
<td>0.679</td>
<td>0.765</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>CompM</td>
<td>0.793</td>
<td>0.569</td>
<td>0.194</td>
<td>0.043</td>
<td>-0.013</td>
<td>-0.197</td>
<td>-0.195</td>
<td>0.755</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM</td>
<td>0.823</td>
<td>0.612</td>
<td>0.194</td>
<td>0.028</td>
<td>0.049</td>
<td>0.079</td>
<td>-0.007</td>
<td>0.440</td>
<td>0.782</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ext</td>
<td>0.867</td>
<td>0.620</td>
<td>0.048</td>
<td>0.021</td>
<td>-0.185</td>
<td>-0.160</td>
<td>-0.110</td>
<td>0.165</td>
<td>0.002</td>
<td>0.788</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AGR</td>
<td>0.728</td>
<td>0.473</td>
<td>0.072</td>
<td>0.038</td>
<td>0.222</td>
<td>0.248</td>
<td>0.269</td>
<td>-0.204</td>
<td>-0.052</td>
<td>0.081</td>
<td>0.688</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OPE</td>
<td>0.871</td>
<td>0.634</td>
<td>0.206</td>
<td>0.054</td>
<td>0.454</td>
<td>0.156</td>
<td>0.273</td>
<td>0.024</td>
<td>0.118</td>
<td>-0.220</td>
<td>0.224</td>
<td>0.796</td>
<td></td>
</tr>
<tr>
<td>SPE</td>
<td>0.937</td>
<td>0.833</td>
<td>0.081</td>
<td>0.026</td>
<td>0.233</td>
<td>0.284</td>
<td>0.134</td>
<td>-0.069</td>
<td>-0.057</td>
<td>-0.103</td>
<td>0.132</td>
<td>0.128</td>
<td>0.913</td>
</tr>
</tbody>
</table>
Common method bias (CMB):

The “common latent factor” method recommended by Podsakoff et al. (2003) for studies that do not explicitly measure a common factor (as in this study) was used to test for Common Method Bias (CMB). I compared the standardized loadings of items in CFA without and with a common latent factor. None of the differences of loadings on same item is above 0.2, indicating that CMB is not a significant threat (Podsakoff et al., 2003).

Invariance test

Invariance tests of CFA at group levels were conducted to make sure it is appropriate to conduct moderation test with categorical variable – professional degree. The unconstrained measurement model with PhD and MD loaded separately still shows a good fit (Chi-square=1276.5, degrees of freedom=788, CMIN/DF=1.62, P value=0, PCLOSE=1; GFI=0.83, AGFI=0.786, NFI=0.822, TLI=0.908; CFI=0.922, RMSEA=0.041, SRMR=0.076), suggesting the model has configural invariance. The test for Chi-square difference between unconstrained and fully equally constrained models is insignificant (p=0.344), indicating that groups are not different at the model level. Thus the model meets the metric invariance criteria as well.

3.5.2 Structural model

Due to the inclusion of variables (AO and CO) represented by indices not amenable for CBSEM, I transformed all item level reflective variables into composites. These composite variables were created based on the CFA model in AMOS. The controls were tested only for their effect on dependent variables and satisfaction on process effectiveness of collaboration. The mediation analysis for the significance of indirect effects was carried out using bootstrapping with 2000 samples and setting “bias-corrected
confidence intervals” to 95%. The presence of mediation effects was evaluated using Baron and Kenny method (1986). The final structural SEM was created by trimming all non-significant paths off. In addition, after consulting modification indices, a regression line from academic promotion criteria to satisfaction on process effectiveness of collaboration was added, because it made both statistical and theoretical sense and improved the model fit. The final model yielded an excellent model fit as indicated by the following parameters: Chi-square=40.8, degrees of freedom=30, CMIN/DF=1.36, P value=0.09, PCLOSE=0.948; GFI=0.984, AGFI=0.964, NFI=0.959, TLI=0.979; CFI=0.989, RMSEA=0.029, SRMR= 0.056. Table B3 shows the correlation among the constructs in the final SEM model.

TABLE B3
Correlation Matrix of Constructs

<table>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SPE</td>
<td>0.932*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CON</td>
<td>.260</td>
<td>0.820</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>OPE</td>
<td>.138</td>
<td>.509</td>
<td>0.863</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AGR</td>
<td>.156</td>
<td>.273</td>
<td>.266</td>
<td>0.721</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Extra</td>
<td>-.112</td>
<td>-.210</td>
<td>-.241</td>
<td>.092</td>
<td>0.853</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RM</td>
<td>-.062</td>
<td>.059</td>
<td>.131</td>
<td>-.065</td>
<td>.003</td>
<td>0.808</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CompM</td>
<td>-.076</td>
<td>-.018</td>
<td>.026</td>
<td>-.243</td>
<td>.182</td>
<td>.496</td>
<td>0.773</td>
<td></td>
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</tr>
<tr>
<td>ChalM</td>
<td>.146</td>
<td>.350</td>
<td>.297</td>
<td>.322</td>
<td>-.122</td>
<td>-.006</td>
<td>-.217</td>
<td>.805</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>PI</td>
<td>.313</td>
<td>.411</td>
<td>.181</td>
<td>.304</td>
<td>-.181</td>
<td>.085</td>
<td>-.223</td>
<td>.751</td>
<td>.050</td>
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<tr>
<td>AO</td>
<td>.340</td>
<td>.122</td>
<td>.146</td>
<td>.077</td>
<td>-.186</td>
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<td>.019</td>
<td>.084</td>
<td>.145</td>
<td>.159</td>
<td>.242</td>
</tr>
<tr>
<td>CO</td>
<td>.305</td>
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<td>.059</td>
<td>-.104</td>
<td>-.011</td>
<td>-.017</td>
<td>.128</td>
<td>.159</td>
<td>.159</td>
<td>.242</td>
</tr>
</tbody>
</table>

Invariance test and moderation

SEM invariance test at physician (MD) and scientist (PhD) group levels was conducted using chi-square difference between unconstrained and fully constrained model. Both unconstrained and constrained SEM models with PhD and MD loaded separately have good fit (Chi-square=53.7, degrees of freedom=44, unconstrained/fully
RESULTS AND FINDINGS

The standardized path coefficients and their p values within the final model are presented in Figure B2. The R-squares of endogenous variables are included in figure as well. The results for all hypothesis tests are summarized in Table B4 (direct effects: H1, H2, H3, H4, H5, H6, H7, H8), Table B5 (mediating effect: H9, H10), and Table B6 (moderating effects: H11, H12).
1. The Direct Effects of Individual Attributes

Table B4 shows the results of hypotheses (H1, H2, H3, H4, H5, H6, H7, H8) tested on the direct effects of independent variables on endogenous variables using the complete data set including MDs, PhDs and MD-PhDs.

**Professional identity:** in the presence of satisfaction on process effectiveness of collaboration (SPE), professional identity has a positive relationship with SPE (β=0.433, p<0.00), but it does not influence academic or clinical outcome directly. In the absence of SPE, professional identity has a positive influence on both academic outcome (β=0.105, p=0.026) and clinical outcome (β=0.101, p=0.026). SPE has a positive influence on both academic outcome (β=0.316, p<0.001) and clinical outcome (β=0.234, p<0.001), indicating a mediating role of SPE.

**Motivation:** in the presence of SPE, recognition motivation has a modest but significant positive direct influence on academic outcome (β=0.096, p=0.03), which supports Hypothesis 2a; but it has a negative influence on SPE (β=−0.111, p=0.013); it does not have a direct influence on clinical outcome. Challenge motivation has a negative effect on satisfaction on process effectiveness (SPE) (β=−0.241, p<0.001), but it has no direct influence on either academic outcome or clinical outcome as I hypothesized (H3a, H3b). Compensation motivation had no relationships with SPE, AO or CO, which does not support hypotheses (H4). In the absence of SPE, surprisingly, none of the three motivations tested has any effect on academic outcome or clinical outcome.

**Personality:** in the presence of SPE as in final model, introversion has a negative effect on AO (β=−0.142, p=0.001), which supports hypothesis H5a, but introversion has
no relationship with SPE or CO. Conscientiousness has a positive effect on SPE ($\beta=0.173$, $p<0.001$), but it does not influence AO or CO directly, which does not support hypotheses H6a, H6b. Agreeableness does not have any direct relationship with either academic outcome or clinical outcome as I expected in H7a and H7b. It has no relationship with SPE either. Similarly, openness does not have any influence on SPE, clinical or academic outcome. In the absence of SPE, only introversion still has a negative influence on academic outcome, no other personality dimensions has any impact on academic or clinical outcome.

Satisfaction on process effectiveness of collaboration has a positive effect on both AO ($\beta=0.316$, $p<0.001$) and CO ($\beta=0.234$, $p<0.001$), therefore, professional identity, challenge motivation, recognition motivation and conscientiousness all have an indirect effect on AO and CO through SPE.

### TABLE B4

**Summary of Hypothesis Test on Direct Relationships**

<table>
<thead>
<tr>
<th>ID</th>
<th>Hypothesis</th>
<th>Evidence</th>
<th>Supported?</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1a</td>
<td>Professional identity has a positive effect on academic outcome</td>
<td>ns</td>
<td>Not directly</td>
</tr>
<tr>
<td>H1b</td>
<td>Professional identity has a positive effect on clinical outcome</td>
<td>ns</td>
<td>Not directly</td>
</tr>
<tr>
<td></td>
<td>Professional identity has a positive effect on SPE</td>
<td>0.433***</td>
<td></td>
</tr>
<tr>
<td>H2a</td>
<td>Recognition motivation has a positive effect on academic outcome</td>
<td>0.096*</td>
<td>Yes</td>
</tr>
<tr>
<td>H2b</td>
<td>Recognition motivation has a positive effect on clinical outcome</td>
<td>ns</td>
<td>Not directly</td>
</tr>
<tr>
<td></td>
<td>Recognition motivation has a negative influence on SPE</td>
<td>-0.111*</td>
<td></td>
</tr>
<tr>
<td>H3a</td>
<td>Challenge motivation has a positive influence on academic outcome</td>
<td>ns</td>
<td>Not directly</td>
</tr>
<tr>
<td>H3b</td>
<td>Challenge motivation has a positive influence on clinical outcome</td>
<td>ns</td>
<td>Not directly</td>
</tr>
<tr>
<td></td>
<td>Challenge motivation has a negative influence on SPE</td>
<td>-0.241***</td>
<td></td>
</tr>
<tr>
<td>H4</td>
<td>Compensation motivation has a positive impact on clinical outcome</td>
<td>ns</td>
<td>No</td>
</tr>
<tr>
<td>H5a</td>
<td>Introversion has a negative effect on academic outcome</td>
<td>-0.142**</td>
<td>Yes</td>
</tr>
</tbody>
</table>
**H5b** Introversion has a negative effect on clinical outcome | No relationship | No

**H6a** Conscientiousness has a positive effect on academic outcome | Through SPE | Not directly

**H6b** Conscientiousness has a positive effect on clinical outcome | Through SPE | Not directly

Conscientiousness has a positive effect on SPE | 0.173*** |

**H7a** Agreeableness has a positive influence on academic outcome | ns | No

**H7b** Agreeableness has a positive influence on clinical outcome | ns | No

**H8a** Openness has a positive influence on academic outcome | ns | No

**H8b** Openness has a positive influence on clinical outcome | ns | No

SPE has a positive influence on academic outcome | 0.316*** | Yes

SPE has a positive influence on clinical outcome | 0.234*** | Yes

Note: the values are from the final model; ns: not significant. All regression weights reported are standardized.

### 2. The Effect of Perceived Satisfaction on Process Effectiveness (SPE) (H9 and H10)

Satisfaction on process effectiveness of collaboration has a positive effect on both academic outcome and clinical outcome, which is consistent with my previous finding.

The direct effect of professional identity on both academic outcome and clinical outcome were lost in the presence of SPE, suggesting a mediating role of SPE. Indeed, SPE fully mediates the positive impact of professional identity on both academic outcome and clinical outcome (Table B5), supporting hypotheses H9a and H9b.

Although recognition motivation has a direct effect on both SPE and academic outcome, and SPE has a direct role on academic outcome, because recognition motivation has no direct relationship with academic outcome in the absence of SPE, my hypotheses (H10a, H10b) that SPE mediates the effect of recognition motivation on academic outcome is not supported.
TABLE B5
The Mediating Effect of Satisfaction on Process Effectiveness

<table>
<thead>
<tr>
<th>Hypothesis: Satisfaction on process effectiveness (SPE) mediates the effect of</th>
<th>Direct without SPE (beta /p value)</th>
<th>Direct with SPE (beta /p value)</th>
<th>Indirect with SPE (beta /p value)</th>
<th>Mediation Effect, Supported?</th>
</tr>
</thead>
<tbody>
<tr>
<td>H9a Professional identity on academic outcome</td>
<td>0.105 /0.026 ns</td>
<td>0.137/p&lt;0.001</td>
<td>Full, Yes</td>
<td></td>
</tr>
<tr>
<td>H9b Professional identity on clinical outcome</td>
<td>0.101/0.026 ns</td>
<td>0.118/p&lt;0.001</td>
<td>Full, Yes</td>
<td></td>
</tr>
<tr>
<td>H10a Recognition motivation on academic outcome</td>
<td>ns</td>
<td>0.096/0.024 -0.03.5/0.009</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>H10b Recognition motivation on clinical outcome</td>
<td>ns</td>
<td>No relationship</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

3. The Moderating Effect of Professional Degree (H11, H12)

The model is invariant between groups divided by professional degree based on the chi-square difference test between unconstrained and fully constrained models (p=0.066). However, group analysis at path level by critical ratio method showed significant difference between PhDs and MDs in several relationships (Table B6).

Although the relationship between academic outcome (AO) and clinical outcome (CO) is significant for MDs but not for PhDs, the positive relationship between AO and CO is not stronger for MDs (β=0.129/p=0.125) than for PhDs (β=0.130/p=0.038) statistically (Z score: -0.084/p>0.10), which does not support hypothesis H11. In addition, I anticipated a stronger relationship between introversion and AO in PhDs, but the data shows that the negative relationship between introversion and AO is stronger for MDs than for PhDs, which does not support H12.

Given the profound deference between physicians and scientist at many aspects, I also investigated if there are other relationships that are different between MDs and PhDs. Group analysis reveals that the positive relationships between professional identity
and satisfaction on process effectiveness (SPE) of collaboration, between Challenge Motivation and clinical outcome, between openness and academic outcome are stronger for PhDs than for MDs; The negative relationship between Recognition motivation and SPE is stronger for PhD than for MDs as well.

In addition, although some relationships have no statistical difference based on Z score, the regression weight and p value data indicate that these relationships are different across groups with different professional degrees (Table B6). For example, the positive relationships between recognition motivation and academic outcome, between conscientiousness and SPE, between agreeableness and satisfaction are stronger for MDs than for PhDs.

**TABLE B6**
The Moderating Effect of Professional Degree

<table>
<thead>
<tr>
<th>Multi-group moderation</th>
<th>Evidence (standardized beta/p value)</th>
<th>Hypothesis supported?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>H11.</strong> The positive effect of AO on CO will be stronger for MDs than for PhDs.</td>
<td>PhD: β=0.129/p=0.125 MD: β=0.130/p=0.038 Z score: -0.084/p&gt;0.10</td>
<td>Statistically no. However, the relationship is significant for MD, not for PhD, although the coefficients are almost identical.</td>
</tr>
<tr>
<td><strong>H12.</strong> The negative relationship between introversion and AO is stronger for PhDs than for MDs.</td>
<td>PhD: β=0.026/p=0.744, MD: β=-0.274/p&lt;0.001, Z score: -3.113/p&lt;0.001</td>
<td>Opposite direction</td>
</tr>
<tr>
<td><strong>NHR1.</strong> The positive relationship between PI and SPE is stronger for PhDs than for MDs.</td>
<td>PhDs: β=0.541/p&lt;0.001 MDs: β=0.291/p=0.001 Z score: -1.864/p&lt;0.10</td>
<td></td>
</tr>
<tr>
<td><strong>NHR2.</strong> The positive relationship between challenge motivation and clinical outcome is stronger for PhD than for MD.</td>
<td>PhD: β=0.254/p=0.002 MD: β=0.012/p=0.843 Z score: -2.433 /p&lt;0.001</td>
<td></td>
</tr>
<tr>
<td><strong>NHR3.</strong> The negative relationship between recognition motivation and SPE is stronger for PhD than for MDs.</td>
<td>PhDs: β=-0.236 /p=0.003 MDs: β=-0.082/p=0.169 Z score: 1.891/p&lt;0.10</td>
<td></td>
</tr>
</tbody>
</table>
NHR4. The positive relationship between recognition motivation and AO may be stronger for MDs than for PhDs.

PhD: $\beta=0.005, p=0.953$

MD: $\beta=0.135, p=0.018$

Z score: $1.269, p>0.10$ (ns)

Statistically no, but the relationship is significant for MD, not for PhD.

NHR5. The positive relationship between conscientiousness and SPE may be stronger for MDs than for PhDs.

PhD: $\beta=0.105, p=0.273$

MD: $\beta=0.22, p<0.001$

Z score: $0.766, p>0.10$ (ns)

Statistically no, but the relationship is significant for MD, not for PhD.

NHR6. The positive relationship between agreeableness and satisfaction may be stronger for MD than for PhDs.

PhD: $\beta=-0.009, p=0.911$

MD: $\beta=0.151, p=0.019$

Z score: $1.588, p>0.10$ (ns)

Statistically no, but the relationship is significant for MD, not for PhD.

NHR7. The positive relationship between openness and AO is stronger for PhD than for MD.

PD: $\beta=0.179, p=0.026$

MD: $\beta=-0.084, p=0.160$

Z score: $-2.627, p<0.001$

4. Controls

Among the controls tested including gender, age, income and academic title, academic title is related to academic outcome ($\beta=0.118, p=0.008$); income has a weak positive relationship with clinical outcome ($\beta=0.083, p=0.083$) at 90% levels; and age has a positive effect on the clinical outcome ($\beta=0.19, p<0.001$). Not surprisingly, age, academic title and income are all significantly correlated (age and academic title: $\beta=0.572, p<0.001$; age and income: $\beta=0.353, p<0.001$; academic title and income: $\beta=0.0378, p<0.001$).

**DISCUSSION**

I. The Effects of Individual Attributes

The previous phase 1 study revealed that individuals are the driving force for medical innovations and discoveries. This current study quantitatively captured the influence of individual attributes including professional identity, motivation and personality on the effectiveness of scientist-physician collaboration, a collaboration that aims to promote biomedical discovery and translating the research findings into practice.
The importance of professional identity

I found that professional identity is a positive predictor of both academic outcome measured by conference abstracts, papers and grants, and clinical outcome measured by patents and clinical applications generated from SPP. Given the association of professional identity and SPP effectiveness, it is advisable to choose collaborators who identify with their career greatly, because those people are the potential collaborators who will put a great deal of effort to make projects successful by various means.

Satisfaction on process effectiveness (SPE) of partnership meditates the positive relationships between professional identity and academic outcome and clinical outcome implying an important role of satisfaction on collaboration process. The positive relationship between satisfaction on process effectiveness of collaboration and SPP effectiveness agrees with the literature on the correlation between satisfaction and successful partnership (Geringer & Hebert, 1989), and with my other studies (study 3 and study 4 of this dissertation).

The role of motivation:

Motivations in inter-professional and interdisciplinary collaborations are different among the collaborators. For example, “developing profitable business opportunities, lobbying policy makers or enhancing personal careers” are the motivations in a team composed of a human geographer, an environmental scientist, a biologist, an agronomist and a rural sociologist (Harris et al., 2008: 382). My qualitative study indicates that challenge and recognition motivations are the factors that drive scientists and physicians to engage in biomedical knowledge production and application. However, the current quantitative study found that both challenge motivation and recognition motivation
negatively influence satisfaction on process effectiveness (SPE) of collaboration, which has a positive effect on both academic and clinical outcome. In other words, challenge and recognition motivation may influence academic and clinical outcome indirectly in a negative manner through their negative influence on SPE.

**Recognition motivation:** Unlike independent projects where there is no recognition issue or dispute on credit, in collaborative projects, proper credit and recognition is the key to the success of the collaboration. However, correctly reflecting each collaboration partner’s contribution is not a straightforward process. For example, the order of authorship in publications, the principal investigator of grant applications, and the allocation of the financial rewards generated from collaborative projects are the ways to recognize the contributions of individuals in the collaboration. In current NIH funding system, there is only one place for the name of principal investigator, and whether someone is a principal investigator is directly linked to the tenure process if the grant application is awarded by the sponsoring agencies. In medical school promotion system, only the primary author of published papers is recognized as making a significant contribution, but as a MD-PhD interviewee commented that since there is only one place for the primary author of a paper, and he would therefore not extend his effort on collaborative projects but only focus on his own independent projects.

Lack of recognition in SPP is observed in my phase 1 study. For instance, some scientists expressed their dismay about working with some physicians. For various reasons including physician’s time, training, skills and attitude, some scientists who collaborated with physicians ended up doing most of the work, because their collaborating partners did not “pull their own weight.” However, this contribution was
not credited and reflected properly on the publications or grant applications or in other forms, because “MDs are not willing to give the credit to the PhDs.” Lack of recognition, credit and respect from clinical partners have affected how some researchers think about their next collaboration with certain physicians, and have made them shy away from working with physicians in general. Although recognition motivation has a positive effect on academic outcomes, due to the negative influence of recognition motivation on SPE, which positively affect SPP effectiveness, a balanced recognition motivation is desirable for SPP.

**Challenge motivation:** My qualitative study suggests that challenge motivation drives some scientists and physician scientists to engage in SPP on interesting and sometimes very challenging projects. However, problems sometimes cannot be tackled and questions cannot be answered as expected, and sometimes there is little or no progress due to the difficulty of the projects. Because challenge projects sometimes do not produce, or take a long time to produce outcomes, working on challenging projects may lead to frustration along the way. The failure to achieve expected goals and objectives can affect the level of collaborators’ satisfaction on the collaboration outcomes and process. In addition, challenge projects may motivate one of the partners in collaboration but not necessary the other partners in the SPP team. Therefore, it is not surprising to see the negative effect of challenge motivation on satisfaction on collaboration. This finding suggests that maybe collaborators ought to set their goals and objectives realistically, because high expectation would lead to dissatisfaction on collaboration process and outcomes.
The impact of personality

Introversion is negatively associated with academic outcome as expected, but has no relationship with clinical outcome. This may imply that more communication is involved in clinical outcome than in academic outcome, because academic outcome is a relatively straightforward process comparing to clinical outcome. This finding supports the critical role of the communication as found in other studies (study 1 and study 3). Theoretically, openness is associated with intellect (Goldberg, 1990), because it measures if the respondent thinks s/he is ingenious, imaginative, inventive and a deep thinker or not. Surprisingly, openness has no relationships with SPP outcomes in the final model when all responses are combined as one group, but it has a significantly positive effect on academic outcome for PhDs, but not for MDs when the responses were divided by professional degree. Agreeableness belongs to the cluster of cooperation (Goldberg, 1990), but this study found no relationship between agreeableness with any endogenous variables (i.e. SPE, AO and CO) of collaboration. This finding indicates that, in our study context, agreeableness does not matter in terms of achieving the goals of collaboration since the final outcomes (AO or CO) is to a large extent judged and decided by non-related third parties. For example, the independent reviewers for grant applications and for publishing papers in peer-reviewed journals. Higgins and colleagues found (2007) that conscientiousness is the only big-five personality dimension that predicts job performance. The influence of conscientiousness on collaboration outcomes is indirect through its influence on satisfaction on process effectiveness of collaboration in this study.
The data of this study indicates that personality might be useful in predicting the collaboration outcomes, especially academic outcome.

II. The Relationship between Academic Outcome (AO) and Clinical Outcome (CO) is not Stronger in MDs than in PhDs

The failure to apply research findings to clinical practice has been framed as a problem of knowledge translation (Graham et al., 2006; Lenfant, 2003; Sung et al., 2003). The majority of the efforts to reduce the research and practice gap has been focused on increasing translation by promoting translational research (TR) (Crist et al., 2004; Zerhouni, 2007) and emphasizing the important role of physician scientists—the translators (Ley & Rosenberg, 2005). Many efforts and initiatives including research funding and educational programs have been made to promote physicians’ participation in research especially translational research (Goldstein & Brown, 1997; Rosenberg, 1999; Crist et al., 2004; Harrington, 2006; Zerhouni, 2007).

Clinical outcome is a result of academic outcome. Given the importance of physician scientists in producing clinical outcomes, plus the different training background and focus of PhDs and MDs, I expected a stronger relationship between AR and CR in MDs than PhDs. Surprisingly, the investigation, using professional degree as a moderator, did not uncover a difference between MDs and PhDs according to critical ratio analysis; i.e. the effect of academic outcome on clinical outcome is not statistically different between MDs and PhDs (z score=-0.084; p>0.10).

One possible explanation for this unexpected finding may lie in the measure of clinical outcome. I included the patents generated from collaboration as CO outcome for its on-going and potential clinical application. Some patents may only have research
application but not clinical application. Future study using only applied clinical application or licensed patents for clinical application as clinical outcome may provide a more accurate picture on the role of PhDs and MDs in transferring research into practice.

Nevertheless, this finding is consistent with what I found previously. As the interviewees in the qualitative phase stated, physician scientists are forced to focus on the basic science in order to compete with basic scientists for grants and for publishing research papers, because clinical research is considered as descriptive lacking mechanism due to the availability of human research models and human samples. In addition, this finding agrees with the result of other survey questions asking about the incentives of their collaboration. Almost identical percentages of MDs, or PhDs, or MD-PhDs (83.2% for PhDs, 83.5% for MDs and 83.9% for MD-PhDs) engaged in SPP to get paper(s) published, and slightly more MDs than PhDs or MD-PhDs to transfer research into clinical practice (68.5% for MD, 76.6% for MD, and 67.7% for MD-PhDs).

III. The Predicting Role of Personal Attribute for SPP Effectiveness:

Although individual factors emerged as significant influencing factors in SPP and its effectiveness, the combination of professional identity, recognition motivation, challenge motivation and conscientiousness explains 15.2% of variance in satisfaction on process effectiveness of collaboration. The combination of satisfaction on process effectiveness, recognition motivation and introversion accounts for 14.7% of variance in academic outcome; Introversion and academic outcome explains 14.8 % of variance in clinical outcome. This suggests personal attributes such as professional identity, motivation and personality a only contribute to SPP effectiveness to a certain degree. In addition, individual factors such as self-efficacy, autonomy, social networking, and
conflict resolution style may also contribute to the academic outcome and clinical outcome of SPP. The low predicting power of personal attributes is not surprising because the transfer of biomedical science to clinical practice in medicine occurs in a complex system involving institutional, social and cultural arrangements and structures at both personal and organizational levels. In addition, the randomness of medical discovery makes it hard to predict outcomes, especially clinical outcomes of research.

CONCLUSIONS

I. Summary of Main Findings

My study reveals the following findings: (1) Professional identity has a positive effect on both academic outcome and clinical outcome through SPE, and SPE fully mediates the role of professional identity on both AO and CO. (2) Recognition motivation has a positive effect on AO, but surprisingly both recognition motivation and challenge motivation have a negative effect on SPE, which has a positive impact on both AO and CO. Compensation motivation is not associated with SPE, AO and CO. (3) Introversion has a negative direct effect on AO, but no relationship with CO; conscientiousness has a positive effect on SPE. Neither agreeableness nor openness is associated with any SPP outcomes. (4) Contrary to traditional beliefs, the group analysis data shows that professional degree does not moderate the relationship between academic outcome and clinical outcome. (5) A lot of relationships between personal attributes and SPP outcomes are stronger in PhDs in than MDs.

II Theoretical Contribution

This study makes several important contributions to the literature on how individual attributes (professional identity, personality and motivation) influence inter-
professional collaboration effectiveness in scientist-physician partnership (SPP), and how the professional degree moderates several relationships as discussed above. As predicted, professional identity has a positive effect on SPP effectiveness. Contrary to traditional belief, our data reveals that professional degree does not moderate the relationship between academic outcome and clinical outcome. Our study provides insights on the relationships between individual attributes and SPP in medical knowledge transfer, as well as the difference between MDs and PhDs.

III. Practical Implications

This study also has several implications for practice. My results reveal the significant roles of professional identity, motivation and personality in SPP outcomes including satisfaction, academic and clinical outcomes. My findings will be of interest to the individual physicians and scientists, to academic communities, to funding agencies. Specifically, it has implication on who to support from the viewpoints of organizations and who to collaborate with from the perspectives of individuals.

1. What can organizations do?

Who to support: My finding of no significant difference in transferring academic outcome to clinical outcome between MDs and PhDs suggests that the approach of focusing on physician scientists is not necessary the only or the best solution in medical knowledge transfer. Organizations and institutions should support, including funding support, all interested and committed physicians and scientists with a high professional identity. In addition, organizations should be aware of the differences between scientist and physicians. Organizations are recommended to indentify promising people based on
the overall considerations based on professional identity, personality, motivation and their relative strengths that are associated with their professional degrees.

Provide a system recognizing everyone’s contribution correctly: The negative influencing of recognition motivation on satisfaction on process effectiveness of collaboration is particular interesting. Due to the academic promotion criteria focusing on grants as principal investigator and publications as primary author, it is important to have a system that recognizes contribution that each partner has made for the collaborating projects correctly. The current sole-applicant funding application system and the focus on only primary authorship in tenure promotion process discourage collaboration. To encourage collaborations, it is necessary to improve the current funding system by encouraging co-applicants, by recognizing the contributions of non-primary authorship in tenure promotion, so that each partner’s contribution is correctly reflected and awarded in grant application and in the tenure process. In addition, guidelines on how to allocate the grants to collaborators should be in place to ensure that partners get their fair shares.

2. What can individuals do?

Who to collaborate with? Another practical implication of this study is on identifying proper and effective collaborators. My previous qualitative study reveals that most collaborations fail because of personality conflicts. My data suggested that conscientiousness and extraversion characteristics are good for collaboration, but a person’s intellectual ability measured by openness construct is irrelevant to SPP effectiveness, and agreeableness has nothing to do with effectiveness of SPP. In addition, it may be wise to avoid collaborating with people who are motivated primary by recognition motivation and/or challenge motivation since these two motivations are
associated with dissatisfaction on process effectiveness of collaboration. Given the important role of professional identity in SPP, it is important to collaborate with those who highly identify with their profession. Lastly, it is important to be aware of the differences between physicians and scientists.

LIMITATIONS OF THIS RESEARCH

This study has several limitations: (1) All data are from a single resource and single method, and they are self-reported data. Since I did not provide any incentives for participating in my survey, I have no reason to suspect the data. In addition, CMB checks do not reveal any concerns. Furthermore, the endogenous variables include both subjective (satisfaction on process effectiveness of partnership) and objective measurements (abstracts, papers, grants, clinical applications and patents). (2) The data are from voluntary participants who have collaborated. This may to a certain degree bias the findings. (3) The unequal numbers for professional degree (MD=243, PhD=164) may have generated a certain bias in the group analysis where the sample number could affect significant levels. However, this may not be a concern since I found that most of the relationships are weaker in MD than in PhD where the sample size (for PhD) is smaller. (4) The generalizability of the findings to other cross-professional collaborations may need to be validated at other contexts.

FUTURE WORK

The findings and limitations of this study offer many opportunities for future research. (1) Obtain data from non-collaborators. Non-collaborator data would generate insights on the constrainers and inhibitors of SPP effectiveness and clinical outcome. (2) Group analysis including MD-PhD group. I did not include MD-PhD group in this study
due to its low sample number. Group analysis including this special groups is especial important in a full assessment of the role of MD-PhDs in knowledge transfer in medicine. In addition, group analysis by other factors such as job category, level of organizational support, and level of social support can be very informative as well. (3) Investigate the effect of personality match of collaborators on SPP effectiveness. (4) A multi-level model incorporating the influence of organization and socio-cultural forces in the same model would strengthen our understanding of SPP and its impact on medical knowledge production and transfer significantly. (5) Investigate the effect of many additional individual and systemic factors on the collaboration and effectiveness of SPP. For example, at the individual level, personal factors including autonomy, self-efficacy, social capital, networking, and conflict resolution style play roles in scientist-physician team. At the organizational and institutional levels, institutional constrains, and government regulatory environment are important factors that affect the collaboration and effectiveness of scientist-physician team.
## ATTACHMENT

### TABLE B7

**Construct Table**

<table>
<thead>
<tr>
<th>Construct</th>
<th>Items</th>
<th>CFA Loading</th>
<th>Resources</th>
</tr>
</thead>
</table>
| Professional Identity | -- I am willing to put a great deal of effort in order to be successful in this profession.  
 | -- I am proud to tell others that I am part of this profession.  
 | -- I am glad that I chose this profession.  
 | -- I really care about the fate of this profession. | 0.819  
 | 0.723  
 | 0.698  
 | 0.738  | Hudson 2007; Mowday et al. 1982; Vandenberg & Scarpello 1994 |
| Challenge Motivation | -- I enjoy trying to solve complex problems.  
 | -- I enjoy tackling problems that are completely new to me.  
 | -- The more difficult the problem is, the more I enjoy trying to solve it. | 0.942  
 | 0.746  
 | 0.557 | Kumar 2009; Miao & Evans 2007 |
| Compensation Motivation | -- I consider the primary purpose of my job is to make money.  
 | -- I am strongly motivated by the money I can earn through my job.  
 | -- I am keenly aware of the income goals I have for myself. | 0.755  
 | 0.905  
 | 0.565 | Miao & Evans 2007; Kumar 2009 |
| Recognition Motivation | -- I am strongly motivated by the recognition I can earn from other people.  
 | -- I want other people to find out how good I really can be at my work.  
 | -- To me, success means doing better than others in my organization. | 0.839  
 | 0.866  
 | 0.618 | Miao & Evans 2007; Kumar 2009 |
| Personality-Introversion | **Please tell us more about yourself: I am**  
 | -- Reserved.  
 | -- Quiet sometimes.  
 | -- Sometimes shy.  
 | -- Inhibited. | 0.800  
 | 0.834  
 | 0.801  
 | 0.710 | Pierce 2008; Goldberg 1990 |
| Personality-Agreeableness | **Please tell us more about yourself: I am**  
 | -- Of a forgiving nature.  
 | -- Generally trusting.  
 | -- Considerate and kind to almost everyone. | 0.727  
 | 0.721  
 | 0.610 | Pierce 2008; Goldberg 1990 |
| Personality-Conscientiousness | **Please tell us more about yourself: I am**  
 | -- A Reliable worker.  
 | -- Persistent until the task is finished.  
 | -- Efficient.  
 | -- Good at making and executing plans. | 0.561  
 | 0.731  
 | 0.765  
 | 0.844 | Pierce 2008; Goldberg 1990 |
| Personality-openness | **Please tell us more about yourself: I am**  
 | -- Ingenious  
 | -- Imaginative  
 | -- Inventive  
 | -- A deep thinker | 0.786  
 | 0.895  
 | 0.889  
 | 0.571 | Pierce 2008; Goldberg 1990 |
Thinking about a recent collaborative experience, how much do you agree with the following statement?
--The goals of the collaborative project were achieved.
--I would rate the collaborative project as a success.
--I am very satisfied with the performance of this collaborative project.
--I am proud of the collaborative project.

Academic Outcome
Thinking about the outcomes of the above collaboration, answer Yes or No to each question.
--Were paper(s)/meeting abstract(s) generated?
--Were grants generated?
--Were grants awarded?

Clinical Outcome
Thinking about the outcomes of the above collaboration, answer Yes or No to each question.
--Did the collaboration lead to clinical application(s)?
--Did the collaboration generate patents (in preparation, pending or awarded)?

TABLE B8
Pattern Matrix

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APPENDIX C
Institutional Factors Influencing Scientist-Physician Partnership

ABSTRACT

Substantial resources invested in biomedical research have generated revolutionary discoveries in medical science. However, it takes on average 17 years to turn about 14% of research findings into changes that benefit patients. Lack of scientist-physician partnership (SPP) is one main reason for the extremely slow translation of science into medical practice. Our previous study identified several institutional and socio-cultural barriers that hinder SPP and slow down knowledge transfer in medicine. However, the relationships among the identified factors, as well as the prevalence of their impacts on scientist-physician partnership and transfer of knowledge are not clear. This study focuses on the influence of institutional forces on SPP effectiveness. We hypothesized that institutional forces and arrangements such as academic promotion criteria and organizational infrastructure are related to partnership satisfaction and performance outcomes including clinical research related outcomes. We posit that communication effectiveness mediates the effect of institutional forces on the partnership satisfaction and outcomes. We surveyed 440 scientists and physicians to test these hypotheses. Our data reveals that the academic promotion criteria serves as an incentive and has a positive effect on communication, satisfaction on partnership effectiveness and academic outcomes as well as clinical outcomes. Access difficulty to collaborators as an indication of lack of organizational support has a direct negative impact on SPP effectiveness. Organizational collaboration mechanism has a positive effect on communication, and communication plays a critical role in SPP effectiveness. Communication mediates effects of institutional factors including academic incentives and organizational collaborative mechanism on the satisfaction and outcomes of partnership. Favorable institutional structures such as promotion and collaboration mechanism play a prominent role in SPP effectiveness. The study has several practical implications on how to foster physician and scientist collaboration. In addition, our study provides insights on effective collaboration and knowledge production and translation beyond healthcare system.

Key words: Scientists-physician partnership; academic culture/incentive; organizational collaboration mechanism; communication; satisfaction; partnership outcome.
INTRODUCTION

Significant resources have been invested in U.S. biomedical research (Kerner, 2006). For example, the National Institutes of Health (NIH) alone has earmarked $30-$32 billion annually for research since 2008 yielding vast knowledge as evidenced by the number of publications generated from sponsored research projects (Grol & Grimshaw, 2003; Kerner, 2006). However, the contributions of research to the improvement of human life has lagged behind, largely because of no or very slow application and adoption of research findings by the medical profession (Berwick, 2003; Lenfant, 2003; Glasgow, 2003; Kerner, 2006). It takes an estimated 17 years, on average, to turn 14% of research findings into clinical practice (Balas & Boren, 2000 cited in Westfall et al., 2007).

There are many reasons for the gap between medical research and practice (Glasgow & Emmons, 2007; Rye & Kimbley, 2007; Colditz et al., 2008; Scott et al 2008). The attributes of innovative research (Titler, 2007; Scott et al., 2008) and physician’s skills and attitudes (Cabana et al., 1999; Scott et al., 2008) are among the many barriers to knowledge transfer. Therefore, engagement of both academics and practitioners is essential in the translation of research findings into practice (Pettigrew, cited by Van De Ven, 2007: 262). Many have called for increased scientist-physician partnership (SPP) to produce knowledge that is worth of and easy to transfer (Moskowitz & Thompson, 2001; Kerner, 2006; Kerner & Hall, 2009).

Understanding factors that influence SPP effectiveness is important for improving knowledge generation, adoption and implementation outcomes in healthcare. However, literature and empirical studies on the interactions between research scientists and
physicians are sparse. “There is very little rigorous research that considers knowledge translation, continuing education, or research utilization in the interprofessional context” (Zwarenstein et al., 2006: 52). Senior management support is one of five success factors for effective partnerships (Nonaka, 1994). However, a study of healthcare teamwork shows that “members of collaborative teams do not always perceive themselves as having the support of the organization” (Kvarnström, 2008: 201).

Investigation of traits and behaviors of both partners is essential to uncover the underlying mechanism that influences SPP effectiveness. Our previous investigation that involved interviews with both scientists and physicians revealed many institutional and socio-cultural factors at both personal and organizational levels that influence partnership effectiveness (Wang et al., 2012). We found that those factors can hinder or facilitate physician-scientist partnership effectiveness and outcomes of translational research. However, the causal links among the identified factors and the degree of their impact on SPP effectiveness are unknown. In this study, we focus specifically on institutional and organizational factors that can predict SPP effectiveness. Specifically, we ask to what extent existing organizational infrastructure, levels of organizational support and incentive systems affect the SPP effectiveness. To address this question we conducted a quantitative survey among 440 research scientists and physicians who collaborated with partners with different skills (i.e. MD and PhD collaborations). To our knowledge this is the first study on factors that influence SPP effectiveness in the context of translational research.

The remainder of the paper is organized in the following sequence. First, we present the theoretical framework and associated hypotheses. Second, we describe the
research design and discuss key measures. Next, we report main findings. We conclude with implications and limitations as well as an outline of future work.

THEORETICAL FRAMEWORK AND HYPOTHESIS DEVELOPMENT

2.1. Research Model

Scientist and physician partnership or collaboration in this study is defined as the relation between research scientists and physicians who “work or act together” and “work with” each other to create and transfer biomedical research into practice. The definition is adopted from the following literature: “Partnership involves co-operation, i.e. “to work or act together” and in a public policy can be defined as co-operation between people or organizations in the public or private sector for mutual benefit” (Holland, 1984 cited in McQuaid, 2000: 2); “Collaborative relations including, for example, public-private partnerships, industrial networks, and strategic alliances” (Vangen & Huxham, 2003: 6).

Scientist-physician partnership (SPP) is expected to promote the transfer of biomedical research into clinical practice by generating transferable medical knowledge and outcomes. The partnerships are expected to reduce physician’s barriers in adopting the newest medical research and to help scientists discover new relevant research opportunities. SPP effectiveness can be defined as the extent to which the partnership promotes such goals in terms of research and clinical outcomes, as well as collaboration satisfaction.

Literature and our findings of a qualitative study interviewing physicians and scientists point out that institutional forces including academic culture, rewarding system and institutional arrangements play important roles in SPP effectiveness. For example, lack of time and funding due to inadequate organizational support is often the reason that
many physicians fail to engage in collaborative research. In addition, physicians often lack skills and motivation to engage themselves in research (Lay & Rosenberg, 2005; Bakken et al., 2006). The standards set by academic appointment and promotion committees often discourage scientists to collaborate with physicians due to time constraints and differences in incentives (Pober et al., 2001; Israel et al., 2001; Butler, 2008). Knowledge transfer is a time and resource-intensive activity with few incentives or rewards (Graham, 2010). Lack of time and funding, as well as lack of reward and recognition from universities prevent researchers from actively involving themselves in the dissemination of knowledge, including collaboration with physicians (Jacobson et al., 2004; Butler, 2008; Manske & Leithwood, 2010; Graham, 2010).

Lack of organizational support has been identified as one reason for scientists’ failure to engage in translational research (Jacobson et al., 2004; Butler, 2008; Manske & Leithwood, 2010), and for physicians’ failure to engage in research and to adhere to medical practice guidelines (Cabana et al., 1999; Scott, 2007). Organizational support makes treatment development a research priority, helps researchers with networking opportunities, and offers funding seeds to foster the articulation and development of treatment ideas by the academic investigators (Brewer, 2006). Overall, organizational factors that may be critical to promote researchers’ engagement in SPP include: promotion and tenure, resource and funding, incentive structure, knowledge transfer orientation and documentation (Jacobson et al., 2004).

Informed by both literature and my phase 1 empirical study (study 1), Figure C1 depicts a conceptual model formulated to guide researchers, consisting of factors that influence SPP effectiveness. This model emphasizes the importance of institutional
forces in the partnership between academic research and medical practice. We propose that organizational forces influence the process and outcomes of academia and practice partnership between scientists and physicians. Collaboration process factor communication mediates the effect of institutional forces on performance outcomes of SPP. Partnership satisfaction on process effectiveness of collaboration has a positive relationship with the outcomes of SPP. Gender, age, academic title and income are included as controls to account for their influences. The sections below review these factors in more detail. In addition, these sections describe the development of the research hypotheses compromising our model.

**FIGURE C1**
Conceptual Model

![Conceptual Model](image)

Institutional factor
- Academic Culture of Promotion
- Level of Access Difficulty
- Organizational Collaboration Mechanism

Communication Effectiveness

SPP effectiveness
- Academic Outcomes (papers, grants)
- Clinical Outcomes (clinical application, patents)

H1 (a, b) H2 (a, b) H3(a, b)

Note: H5, H6, H7, H9 and H10 are mediated relationships

**Scientist and physician partnership (SPP) effectiveness:** “Collaborative Practice is an inter-professional process for communication and decision making that enables the separate and shared knowledge and skills of care providers to synergistically influence the client/patient care provided”(Way et al., 2000: 3). Effectiveness is a
measure of achieving expected and desired objectives and outcomes (Parkhe, 1993; Saxton, 1997). Our previous study suggests outcomes motivating researcher and physician collaboration include: obtaining clinical samples for research purposes; obtaining grants; applying research findings in clinical practice, and conducting clinical research with the aim of creating new treatments. We therefore use academic outcome (AO) and clinical outcome (CO) as key dimensions defining SPP effectiveness.

**Academic outcome** refers to the creation of research abstracts and papers, as well as research grants generated and awarded. **Clinical outcome** is defined as the generation of patents and new clinical applications of research findings. Both dimensions are objective measures of collaboration outcomes.

**Satisfaction on process effectiveness (SPE):** Collaboration research typically uses three types of measures to define the performance: financial, objective and subjective measures (Cooke-Lauder, 2006). Grants awarded measure financial performance. Publications, patents and clinical applications of translational outcomes are objective measures of SPP effectiveness. We use perceived satisfaction on process effectiveness of SPP as subjective measures in this study. Partnership satisfaction on collaboration process is related to partnership performance and has been used as a measure of partnership success in many studies (Geringer & Hebert, 1989; Hausman, 2001; Sriram & Stump, 2004). We define **satisfaction on process effectiveness** as the performance of collaboration that partners perceived on whether the collaboration achieved desired objectives and whether they are satisfied with the collaboration process.

**Communication effectiveness (CE):** Communication plays a central role during collaboration. The effect of communication on collaboration and partnership has been
well documented. For example, communication strategy influences financial performance (Koza & Dant, 2007). Inter-organizational communication has been shown to impact the performance outcomes in collaborative buyer-supplier relationships (Paulrajia, Lado, & Chen, 2007; Hunter & Perreault, 2007). Clinician’s communication behavior has been shown to predict healthcare use and perceptions of quality of care (Clark et al., 2008). More frequent and higher caliber inter-professional communication and collaboration are also associated with positive experiences of all healthcare providers in a care unit (Conn et al., 2012). A study by Kraut and colleagues (1988) also demonstrates the importance of the frequency and quality of communications in scientific collaboration.

**Communication effectiveness** in this study is defined as effective and timely flow of information between partners to ensure the objectives of communication are achieved.

Our previous research (Wang et al., 2012) reveals many institutional factors that inhibit or facilitate SPP. These factors include academic promotion criteria, access opportunity to potential collaborators and existence of supportive organizational collaboration mechanism. We therefore use these factors as exogenous variables representing key dimensions of institutional forces in this study.

**Academic promotion criteria (APC) may serve as academic incentive (AI):**

The need for advocating and championing the value and merits of the clinical researchers at local and national levels by respective stakeholders has been often proposed (Murillo et al., 2006). However, engaging in clinical research imposes the risk of severe career damage to research scientists: “one of the most frequently mentioned institutional barriers for faculty conducting community based participatory research are the risks associated with trying to achieve tenure and promotion” (Israel et al., 2001: 191). Our
previous research (Wang et al., 2012) also supports that academic culture negatively influences scientists’ participation in SPP. For example, a MD-PhD commented that “the system doesn’t value collaborative productivity as much as they value first and last author productivity. And there are only two positions for first and last, even middle is almost discounted for not having had important role, which I think is unfair”. This is echoed by a research scientist: "within the department, you get … sort of unofficial feedback that too much collaboration is dangerous early on”. However, the potential rewards from collaboration include grants, papers, patents and clinical application of research into practice, which also serve as incentives to engage in SPP, because obtaining grants and publication are the key promotion criteria in universities. As a basic research scientist commented, forced collaboration is becoming more common in order to obtain funding. Accordingly, we define academic promotion criteria as the generation and award of grants and publishing papers.

**The Level of access difficulty to collaborators (LAD):** A rewarding and incentive system may motivate individuals to engage SPP. However, the opportunity to access to potential collaborators may influence the initiation of SPP. As found by Graham, scientists need help to communicate with non-research parties, and to engage them in knowledge transfer activities (2010). Some of scientists we interviewed stated that they have no or little access to clinical samples and clinical partners to conduct clinical related research. Some physicians also commented that they do not have time and/or funding to engage in research or networking events with scientists. The opportunity for access to potential collaborators especially for young scientists and physicians is very limited. Access difficulty to collaborators reflects a lack of supportive collaboration mechanism.
such as a collaboration office and networking opportunity as well as availability of funding and time for collaboration. Our qualitative inquiry indicated the level of access difficulty to partners is associated with their engagement in SPP. In this study, we therefore define the level of access difficulty as the level of participants’ opportunity to identify and access to potential partners.

Organizational collaboration mechanism (OCM): Management support can contribute to partnership effectiveness directly through resource commitments such as available financing and personnel (Brinkerhoff, 2002). Indeed, the importance of supportive leadership was one of the findings on the study of collaboration between acute care hospitals and community-based primary healthcare agencies (van Eyk & Baum, 2002). In addition to providing funding and personnel support, organizational support can include providing collaboration contexts such as supportive leadership, a collaboration office and organizing networking events. These contexts are critical in initiating and facilitating SPP. Lack of organizational collaboration mechanism to foster and support physician and scientist collaboration was identified in our earlier interview (Wang et al., 2012). While some collaboration practices such as seminars and supportive leaders exist to a certain degree in a few organizations, most of our interview participants mentioned the inadequacy or dearth of organizational collaboration mechanisms such as senior management support, a Technology Transfer Office-like Collaboration Office, and collaboration oriented meetings or networking events. As participants clearly confirmed, individuals are far more helpful than organizations in their collaborations. Based on our interview findings, we define the organizational collaboration mechanism as the
existence of supportive leadership, collaboration office, seminars and meetings, as well as social events for networking in organizations.

2.2. Hypothesis Development

2.2.1 The effect of Academic promotion criteria

Failure of the academic reward system to encourage dissemination of research finding is a major factor explaining the disconnection between researchers and practitioners (Manske & Leithwood, 2010). Our earlier qualitative study confirmed the negative role of academic culture in SPP. For example, a MD-PhD physician scientist interviewee told me that he “will be very focused on not extending myself collaboratively any longer (because) the system doesn’t value collaborative productivity”. A research PhD shared that the unofficial departmental feedback include “too much collaboration is dangerous early on. …. you’re not just good because you help out all your clinicians on their projects”.

Academic culture often inhibits scientists to engage in clinical research and practices, because the standards set by appointment and promotion committees discourage it (Pober et al., 2001). Due to the nature of clinical research, it is often hard for scientists to get pure clinical research published in top journals---the principal factor of funding and promotion for scientists (Butler, 2008). Having an incentive system that rewards collaborative behaviors has been identified as one of enablers for SPP in the past studies (Austin, 2000).

The academic rewards of grants, publications, and the clinical rewards of patents and application of research into practice also serve as incentives to engage in SPP. Both the literature and our previous inquiry (Wang et al., 2012) suggest that academic
culture/incentive influences communication, the level of partnership satisfaction on collaboration process and outcomes of partnership. For example, a PhD researcher pointed out that "the most persuasive reason for clinicians and basic scientists to talk to each other is getting the grant". A physician scientist noted “the publication is related to whether I will or not get future grant funding”. This indicates that academic reward of obtaining grants and getting papers published can promote academic incentive oriented SPP, but may not encourage clinical oriented SPP outcomes. As a scientist commented, “If all that matters are papers, you’re not going to make a company, because that takes money and time, or you’re not going to write patents, again money and time”. In addition, academic culture/incentive may also influence satisfaction on the collaboration process, since “there are only two positions for first and last (author)” in publication and grants are awarded to only one Principal Investigator in grant applications.

It is likely that individuals motivated by academic promotion will engage in SPP to obtain supportive grants through publication (academic outcome). They may be discouraged, however, from involving themselves in clinical research (clinical outcome) since clinical research takes long time and it is hard to get the results of pure clinical research published in top journals, which can affect their career advancement negatively (Butler 2008). We therefore propose:

**H1: Academic promotion criteria have a positive impact on academic outcome (H1a), but a negative impact on clinical outcome (H1b).**
2.2. 2 The role of access difficulty to collaborator

The access opportunity to potential collaborator is an important determinant in the initiation of SPP. It promotes communication, enhances satisfaction on collaboration process and outcomes of collaboration. A scientist or physician who is interested in SPP would not be able to engage in the potential collaboration if s/he does not know how to identify the right collaborators or has no or little access to potential collaborators. In other words, one would not engage in SPP and/or the outcomes and process satisfaction of SPP would be negatively affected due to the lack of access to collaborators regardless of interest. As many scientists mentioned, the challenge of working with physicians is the availability of the physicians. If an individual has abundant access to potential collaborators, the chance of the individual engaging in SPP would be higher than that of an individual with no or little access opportunity. It is reasonable to assume the level of access opportunity is associated with status, process and outcomes of collaboration. We hypothesize:

H2: The level of access difficulty has a negative effect on both academic (H2a) and clinical outcome (H2b).

2.2. 3 The influence of organizational collaboration mechanism through management support

Senior management support is one of five core successful factors of partnership (Brinkerhoff, 2002). A study of inter-professional healthcare teamwork showed that “members of collaborative teams do not always perceive themselves as having the support of the organization” (Kvarnström, 2008: 201). As noted by Pober et al. (2001: 2308), “clinical investigators, like other medical practitioners, are pressured to see more
patients and spend less time in the laboratory. At the same time, laboratory investigators who obtain salary support from NIH or other grants are pressed to pursue a more traditional, basic science career…. which minimizes their clinical time”. This coincides with a PhD’s comment: "this (organizational support) is more like a wish. As far as I can tell, most of my colleagues, except a few areas, they get into such collaboration by chance, by meeting somebody or hearing about something…which is not good”.

In addition to supportive leadership, having a collaborative infrastructure is helpful in cultivating physician and researcher collaboration. For example, a MD in our interview commented that “having us exposed to some of the problems in clinical medicine is very, very useful. And the primary clinicians getting exposed to some of the basic research that is going on can be very useful. But I don’t think there is anything established to set that up”. This thought was echoed by a PhD researcher as he noted that "they don’t have a department or an office that sort of tries to foster that. So as far as they’re concerned, if you’re doing research on a particular subject, and you wanna collaborate with a physician, and he’s willing, then you do it”. Organizational support in the form of providing collaborative infrastructure such as a collaboration office, providing networking opportunities and supportive leadership is important for SPP. Indeed, organizational characteristics such as service breadth have a positive effect on collaboration outcomes (Arya & Lin, 2007). We reasoned collaboration practices can help both scientists and physicians with needed funding, identifying potential collaborators, promoting communication and offering conflict resolving solutions for issues in collaboration. In other words, organizational collaboration mechanism and
practices through management support will impact the outcome and process of SPP.

Specifically, we posit:

**H3:** Organizational collaboration mechanism has a positive influence on both academic outcome (**H3a**) and clinical outcome (**H3b**) of partnership.

**H3c:** Organizational collaboration mechanism has a positive influence on communication effectiveness between partners.

2.2. 4 The mediating role of communication effectiveness

Literature on the importance of communication for partnership effectiveness is abundant. For example, communication is one of the critical determinants of collaborative success in academic-practitioner research collaboration (Amabile et al., 2001). Communication skills and effective behaviors have been related to partnership success (Mohr & Spekman, 1994). Internal communication has a positive effect on the proposal for innovation at middle but not lower echelons (Aiken et al., 1980). Communication, especially face-to-face dialogue and good faith negotiation, is a crucial collaborative process factor (Ansell & Gash, 2007). Communication frequency has a positive effect on relationship quality (Sriram & Stump, 2004).

We also identified communication as a key process factors in successful SPP (Wang et al 2012). The desire and determination of collaboration influences the levels of communication. The following quotes from physicians and scientists describe how communication kept the collaborative relationships alive and effective. "you don’t wanna lose that collaboration or friendship, and so we kept talking through things and working through things…. I just kept trying to say, I’m working on it. Here’s what I did. Here’s an e-mail, and to show them that I was making an effort to do things. I just kept trying to
reassure them. It did take a lot of effort on my part, and maybe some people wouldn’t be willing to put in that effort”; “We tried really hard to have open communication”.

Drawing from literature and our interviews, we hypothesized that:

**H4: Communication effectiveness has a positive effect on perceived satisfaction on process effectiveness of SPP.**

The academic promotion criteria will promote scientists to initiate communication with potential collaborators, and to communicate effectively in order to achieve the desired academic objectives. Given the links between communication quality with successful partnership as noted and with academic promotion incentive, we reasoned that academic promotion criteria will have a positive impact on communication effectiveness, which in turn will have a positive influence on academic outcome. Therefore we hypothesized:

**H5: Communication effectiveness mediates the effect of academic promotion criteria on academic outcome.**

Regardless the incentive of academic promotion, however, lack of access to potential collaborator would make the communication difficult and it would influence negatively the effectiveness of communication. Indeed, lack of access to clinical partners and to clinical tissue samples is one of the reasons disclosed as to why several research scientists has not engaged in clinical research and collaboration with physicians in our prior study. Physicians are pressured to conduct clinical related tasks, therefore they have little time or funding to participate in networking events that can help them with identifying and finding potential scientists to collaborate with.
Communication effectiveness has an effect on the outcome of collaboration as found by previous studies (Mohr & Spekman, 1994; Conn et al., 2012). It is reasonable to expect that a higher level of difficulty of access will lead to a lower level of communication opportunity and effectiveness, which in turn leads to a lower level of partnership satisfaction and success in achieving desired outcomes. We therefore reasoned:

**H6: Communication effectiveness mediates the effect of the level of access difficulty on both academic outcome (H6a) and clinical outcome (H6b).**

The access difficulty to the potential collaborators, to a large extent, is a reflection of lacking organizational support. The access opportunity could be improved by organizational collaboration mechanism such as supportive management, Collaboration Office, networking events and alliance oriented-meetings. The organizational collaboration mechanism would greatly enhance the communication opportunity and effectiveness. As a result, it may have a direct or indirect effect on the outcome of SPP effectiveness. In other words, communication effectiveness would be the underlying mechanisms linking organizational collaboration mechanism and SPP effectiveness. Consequently, we hypothesized:

**H7: Communication effectiveness mediates the effect of organizational collaboration mechanism on both academic outcome (H7a) and clinical outcome (H7b)**

### 2.2.5 The role of satisfaction on process effectiveness of collaboration

The study of Geringer and Hebert (1989) reveals a strong association between perceptual assessments of collaboration performance and satisfaction with objective
measures. Our interview findings also support a positive link between partnership satisfaction and performance outcomes (Wang et al., 2012). If collaborators feel that the collocation process is effective, and it has achieved the desired objectives, then most likely, the collaboration would generate favorable outcomes. Therefore it is reasonable to expect a relationship between satisfactions on the process effectiveness of collaboration with SPP effectiveness. We therefore propose:

**H8: Satisfaction on process effectiveness (SPE) of collaboration has a positive effect on both academic (H8a) and clinical outcome (H8b).**

The incentive for academic promotion would motivate collaborators to work together effectively in order to achieve the expected objectives of collaboration. Given the relationships between satisfaction on process effectiveness with academic incentive, and its association with collaboration performance, we reasoned that a higher level of academic incentive will lead to a higher level of collaboration effectiveness resulting in a higher level of satisfaction on collaboration process effectiveness, which in turn will lead to a higher level of SPP effectiveness. We hypothesize:

**H9: Satisfaction on process effectiveness mediates the effect of academic promotion criteria on academic outcome.**

*Communication and satisfaction:* A study among physicians, nurses and other health care providers indicates that “mutually advantageous communication can result in increased provider satisfaction, collaboration, and high quality patient care” (Conn et al., 2012: 14). Consistent with this finding, Vazirani and colleagues’ work (2005) shows that improved communication and collaboration among physicians and nurses improved the satisfaction of participants and the quality of patient care. Our earlier study supports the
importance of communication effectiveness in SPP. “Everybody met together in a weekly lab meeting and the people that came to the lab meeting were the physicians in the research project. We had a couple of PhD’s that were in it and we all just sort of met regularly. That was a good way of keeping it going”, as reveled by a physician scientists. Drawing on the literature and our own study, we infer that communication effectiveness influences partnership satisfaction on perceived effectiveness of collaboration process, which has a positive impact on SPP effectiveness as reasoned previously. Therefore, we hypothesize:

**H10: Satisfaction on process effectiveness mediates the effect of communication on academic outcome (H10a) and clinical outcome (H10b).**

**RESEARCH DESIGN AND METHOD**

**3. 1. Methodology and Study Context**

We carried out a quantitative psychometric study to test our hypotheses and validate the proposed research model. A structured survey was designed to measure the factors influencing scientist-physician partnership effectiveness by collecting response data from physicians and scientists who have collaborated with one another. SPSS and AMOS (version 20.0) were utilized to conduct statistical analysis. SPSS was used to conduct basic statistical analysis (data screening), computing Cronbach’s alphas and exploratory factor analysis (EFA). We used AMOS to conduct covariance based structural equation model analysis (CBSEM). Structural equation model (SEM) was chosen, because it offers many advantages over linear regression analysis including integration of the measurements and the hypothesized causal paths into a simultaneous assessment (Bollen, 1989). In addition, “SEM allows the creation and estimation of
models with multiple dependent variables and their interconnections at the same time” (Gefen, Rigdon, & Straub, 2011: 4). AMOS software (CBSEM) was chosen because it brings the error terms into one unified model, therefore providing better protection from measurement errors (Gefen et al., 2011).

The following sections detail the methods used including the development of survey instruments, sampling, data collection and statistical analysis.

### 3.2. Construct Operationalization

Measurement items of constructs were either adapted from existing measures when available and appropriate, or developed for the study based on the literature and the qualitative phase study (study 1). Table C9 (in appendix) lists the multi-item scales for each construct that were used to collect the data.

#### 3.2.1. Adapted Scales

**Communication effectiveness**: Measures for communication effectiveness were adopted from Judge and Douglas (2009). There are 4 items to measure communication effectiveness in a 5-point Likert scale (1=strongly disagree and 5= strongly agree). A 5-point Likert-type scale is believed easy for respondents to master (Arya & Lin, 2007). This construct operationalized as a reflective construct, because the items reflect the construct they measured, and the causal directions are from construct to items and the items of each individual construct are interchangeable since they measure similar things that correlate with each other, and the items manifest instead of defining the construct they measure (Bollen, 1989; Jarvis et al., 2003). The Cronbach’s alpha for this construct is 0.920.
**Satisfaction on process effectiveness**: Items for satisfaction on process effectiveness (SPE) of calibration were adapted from Cooke-Lauder (2006) who adapted from literature (Lui & Ngo, 2004; Saxton, 1997). Three are 3 items measuring satisfaction on process effectiveness in a 5-point Likert scale. This construct operationalized as a reflective construct. The Cronbach’s alpha for this construct is 0.932.

### 3.2.2 Scale Development

The measurements for academic promotion criteria, level of access difficulty, organizational collaboration mechanism, and outcomes of SPP were developed specifically for this study.

**Academic promotion criteria (APC) as an incentive**: Academic culture, which counts for tenure and promotion process, has been claimed as one of the inhibitory factors in clinical research and SPP (Israel et al., 2001; Pober et al., 2001; Jacobson, 2004). To capture what’s in the literature and what researchers have said about academic promotion and academic incentives we developed 3 items to tap into academic incentives of promotion: “I received promotions because of the grants I obtained as the Principal Investigator”; ‘I was promoted because of the papers I published as primary (first or last) author”; “I restrain from collaboration because I need independent work to get promoted”. The construct was measured in a 5-point Likert scale (1=strongly disagree and 5= strongly agree). The last item was dropped out from analysis because it did not load well with the first two items. This construct was operationalized as a reflective construct. The Cronbach’s alpha for this construct is 0.785.

**Level of access difficulty to collaborators (LAD)**: Our prior qualitative inquiry indicates that access difficulty to potential collaborators and clinical tissues is a barrier
for research scientists’ involvement in clinical research, and time and funding are issues for physicians in their engagement in research. We therefore developed the following three items to measure the level of access difficulty: “I do not know how to identify the potential collaborator(s)”; “I do not have access to potential collaborator(s)”; and “My organization does not encourage collaborative work”. The construct was measured in a 5-point Likert scale (1=strongly disagree and 5= strongly agree). This construct was operationalized as a reflective construct. The third item was dropped because it did not load together with the first two items. The Cronbach’s alpha for this construct is 0.822.

**Organizational collaboration mechanism (OCM):** Consistent with the role of organizational support, my prior qualitative study reveals the importance of many supportive collaboration infrastructures. They revealed “people are more helpful than organization—a MD”; “they don’t have a department or an office that sort of tries to foster that (SPP) --a PhD”; “As far as I can tell, most of my colleagues, except a few areas, they get into such collaboration by chance, by meeting somebody or hearing about something--a PhD)”. The following 6 items were developed to measure OCM: “Supportive leader(s) in a department and /or institute /school /hospital”; “Collaboration office”; “Regular meetings with potential collaborators”; “Seminars”; “Organizing social events such as happy hours” and “other collaborative context”. The respondents were asked to choose “yes”, “no” or “not sure” to above questions. “No” and “not sure” answers were coded as 0, and “yes” as 1. This construct was operationalized as a formative construct, because the casual directions are from items to constructs since the items “cause” the construct (Jarvis et al., 2003). These items define the characteristics of the construct they measure, and each item reflects an unique aspect of the construct,
therefore the items within the construct are not interchangeable (Jarvis et al., 2003). The index of total collaboration practices was obtained by adding the numerical answers together. This is appropriate because these items are not mutually exclusive, and a higher number conveys a higher level of collaboration practices in a given organizational unit.

**Dependent variables (outcomes of partnership):** In addition to measuring the perceptual understanding of partnership quality including satisfaction on process effectiveness of collaboration, we also measured the factual outcomes of collaboration. To this end we developed several items that reflect the results of SPP including generation of research abstracts, papers, research grants, patents and clinical applications. The questions we asked were: (1) were paper(s)/meeting abstract(s) generated? (2) were grants generated? (3) were grants awarded? (4) did the collaboration lead to clinical application(s)? (4) did the collaboration generate patents (in preparation, pending or awarded)? (5) did you establish a sustainable collaborative relationship? The respondents were asked to choose between “Yes” or “No” to the above questions. A “no” answer was assigned as “0”, and a “yes” answer was assigned a numerical number based on the importance of the item in the outcome as explained below. This construct was operationalized as a formative construct.

**Academic outcome (AO):** the academic paradigm of “publish or perish” dictates the academic incentive and collaboration outcomes especially for research scientists. A “yes” answer to first (paper/meeting abstract), second (grant generated) or third (grant awarded) question was assigned as “2”, “2” or “3” respectively. The numerical numbers for all three items were added together to obtain the index of academic reward. Although items 2 (grant generated) and 3(grant awarded) loaded very well together as a factor in
both EFA and CFA with high loadings, we did not use them as a separate construct in our analysis, because they are part of index of academic outcome.

**Clinical outcome (CO):** Most of research findings are supposed to contribute to general knowledge without clinical or practical applications. Although some patents filed and awarded are for research purposes only, a patent generated from research indicates the potential application of knowledge in practice. Clinical applications of research are the ultimate goal of a vast majority of biomedical research. Therefore, a “yes” answer to item 4 regarding patent was assigned as “5”, and to item 5 regarding clinical application as “10”. The index of academic reward was obtained by adding the numbers for these two items together.

### 3.2.3. Controls

We included controls to account for other factors that are known to impact the collaboration and its outcomes. **Income:** Pober et al. notes that “the need to cover one’s salary promotes polarizing career choices that limit efforts in ‘bridge’ research” (2001: 2308). Wage dispersion is associated with satisfaction, productivity and working collaboratively (Pfeffer & Langton, 1993). Our prior study also reveals the role of income plays in physicians’ decision on research activities and in scientists’ engagement of physicians in their research, as a scientist pointed out that it is expensive to collaborate with physicians. **Gender:** Although our qualitative data does not suggest a link between gender and collaboration, traditionally and socially, men are more firm, aggressive, controlling and dominant than women, and they are more goal- and results- oriented than women. Women are generally more sensitive and more focused on relationships than men do. The requirement and tolerance levels for the ability to communicate and to
control between males and females might be different, and their perceptions for satisfaction can be different as well. **Academic title:** Our prior qualitative data does not reveal any relationship between academic title and SPP. However, an early study on 50 R&D project groups suggests a link between tenure and performance (Katz & Allen, 1982). We therefore controlled for income, sex and academic title to account for the potential influence of these factors. In addition, we also controlled for **age**, because age is associated with income and academic title to a large extent.

These variables were operationalized as categorical variables as follows: sex (male=0, female=1); age (<31=1, 31-40=2, 41-50=3, 51-60=4, >60=5); academic title (postdoc=1; instructor=2; assistant professor=3, associate professor=4, full professor=5, physician without academic degree=6, other=7); income (less than 50K=1, 50K-100K=2, 100K-150K=3, 150K-200K=4, great than 200K=5). These categorical variables reflect the demographic data of our respondents.

**Pretesting of scales:** After interviewing and discussing with several scientists and physicians, the initial survey was tested with two physicians and two research scientists for content, face validity and comprehensibility (Bolton, 1993). The pretest did not reveal any conceptual issues. We changed a few questions clearer by adding “in above collaboration” to several questions. The refined survey was then distributed to the unit of our analysis—physicians, scientists and physician scientists with a MD, PhD or MD-PhD degree.

### 3.3 Data Collection

Data was collected using the above survey instrument we developed with the assistance of online survey software Qualtrics (www.qualtrics.com/). Because scientist
and physician collaboration is the focus of this study, we excluded MD and MD or PhD and PhD collaborations, and only sampled the collaborative relationships based on respondent’s professional degrees: PhD and MD collaboration, PhD and MD-PhD collaboration, and MD and MD-PhD collaboration. Due to the small (13.9%) population of MD-PhDs in our respondents, the majority of the collaboration occurred between professionals who have a MD and a PhD.

**Sample population:** Informed by the findings of our previous qualitative study, the study population was practicing physicians, research scientists, and physician scientists in the United States of America. The data was collected by invitation primarily through two methods: (1) email listings including both physicians and research scientists were compiled based on the contact information of potential respondents whose information are available on the websites of the research departments and research centers of top US hospitals and medical schools. Invitation e-mails containing brief description of research purpose and content, IRB information and the survey link were emailed to the individuals on the e-mail listings. (2) The survey link was distributed to the members of several Clinical Translational Science Award (CTSA) centers through their local offices. In addition, 3 qualified (with MD-PhD collaboration) responses were received from people through personal connections whose names were not among the email listings mentioned above. The response rate is 8.2%, probably due to the highly time sensitive nature of our unique survey population (physicians and scientists).

**Non-response bias:** Although a 8.2% of response rate is not desirable, it is similar or higher than similar studies among physicians (Scott et al., 2008; Clark et al., 2008; Brewster, 2010). We noticed that there were respondents who opened the survey,
but did not answer any question. The analysis of demographics and main constructs showed no significant difference (Armstrong & Overton, 1977; Pavlou & Sawy, 2006) between early and late responders or between completed or partial responders, suggesting non-response bias is not likely threat in our study.

**Demographics of respondents:** A total of 440 responses that satisfy the analysis conditions (i.e. collaborated with physicians or scientists, and the collaboration partners are physicians and scientists with a MD or PhD) were obtained for further data analysis. Table C1 summarizes the demographics of respondents.

<table>
<thead>
<tr>
<th>Gender</th>
<th>Percentage</th>
<th>Age</th>
<th>Percentage</th>
<th>Income</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>63.2</td>
<td>&lt;=30</td>
<td>.5</td>
<td>&lt;50K</td>
<td>3.0</td>
</tr>
<tr>
<td>Female</td>
<td>36.8</td>
<td>31-40</td>
<td>20.7</td>
<td>50K-100K</td>
<td>14.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>41-50</td>
<td>29.5</td>
<td>100K-150K</td>
<td>16.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>51-60</td>
<td>30.5</td>
<td>150K-200K</td>
<td>24.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;60</td>
<td>18.9</td>
<td>&gt;200k</td>
<td>42.0</td>
</tr>
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</table>

Professional Degree | Percentage | Professional Degree of collaborators | Percentage |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>PhD</td>
<td>30.9</td>
<td>PhD</td>
<td>38.0</td>
</tr>
<tr>
<td>MD</td>
<td>55.2</td>
<td>MD</td>
<td>39.5</td>
</tr>
<tr>
<td>MD-PhD</td>
<td>13.9</td>
<td>MD-PhD</td>
<td>20.9</td>
</tr>
</tbody>
</table>

Job category | Affiliation | Percentage |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientist</td>
<td>University alone</td>
<td>24.5</td>
</tr>
<tr>
<td>Physician</td>
<td>Hospital alone</td>
<td>6.1</td>
</tr>
<tr>
<td>Physician</td>
<td>Dual affiliation with both university and hospital</td>
<td>68.9</td>
</tr>
<tr>
<td>Scientist</td>
<td>Industry</td>
<td>0.5</td>
</tr>
<tr>
<td>Other</td>
<td>Other</td>
<td>2.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Professional title</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postdoc</td>
<td>2.0</td>
</tr>
<tr>
<td>Instructor</td>
<td>4.3</td>
</tr>
<tr>
<td>Assistant Professor</td>
<td>30.0</td>
</tr>
<tr>
<td>Associate Professor</td>
<td>22.3</td>
</tr>
<tr>
<td>Full Professor</td>
<td>37.0</td>
</tr>
<tr>
<td>Physician</td>
<td>1.8</td>
</tr>
<tr>
<td>without Academic Title</td>
<td>2.5</td>
</tr>
</tbody>
</table>

3.4. Data Screening

**Missing values:** Among the 440 responses we analyzed, there were 4 values of income were missing in the data set, which accounted for less than 0.025% of the total
values of data (n=440*36=15840 values). We replaced these 4 missing values with median, which is acceptable given the missing value is way below 5% as suggested by Tabachnick et al. (2001). There are not any other missing values for any of other items measured.

**Outliers:** Extreme outliers did not exist, because values for all reflective variables were based on Likert-like scales with five intervals or categorical values for categorical variables.

**Normality:** Only 4 items showed slight non-normal distribution with negative skewness values being -1.089, -1.191, -1.075, and -1.470, respectively. Visual inspection of the normality plots showed that the distributions are roughly normal. At variable levels, all the values for skewness (-1.470 to + 0.085) and kurtosis (-1.546 to + 1.754) are within acceptable range with good variance (Hair et al. 2010). The slightly negative skewness is not surprising considering that it is likely that more successful collaborators participated and finished our survey, which may account for the observed non-normal distribution. Because our variables are based on Likert-type scales, we did not exclude any variables with minor distribution issues.

**Linearity:** Deviation from Linearity Test was conducted to check linearity for all direct effects in the model. We found that all relationships between IVs and DVs are linear with significance values all above 0.05, except for the relationship between organizational collaboration mechanism and academic outcome, which has a p-value of 0.02. Further analysis using simple OLS regression test on this relationship indicates that this relationship is sufficiently linear as well (p<0.05).
**Homoscedasticity:** We tested homoscedasticity by creating a simple scatter plot with the variables on X-axis and the variable’s residual on Y-axis. The scatter plots showed consistent patterns indicating that the relationships between IVs and DVs are homoscedastic (Hair et al./ 2010).

**Multicollinearity:** To check for multicollinearity, the Variable Inflation Factor (VIF) and tolerance tests were conducted for all exogenous variables simultaneously. Both VIF (maximum: 1.3) and tolerance values indicated no multicollinearity (Stine. 1995).

3.5. Statistical Analysis

3.5.1 Measurement model

*Exploratory factor analysis (EFA):* EFA was carried out by fixing the number of extracted factors to 5 and using Principle Axing Factoring (PFA) and Promax rotation in SPSS (20). PAF was chosen to determine unique variance among items and the correlation between factors. Promax was chosen, because it can account for the correlated factors in a large data set (n=440).

Pattern matrix (Table C2) shows that all the items loaded as excepted after the deletion of three items with unacceptable cross loadings (difference of loadings <0.2) or no loading. Eigen values for all five factors extracted were above 1.0. The analyses for reliability, validity and data adequacy of EFA indicate a great factor solution (Hair et al., 2010): KMO=0.849, Chi-square =4116, df=91, p=0.000). All communalities were above 0.6. Five factors explained 73% of variance, there were 1% non-redundant residuals with absolute values >0.05; no cross loadings; correlations among extracted factors were <0.7; and all loadings >0.7. Cronbach's Alphas for all factors were above 0.7 (Nunnally, 1978).
Because the factors represent all reflective scales, the indicators under each factor are as expected highly correlated and thus interchangeable (Jarvis et al., 2003).

**TABLE C2**
Pattern Matrix

<table>
<thead>
<tr>
<th>Items</th>
<th>Satisfaction on Process Effectiveness (SPE)</th>
<th>Communication Effectiveness (CE)</th>
<th>Level of Access Difficulty (LAD)</th>
<th>Academic Promotion criteria (APC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAD1</td>
<td></td>
<td></td>
<td>.811</td>
<td>.865</td>
</tr>
<tr>
<td>LAD2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>APC1</td>
<td></td>
<td></td>
<td></td>
<td>.834</td>
</tr>
<tr>
<td>APC2</td>
<td></td>
<td></td>
<td></td>
<td>.781</td>
</tr>
<tr>
<td>SPE1</td>
<td>.915</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPE2</td>
<td>.944</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>SPE3</td>
<td>.879</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPE4</td>
<td>.682</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CE1</td>
<td></td>
<td>.730</td>
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<tr>
<td>CE2</td>
<td></td>
<td>.783</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CE3</td>
<td></td>
<td>.953</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CE4</td>
<td></td>
<td>.875</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Confirmatory factor analysis (CFA)**

**Model fit:** The obtained EFA solution was defined as a CFA model. The final measurement model has a great fit as indicated by the following fit parameters: Chi-square=56, degrees of freedom=46, CMIN/DF=1.219, P value=0.147, PCLOSE=0.996; GFI=0.980, AGFI=0.965, NFI=0.990, TLI=0.996; CFI=0.997, RMSEA=0.022, SRMR=0.021. In order to achieve a good model fit, the following error terms were covaried within constructs: between CE3 and CE4 within communication, and between SPE1 and SPE2 within satisfaction on process effectiveness.

**Reliability and validity:** All loadings in the final CFA model are greater than 0.7 (see Table C9 in appendix). As Table C3 shows, there are no any convergent,
discriminant or reliability concerns for communication effectiveness, academic incentive, level of access difficulty and satisfaction on process effectiveness.

### TABLE C3
Convergent and Discriminant Validity of the Construct

<table>
<thead>
<tr>
<th>Construct</th>
<th>CR</th>
<th>AVE</th>
<th>MSV</th>
<th>ASV</th>
<th>LAD</th>
<th>CE</th>
<th>APC</th>
<th>SPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of Access Difficulty (LAD)</td>
<td>0.830</td>
<td>0.711</td>
<td>0.095</td>
<td>0.072</td>
<td>0.843</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communication Effectiveness (CE)</td>
<td>0.909</td>
<td>0.716</td>
<td>0.501</td>
<td>0.193</td>
<td>-0.225</td>
<td>0.846</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Academic Promotion criteria (APC)</td>
<td>0.793</td>
<td>0.657</td>
<td>0.095</td>
<td>0.064</td>
<td>-0.309</td>
<td>0.163</td>
<td>0.811</td>
<td></td>
</tr>
<tr>
<td>Satisfaction on Process Effectiveness (SPE)</td>
<td>0.930</td>
<td>0.770</td>
<td>0.501</td>
<td>0.214</td>
<td>-0.267</td>
<td>0.708</td>
<td>0.266</td>
<td>0.877</td>
</tr>
</tbody>
</table>

**Common Method Bias (CMB):** We conducted a CMB test using the unmeasured latent factor method as recommended by Podsakoff et al. (2003). We compared the item loadings of CFA without and with a common latent factor. None of the differences of loadings on same item is above 0.2 indicating that CMB is not a significant threat (Podsakoff et al., 2003).

#### 3.5.2 Structural model

Due to the inclusion of variables represented by indices not amenable for CBSEM, we transformed all item level reflective variables into composites. These composite variables were created based on the CFA model in AMOS.

The controls were tested only for their effect on dependent variables and communication effectiveness. The mediation analysis for the significance of indirect effects was carried out using bootstrapping with 2000 samples and setting “bias-corrected confidence intervals” to 95%. The presence of mediation effects was evaluated using Baron and Kenny method (1986).
The final structural SEM was created by trimming all non-significant paths off except for the ones from organizational collaboration mechanism to academic outcome, and from communication effectiveness to academic outcome and clinical outcome. These three insignificant paths were kept in the model for mediation test purposes. In addition, after consulting modification indices, a regression line from academic promotion criteria to satisfaction on process effectiveness of collaboration was added, because it made both statistical and theoretical sense and improved the model fit. This final model yielded an excellent model fit as indicated by the following parameters: Chi-square=14.07, degrees of freedom=13, CMIN/DF=1.082, P value=0.369, PCLOSE=0.948; GFI=0.993, AGFI=0.976, NFI=0.983, TLI=0.996; CFI=0.999, RMSEA=0.014, SRMR= 0.0265. Table C4 shows correlations of the constructs in the final SEM model.

### TABLE C4
Descriptive Statistics and Construct Correlation Matrix

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>CE</th>
<th>APC</th>
<th>LAD</th>
<th>SPE</th>
<th>OCM</th>
<th>CO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication Effectiveness (CE)</td>
<td>3.9713</td>
<td>.70835</td>
<td>0.920*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Academic Promotion criteria (APC)</td>
<td>3.0722</td>
<td>.83167</td>
<td>.189</td>
<td>0.785</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level of Access Difficulty (LAD)</td>
<td>1.2435</td>
<td>.77164</td>
<td>-.261</td>
<td>-.362</td>
<td>0.822</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Satisfaction on Process Effectiveness (SPE)</td>
<td>3.2708</td>
<td>.54966</td>
<td>.762</td>
<td>.300</td>
<td>-.306</td>
<td>0.932</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organizational Collaboration Mechanism (OCM)</td>
<td>2.41</td>
<td>1.230</td>
<td>.171</td>
<td>.119</td>
<td>-.338</td>
<td>.177</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Clinical Outcome (CO)</td>
<td>5.78</td>
<td>5.914</td>
<td>.281</td>
<td>.149</td>
<td>-.169</td>
<td>.315</td>
<td>.070</td>
<td>NA</td>
</tr>
<tr>
<td>Academic Outcome (AO)</td>
<td>4.90</td>
<td>2.392</td>
<td>.264</td>
<td>.306</td>
<td>-.264</td>
<td>.351</td>
<td>.163</td>
<td>.242</td>
</tr>
</tbody>
</table>

*: Values on diagonal are Cronbach’s alpha; NA: not applicable
RESULTS AND FINDINGS

The path standardized coefficients and their p values within the final model are presented in Figure C2. The R-squares of endogenous variables are included in Figure C2 as well. The results for all hypothesis tests are summarized in Table C5 (H1, H2, H3, H4), Table C6 (H5, H6, H7), Table C7 (H8) and Table C8 (H9 and H10). All regression weights reported are standardized.

1. The Effects of Institutional Factors (hypotheses H1, H2, H3, H4)

Table C5 shows the results of hypotheses (H1, H2 and H3, H4) tested on the direct effects of independent variables on endogenous variables. Academic promotion criteria (APC) has a positive relationship with academic outcome ($\beta=0.185$, $p<0.001$), which supports hypothesis H1a. In addition, APC has a positive significant direct effect...
on communication ($\beta=0.101, p<0.001$) and perceived satisfaction on process effectiveness (SPE) of SPP ($\beta=0.163, p<0.001$). To our surprise, academic culture does not have a negative effect on clinical outcome ($\beta=0.016, p=0.741$), which does not support H1b. As a matter of fact, academic culture has a positive indirect effect on clinical outcome through its positive influence on academic outcome, because academic outcome has a positive effect on clinical outcome ($\beta=0.115, p=0.017$).

As expected, the level of access difficulty (LAD) has a direct negative relationship with academic outcome (AO) ($\beta=-0.084/p=0.092$) supporting H2a. LAD also has a negative influence on communication effectiveness ($\beta=-0.183/p<0.001$). However, LAD does not have a direct influence on clinical outcome as we hypothesized (H2b).

Organizational collaboration mechanism (OCM) has a modest direct impact on communication effectiveness at 90% confidence interval levels ($\beta=0.097, p=0.041$) supporting H3a. Surprisingly, organizational collaboration mechanism does not have any direct relationship with either academic outcome or clinical outcome as we expected in H3a and H3b when both mediators (communication effectiveness and satisfaction on process effectiveness) are present. The relationship between OCM and AO is significantly positive ($\beta=0.092, p=0.049$) when both mediators were removed from the model. The combination of academic promotion criteria, level of access difficulty and organizational collaboration mechanism only explains 13% of variance in communication effectiveness suggesting other factors influence communication effectiveness as well.

Communication effectiveness has a strong positive impact on both satisfaction on process effectiveness ($\beta=0.731, p<0.001$) supporting H4. In addition, academic
promotion criteria also have a positive influence on satisfaction on process effectiveness as stated above. The combination of academic incentive and communication effectiveness explains 60.4% of variance in satisfaction on process effectiveness.

**TABLE C5**

**Summary of Hypothesis Test on Direct Relationships**

<table>
<thead>
<tr>
<th>ID</th>
<th>Hypothesis</th>
<th>Evidence</th>
<th>Supported?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Academic promotion criteria has a positive effect on academic outcome</td>
<td>0.185***</td>
<td>Yes</td>
</tr>
<tr>
<td>1b</td>
<td>Academic promotion criteria has a negative effect on clinical outcome</td>
<td>0.016</td>
<td>No</td>
</tr>
<tr>
<td>2a</td>
<td>The level of access difficulty to partners has a negative impact on academic outcome</td>
<td>-0.084+</td>
<td>Yes 90% CI</td>
</tr>
<tr>
<td>2b</td>
<td>The level of access difficulty to partner has a negative impact on clinical outcome</td>
<td>-0.026 ns</td>
<td>Not directly</td>
</tr>
<tr>
<td>3a</td>
<td>Organizational collaboration mechanism has a positive influence on academic outcome</td>
<td>0.072 ns</td>
<td>Not directly</td>
</tr>
<tr>
<td>3b</td>
<td>Organizational collaboration mechanism has a positive influence on clinical outcome</td>
<td>ns</td>
<td>No</td>
</tr>
<tr>
<td>3c</td>
<td>Organizational collaboration mechanism has a positive influence on communication</td>
<td>0.097+</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>Communication effectiveness has a positive effect on perceived satisfaction on process effectiveness of SPP</td>
<td>0.731***</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Note: the values are from the final model; ns: not significant. +: p<0.1; ***: p<0.001

2. The Mediating Effect of Communication Effectiveness (CE) (H5, H6 and H7)

Table C6 summarizes the results of mediating effects of communication effectiveness (CE). CE partially mediates the positive effect of academic incentive on academic outcome as hypothesized (H5). It also partially mediates the negative effect of level of access difficulty on academic outcome supporting H6a. In addition, CE partially mediates the positive effect of organizational collaboration mechanism on academic outcome supporting H7a. However, because neither organizational collaboration mechanism nor level of access difficulty has a relationship with clinical outcome, our
hypotheses of CE mediating the effect of organizational collaboration mechanism or level of access difficulty on clinical outcome are not supported.

**TABLE C6**

**Summary of the Mediating Role of Communication Effectiveness**

<table>
<thead>
<tr>
<th>Hypothesis: Communication effectiveness (CE) mediates the effect of</th>
<th>Direct without CE but with SPE</th>
<th>Direct with EC and SPE</th>
<th>Indirect with CE and SPE</th>
<th>Mediation Effect Supported or not</th>
</tr>
</thead>
<tbody>
<tr>
<td>H5 Academic promotion criteria on academic outcome</td>
<td>0.188***</td>
<td>0.185***</td>
<td>0.06***</td>
<td>Yes, Partial</td>
</tr>
<tr>
<td>H6a The level of access difficulty on academic outcome</td>
<td>-0.084+</td>
<td>-0.084+</td>
<td>-0.032**</td>
<td>Yes, Partial</td>
</tr>
<tr>
<td>H6b The level of access difficulty on clinical outcome</td>
<td>-0.029/0.545</td>
<td>-0.026/ns</td>
<td>-0.05***</td>
<td>No</td>
</tr>
<tr>
<td>H7a Organizational collaboration mechanism on academic outcome</td>
<td>0.071*</td>
<td>0.072/ns</td>
<td>0.017*</td>
<td>Yes, Full</td>
</tr>
<tr>
<td>H7b Organizational collaboration mechanism on clinical outcome</td>
<td>Not significant</td>
<td>Not significant</td>
<td>0.03*</td>
<td>No</td>
</tr>
</tbody>
</table>

3 **The Effect of Perceived Satisfaction on Process Effectiveness (SPE) (H8, H9 and H10)**

Satisfaction on process effectiveness of collaboration has a positive effect on both academic outcome (β=0.262, p<0.001) and clinical outcome (β=0.192, p=0.007), which support hypotheses H8a and H8b (Table C7). As noted, academic incentive and level of access difficulty also influence academic outcome, however, the combination of academic incentive, satisfaction on process effectiveness and level of access difficulty only explains 18.2% of variance in academic outcome. The combination of satisfaction on process effectiveness and academic outcome on clinical outcome accounts for 15.9%
of variance in clinical outcome. This suggests that additional factors contribute to the academic outcome and clinical outcome.

Satisfaction on process effectiveness partially mediates the positive effect of academic incentive on academic outcome. In addition, it fully mediates the positive impact of communication effectiveness on both academic outcome and clinical outcome (Table C8). These findings support our hypotheses on the mediating role of satisfaction on process effectiveness (SPE). Because SPE mediates the effect of communication effectiveness on academic outcome and clinical outcome, it potentially could mediate the relationships that communication effectiveness mediated such as level of access difficulty and organizational collaboration mechanism on academic outcomes which we did not test.

**TABLE C7**
The Direct Effect of Satisfaction on Process Effectiveness

<table>
<thead>
<tr>
<th>ID</th>
<th>Hypothesis</th>
<th>Evidence (beta/p value)</th>
<th>Hypothesis Supported?</th>
</tr>
</thead>
<tbody>
<tr>
<td>H8a</td>
<td>Satisfaction on process effectiveness has a direct positive effect on academic outcome</td>
<td>0.262/***</td>
<td>Yes</td>
</tr>
<tr>
<td>H8b</td>
<td>Satisfaction on process effectiveness has a direct positive effect on clinical outcome</td>
<td>0.192/**</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**TABLE C8**
The Mediating Effect of Satisfaction on Process Effectiveness

<table>
<thead>
<tr>
<th>ID</th>
<th>Hypothesis: Satisfaction on process effectiveness (SPE) mediates the effect of</th>
<th>Direct without SPE but with CE</th>
<th>Direct with SPE and CE</th>
<th>Indirect with SPE and CE</th>
<th>Mediation Effect, Supported?</th>
</tr>
</thead>
<tbody>
<tr>
<td>H9</td>
<td>Academic promotion criteria on academic outcome</td>
<td>0.222***</td>
<td>0.185***</td>
<td>0.06/***</td>
<td>Partial, Yes</td>
</tr>
<tr>
<td>H10a</td>
<td>Communication effectiveness on academic outcome</td>
<td>0.169/***</td>
<td>-0.019 ns</td>
<td>0.191/***</td>
<td>Full, Yes</td>
</tr>
<tr>
<td>H10b</td>
<td>Communication effectiveness on clinical outcome</td>
<td>0.197/***</td>
<td>0.063 ns</td>
<td>0.160/***</td>
<td>Full, Yes</td>
</tr>
</tbody>
</table>
Among the controls tested including sex, age, income and academic title, income has a positive relationship with communication ($\beta=0.221$, $p<0.001$), and age positively influences both academic outcome ($\beta=0.095$, $p=0.03$) and clinical outcome ($\beta=0.208$, $p<0.001$). Not surprisingly, age and income is significantly correlated ($\beta=0.356$, $p<0.001$). There is no other relationship between controls tested with academic outcome, clinical outcome or communication effectiveness.

**DISCUSSION**

I. **On Findings:**

*The outcomes of scientist-physician partnership:*

Academic incentive and satisfaction on process effectiveness are positively, and access difficulty is negatively related to academic outcome. The combination of these three factors only explains 18.2% of variance in academic outcome, suggesting that additional factors contribute to academic outcome. Academic outcome is a positive predictor of clinical outcome, and satisfaction on process effectiveness of partnership also positively predicts clinical outcome. However, the combination of satisfaction on process effectiveness and academic outcome explains only 15.9% of clinical outcome. This study focused only on the role of organization in SPP and clinical outcome. Other factors such as social and cultural forces, randomness of discovery, personal attributes including motivation and personality may play important roles in SPP as well. In addition, the clinical application of research is a very complicated process involving many additional factors and institutions. The role of other institutional factors (funding, regulatory factors, insurance etc.) as well as social and personal forces is not accounted in our model. Some of them are the focus of other on-going studies.
**The importance of communication:**

Our findings on communication agree with the literature on the role of communication in collaboration. Communication effectiveness plays a central role in our model. It fully or partially mediates many relationships in our model. For example, communication effectiveness fully mediates the effect of organizational collaboration mechanism on academic outcome, and partially mediates the effects of academic promotion criteria and level of access difficulty to collaborators on academic outcome. The combination of collaboration mechanism, access difficulty and academic incentive explains 13. % of variance in communication suggesting other factors such as professional language difference influence communication as well. Given the central and crucial role communication plays, establishing regular communication through organizational collaboration practices such as supportive leaders, regular meetings and seminars and collaboration office is highly recommended. A structured organization can facilitate design communication and collaboration, and that contributes to the success of collaborative project (Chiu, 2002).

**The effect of satisfaction on process effectiveness of collaboration:**

Our model adequately measures the satisfaction on process effectiveness (SPE) of physician and scientist collaboration ($R^2=0.609$). Our data revealed a strong predicting role of communication effectiveness on SPE ($\beta=0.731, p<0.001$). In addition, our data also reveals a predicting role of SPE on physician and scientist collaboration effectiveness including both clinical and academic outcomes. These findings agree with the literature on the correlation between satisfaction and successful partnership (Geringer & Hebert, 1989).
The role of organization:

Our findings indicate that organizations providing broad collaborative support such as a collaboration office, organizing seminars and social events facilitate communication between scientists and physicians. Our data on the positive effect of organizational support in the form of providing organizational collaboration mechanism including supportive leadership and providing collaboration contexts agrees with prior literature (Arya & Lin, 2007). The negative impact of lack of organizational support as reflected by access difficulty to collaborators on communication effectiveness and academic outcome is consistent with the literature and our previous findings (Wang et al., 2012). For instance, some scientists we interviewed stated that they have no access to clinical samples or clinical partners. We acknowledge we only measured organizational support in the forms of providing organizational collaboration mechanism, and the level of respondents’ access to potential partners and clinical samples. Other forms of organizational support including time and funding were not included in this study.

II. The Relationship between Structure and Behavior

Literature suggests that academic culture such as appointment and promotion discourages the collaborative effort (Israel et al., 2001; Pober et al., 2001; Jacobson et al., 2004). However, obtaining funding as a Principal Investigator and publishing as a primary (first or last author) author have a positive, not a negative effect on communication effectiveness, partnership satisfaction on collaboration process effectiveness and academic reward directly, and on clinical outcome indirectly. This is in line with Giddens’s Structuration Theory where he (1984: 25) points out “structure is not to be equated with constraint but is always both constraining and enabling”. Our findings
suggest that organizational structure such as promotion standards created by institutional forces serve as an incentive for the actors to adjust their action in order to pursue the reward. In our study context, the academic incentive of publications and grants is a result of academic structure of appointment and promotion and the academic culture of publish or perish (Pfeffer, 2007). Academic incentives drive the collaboration between physicians and scientists to pursue primarily the academic reward and clinical reward to a certain degree. For instance, more collaboration has been seen in response to policy and funding changes. “The increasing number of authors per article in academic journals is the consequence of a changing scientific culture”. It may shape a new paradigm of “publish together or perish” (Baethge, 2008).

“Institutional features of the organizational environments shape both the goals and means of actors” (Scott 1987). Institutional forces influence behaviors, and it is well documented that individuals accept and conform to institutionalized norms (Pfeffer, 1992). The positive links between academic culture as a form of institutional structure and many other factors including communication, collaboration process effectiveness, academic outcome, and clinical outcome support these arguments and Barnard’s belief that “behaviors can be controlled and predicted if people are rewarded by incentives to perform specific tasks required by the organizations to be efficient” (Barnard, 1968, cited in Bouclier, 2010).

CONCLUSIONS

I. Summary of Main Findings

We aimed to study the influence of instructional forces on scientist-physician partnership (SPP) and clinical outcome in this study. Contrary to traditional beliefs, our
data reveals that academic standards of appointment and promotion serve as an incentive and have a positive effect on communication, perceived satisfaction on process effectiveness of SPP and both academic outcome directly and clinical outcome indirectly. As predicted, organizational collaboration mechanism positively influences communication, and access difficulty has a negative relationship with communication and academic outcome. Communication plays a central role in SPP by partially or fully mediating the effects of academic promotion criteria, level of access difficulty and organizational collaboration mechanism on academic outcome. Satisfaction on process effectiveness of collaboration has a direct positive impact on both academic outcome and clinical outcome. It also fully mediates the effect of communication effectiveness on both academic outcome and clinical outcome. In addition, satisfaction on process effectiveness also partially mediates the effect of academic incentive on academic outcome.

The slow transfer of biomedical science to clinical practice in medicine is a complex problem involving institutional, social and culture arrangements and structures at both personal and organizational levels. Our study provides insights on the relationships between institutional structure and SPP in medical knowledge transfer. Academic outcome and satisfaction on process effectiveness positively predict the clinical outcomes of SPP measured by clinical application of research and the generation of patents. Organizational support plays an important role by influencing communication, academic outcome, and partnership satisfaction. Other factors such as personal attributes and the role of social-cultural influence are the focus of ongoing research projects. Successful SPP measured by academic reward and partnership effectiveness leads to
clinical outcome. This supports our hypothesis that SPP plays an important role in knowledge transfer in medicine.

II. Implications for Managerial Practice:

This study has several implications for practice. Our results reveal the significant role institutional and organizational infrastructure, academic culture, academic incentive and communication play in influencing SPP and consequently clinical outcomes. Such clinical outcome will be of interest to the academic community, medical centers, government and funding agencies. Specifically, the following is what should be taken into consideration when designing an institutional structure to bridge the valley of death by promoting SPP.

(1) Our data revealed that academic outcome predicts clinical outcome at a certain degree ($\beta=0.115, p=0.009$). In addition, academic promotion criteria do not inhibit but promote clinical research indirectly through its effect on academic outcome. This suggests that the institutional structure such as academic promotion criteria has merit, and it is necessary in knowledge creation and transfer. Knowledge creation is an essential condition of knowledge transfer. Clinical outcome is rooted in academic outcome. Basic research is needed for knowledge transfer and clinical outcome. Policies should continue to support and encourage research in basic sciences.

(2) Although organizational collaboration mechanism has no direct relationship with satisfaction on process effectiveness, academic and clinical outcome, it has a direct positive effect on communication effectiveness, which mediates the effect of academic incentive and level of access difficulty on academic outcome. These factors contribute to clinical outcome directly or indirectly through their influence on academic
outcome. Therefore, it is important for organizations to provide supportive collaboration contexts to initiate mediate and facilitate collaborations between scientists and physicians. Organizations should promote this communication by providing such things as supportive leadership, collaboration office, organizing seminars and networking social events.

(3) Institutions need to design a system with fewer barriers that recognizes and encourages the engagement of both scientists and physicians in research especially translational research. A funding oriented institutional structure might be a good strategy. Scientists have to obtain funding to survive by publishing. For many physicians with research interests, funding would encourage and make their participation in research possible.

In summary, institutions should create an organizational collaboration infrastructure, an incentive and a reward system to foster and facilitate physician-scientist collaboration. Pennington (2008) notes that cross-disciplinary collaboration depends on creating a receptive environment and process to facilitate cross-boundary interactions. An environment with infrastructure, funding and facilitator, and a process including individual and group processes such as communication facilitate cross-disciplinary interactions, which influence collaborative outcomes including innovative research. “The entire collaboration process, although possible to achieve without design, could be more effectively enabled through highly orchestrated methods that allow for iterative divergent and convergent thinking … Effective management of the system requires leaders who are facilitators and are capable of orchestrating effective environments and interactions” (Pennington, 2008: 11).
LIMITATIONS OF THIS RESEARCH

This study has several limitations: (1) this study is based on single resource and single method obtained self-reported data. Nevertheless, CMB checks do not reveal any concerns. In addition, we designed both subjective (satisfaction on process effectiveness of partnership) and objective outcomes (abstracts, papers, grants, clinical applications and patents) as variables. (2) The data is from voluntary participants who have collaborated. We noticed that many respondents who started the survey stopped the survey at the question asking “have you collaborated with a physician or a scientist”. These partial responses were excluded from the study. The complete non-collaborator responses consists of less than 10% of total responses, therefore are excluded as well from data analysis. This may at a certain degree bias our finding. (3) The findings on the relationships between organizational forces and the outcomes of scientist-physician partnership may be specific to the research field. Its generalizability to other cross-boundary and cross-disciplinary collaborations may need to be validated at other contexts.

FUTURE WORK

There are many lines of research that warrant future study. (1) While the data obtained from collaborator respondents provides insights on institutional enablers in SPP and clinical outcome, it is necessary to obtain data from non-collaborators. Non-collaborator data would generate insights on constrainers of SPP and clinical outcome. (2) It is interesting to investigate the interaction effects of several institutional forces on SPP as well as their impacts on clinical outcome. (3) To further confirm and validate the findings, a longitudinal study of obtaining objective collaboration outcomes from non-
self-reporting data resources such as public records on papers, grants, patents and clinical applications should be conducted. A longitudinal study may strengthen our understanding of SPP and its impact on knowledge transfer in medicine.

Collaboration structure is related to collaboration performance and participants and their objectives. In addition, political, social, economic and cultural environments have both obvious and subtle influence on collaborators, their performance and collaboration projects as found in a service delivery collaboration model (Dawes & Eglene, 2004). Therefore, future work should also (4) investigate the influence of other forces on SPP and their effect on clinical outcome. The factors to consider include personal attributes and socio-cultural influences. Furthermore, (5) further work could be conducted on the effects of other institutional arrangements such as government regulations, insurance policy, funding agencies and regulation, and hospital operations.
## ATTACHMENT

### TABLE C9

**Construct Table**

<table>
<thead>
<tr>
<th>Construct</th>
<th>Items</th>
<th>Factor Loading</th>
<th>Academic Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Communication Effectiveness (CE)</strong></td>
<td>1. Information flowed effectively between me and my collaborator(s). 2. Information flowed effectively in a timely fashion. 3. Both parties kept each other informed about the events that may affect the other. 4. There was strong two-way communication.</td>
<td>0.89 0.88 0.80 0.81</td>
<td>Cooke-Lauder, 2006; Judge &amp; Douglas 2009</td>
</tr>
<tr>
<td><strong>Level of Access Difficulty to Collaborator (LAD)</strong></td>
<td>1. I do not know how to identify the potential collaborator(s). 2. I do not have access to potential collaborator(s). 3. My organization does not encourage collaborative work.</td>
<td>0.91 0.77</td>
<td>Dropped</td>
</tr>
<tr>
<td><strong>Academic promotion criteria (APC)</strong></td>
<td>1. I received promotions because of the grants I obtained as the Principal Investigator. 2. I was promoted because of the papers I published as primary (first or last) author. 3. I restrain from collaborating because I need independent work to get promoted.</td>
<td>0.76 0.86</td>
<td>Dropped</td>
</tr>
<tr>
<td><strong>Satisfaction on Process Effectiveness (SPE)</strong></td>
<td>1. The goals of the collaborative project were achieved. 2. I would rate the collaborative project as a success. 3. I am very satisfied with the performance of this collaborative project. 4. I am proud of the collaborative project. 5. I learned new skills and competencies through this collaborative project.</td>
<td>0.88 0.91 0.92 0.79</td>
<td>Dropped Cooke-Lauder 2006 who adapted from Saxton, 1997; Lui and Ngo, 2004.</td>
</tr>
<tr>
<td><strong>Organizational Collaboration Mechanism (OCM)</strong></td>
<td>1. Supportive leader(s) in a department and or institute/school/hospital 2. Collaboration office 3. Regular meetings with potential collaborators 4. Seminars 5. Organizing social events 6. Other</td>
<td>Not applicable</td>
<td>This study</td>
</tr>
<tr>
<td><strong>Academic Outcome (AO)</strong></td>
<td>1. Were paper(s)/meeting abstract(s) generated? 2. Were grants generated? 3. Were grants awarded?</td>
<td>Not applicable</td>
<td>This study</td>
</tr>
<tr>
<td><strong>Clinical Outcome (CO)</strong></td>
<td>1. Did the collaboration lead to clinical application(s)? 2. Did the collaboration generate patents (in preparation, pending or awarded)?</td>
<td>Not applicable</td>
<td>This study</td>
</tr>
</tbody>
</table>
APPENDIX D
Socio-Cultural Factors Influencing Scientist-Physician Partnership in Biomedical Research and Knowledge Transfer

ABSTRACT

Substantial resources invested in biomedical research have generated revolutionary discoveries in medical science. However, it takes on average 17 years to turn about 14% of research findings into changes that benefit patients. Lack of scientist-physician partnership (SPP) is one of main reasons for the extremely slow translation of science into medical practice. My previous qualitative study identified several socio-cultural factors that hinder or facilitate SPP and knowledge transfer in medicine. However, the relationships among the identified factors and the prevalence of their impacts on SPP and medical knowledge transfer are unclear. This study investigates the influence of social factors on SPP effectiveness. I hypothesized that both socio-cultural difference and professional language difference between scientists and physicians have a negative effect on SPP and partnership outcomes including both academic outcome and clinical related outcome; and social support and shared vision/goals positively influence the outcomes of SPP. I proposed that communication effectiveness and mutuality mediate the effects of these social factors on collaboration outcomes. I surveyed 440 scientists and physicians to test these hypotheses. My data reveals that, (1) both professional language difference and socio-cultural difference, to my surprise, do not have a negative but have a positive influence on SPP outcomes directly or indirectly through their positive effects on communication effectiveness and mutuality as well as satisfaction on collaboration process effectiveness; (2) as hypothesized, social support and shared vision/goals are positively associated with SPP outcomes; (3) communication effectiveness, mutuality and satisfaction on collaboration process mediate the effects of perceived socio-cultural difference, professional language difference, social support and shared vision and goals on SPP outcomes. The study provides new insights and practical implications on effective inter-professional collaboration in knowledge production and translation in medicine.

Key words: Scientist-physician partnership; collaboration; socio-cultural influence; professional language difference; social support; shared vision/goals; communication effectiveness; academic outcomes; clinical outcomes; satisfaction.
INTRODUCTION

1.1 The Knowledge and Practice Gap

Significant resources have been invested in biomedical research in the USA (Kerner, 2006). For example, the National Institutes of Health (NIH) alone has earmarked $30-$32 billion annually for biomedical research since 2008 yielding vast knowledge as evidenced by the revolutionary discoveries in medicine such as the completion of Human Genome Project in 2003, and by the number of publications generated from sponsored research projects (Grol & Grimshaw, 2003; Kerner et al., 2006). However, the application and adoption of research findings into medical practice to improve human life have lagged behind (Berwick, 2003; Lenfant, 2003; Glasgow et al., 2003; Kerner, 2006). It takes an estimated 17 years, on average, to turn 14% of research findings into clinical practice (Balas & Boren, 2000 cited in Westfall et al., 2007). This demonstrates a “very real gulf separating cutting edge laboratory discoveries from their transformation into effective treatments” (Nabel, 2010).

1.2 The Importance of Scientist-Physician Partnership (SPP)

There are many reasons for the gap between medical research and practice because medical knowledge transfer occurs in a complex system of interactions among researchers, physicians, patients, and other decision makers such as hospital administrators and insurance companies (Dobbins et al., 2007; Estabrooks et al., 2006; Ploeg et al., 2007; Sinuff et al., 2007; Zwarenstein & Reeves, 2006). Partnership between researchers and practitioners is the key for the generation of transferable biomedical knowledge, as well as for other knowledge transfer process—diffusion, dissemination and implementation of knowledge. Translating research into practice requires common
understanding and common language among scientists and physicians. A collaborative partnership between research scientists and health care practitioners could expand the research implementation efforts greatly (Kerner & Hall, 2009). Physician-scientist partnership makes the research relevant and easy to transfer. Collaborations between physicians and scientists have generated many of the revolutionary advances in medicine (Goldstein & Brown, 1997). For example, the power of physician and scientist interaction and collaboration is well demonstrated by the successful application of in vitro fertilization procedures to benefit a large sub-fertile population (Edwards, 2001).

Compared to a physician-led or scientist-led research team model, the physician and scientist team model is the most successful model for sustaining the clinical researcher pipeline (Moskowitz & Thompson, 2001). Because SPP is so important, consideration for collaborative investment in integrating the lessons from practice and research, as well as incorporation of partnership into publications and meetings, are proposed as ways to promote practice-research partnership and collaboration (Kerner & Hall, 2009).

1.3 Socio-Cultural Influence and Collaboration

Despite the importance of SPP in biomedical research, “the clinical and basic scientists do not really communicate” (Butler, 2008: 840). SPP faces many challenges similar to other inter-professional collaboration such as difference in language, power, structure, professional agenda, and institutional pressure (Freeth, 2001: 44; Choi & Pak, 2007; Harris et al., 2008). Collaboration is influenced by many socio-cultural factors including economic and social environment, communication gap and social and cultural incompatibility (Unhelkar et al., 2010). Social influence is described as “a change in a
person’s cognition, attitude or behavior which has its origins in another person or group” (French & Raven, 1959 cited in Strolin, 2009). Culture is “the deeper level of basic assumptions and beliefs that are shared by members of an organization, that operate unconsciously and define in a basic ‘taken for granted’ fashion an organization's view of its self and its environment” (Schein, 1985: 6). Cultural influence refers to the geographical, familial and historical factors that affect the change in behavior. The social cultural difference between scientists and physicians and its influence on SPP was identified as a strong factor influencing SPP in my previous study. Oborn & Dawson (2010: 1854) also found that “the social context of interpersonal relations, socialized professional roles and asserted privilege of certain knowledge” are strong elements in multidisciplinary team including experts of surgery, radiotherapy oncology, pathology, nursing and radiology.

1.4 Research Gap: No Studies on Social-Cultural Influence on SPP

Awareness of cultural and value system differences, as well as organizational, societal and cultural differences can be of immense help in collaboration; and failure to recognize and address the different social and cultural environment, value systems, mistrust and lack of respect for other parties can quickly lead to the demise of an otherwise strong strategic alliance (Unhelkar et al., 2010). Although socio-cultural factors play important role in collaboration, this specific dimension of collaboration tends to be ignored, because it is very difficult to put this dimension in a well–defined formula (Unhelkar et al., 2010). It is not surprising that literature on the socio-cultural difference between physicians and scientists and its effect on the collaboration between physicians and scientists is sparse. My qualitative investigation interviewing both scientists and
physicians reveals a “day and night” cultural difference between physicians and scientists. This finding is partially consistent with the socio-economic status difference between physicians and scientists (Miller & Salkind, 2002).

In this study, I address the influence of socio-cultural dimension of SPP on collaboration effectiveness using a quantitative approach. I investigate the causal links among social-cultural factors and the degree of their impact on SPP effectiveness. Specifically, I asked to what extent professional language difference, social and cultural difference between physicians and scientists, as well as social support of individuals influence both academic and clinical related outcomes. I conducted a quantitative research surveying 440 research scientists and physicians who collaborated with partners who have different skills (i.e. MD and PhD collaborations) to explore this question.

The remainder of the paper is organized in the following sequence. First, I discuss literature background and present the development of the research hypotheses. Second, I describe the research design and key measures of the study. Third, I report the main findings. Next, I discuss the meanings of my findings. I conclude with practical implications and limitations of this study. I finally end with an outline for future work.

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

2.1 Research Model

“Partnership involves co-operation, i.e. “to work or act together,” and in a public policy can be defined as co-operation between people or organizations in the public or private sector for mutual benefit” (Holland, 1984 cited in McQuaid, 2000: 2); Because of these similarities, in this study, I use partnership or collaboration interchangeably. Scientist and physician partnership or collaboration is defined as the relation between
research scientists and physicians who “work or act together” and “work with” each other to create and transfer biomedical research into practice.

Scientist-physician partnership (SPP) is expected to promote the transfer of biomedical research into clinical practice by generating transferable medical knowledge and outcomes and by better applying the research findings into practice through working together. The partnership is expected to reduce physician’s barriers in adopting the newest medical research knowledge and to help scientists identify new relevant research opportunities. **SPP effectiveness** is defined in this study as the extent to which the partnership promotes such goals in terms of research and clinical outcomes, as well as satisfaction on process effectiveness of collaboration.

Socio-cultural factors play critical role in collaboration (Unhelkar et al., 2010). Unhelkar et al. (2010) point out that “social influence is experienced not only in the society where the customers exist, but also within the internal organization, employees”. Both organizations and individuals in society experience the social and cultural influence. At an individual level, for instance, the index of socioeconomic status for physicians is higher than for scientists (Duncan’s Socioeconomic Index, Miller & Salkind, 2002). This is in agreement with the finding of asymmetry in social status and income between physicians and scientists in my qualitative study interviewing physicians and scientists, which revealed that socio-cultural forces including social-cultural differences and professional language differences between scientists and physicians, social support, shared vision and goals and mutuality play important roles in SPP effectiveness.

Informed primarily by my earlier empirical study, Figure D1 depicts a conceptual model which guided this research. It consists of factors that influence SPP effectiveness.
This model focuses on the socio-cultural influence on the partnership between academic research and medical practice. I propose that social-cultural factors including social-cultural and professional language difference influence the process and outcomes of academia and practice partnership between scientists and physicians. Social support along with shared goals and vision among scientists and physicians have a positive effect on SPP outcomes. Collaboration process factors (communication and mutuality) mediate the effect of social-cultural forces on performance outcomes of SPP. Partnership satisfaction on process effectiveness of collaboration has a positive relationship with the outcomes of SPP. Gender, age, academic title and income are included as controls to account for their influences. The sections below review these factors in detail. In addition, these sections describe the development of the research hypotheses compromising the model.

**FIGURE D1**
Conceptual Model

- **Social Factors**
  - Social-Cultural Difference
  - Professional Language Difference
  - Social Support
  - Shared Vision/Goals
- **Mediators**
  - Communication
  - Mutuality
  - Satisfaction on Process
- **SPP Effectiveness**
  - Academic Outcomes
  - Clinical Outcomes
- **Moderators**
  - Professional Degree (MD, PhD, MD-PhD)
- **Controls**
  - Sex
  - Age
  - Academic Title
  - Income
Constructs of Research Model

*Scientist and physician partnership (SPP) effectiveness*: “Collaborative practice is an inter-professional process for communication and decision making that enables the separate and shared knowledge and skills of care providers to synergistically influence the client/patient care provided” (Way et al., 2000: 3). Effectiveness is a measure of achieving expected and desired objectives and outcomes (Parkhe, 1993; Saxton, 1997). My previous study suggests outcomes motivating researcher and physician collaboration include: obtaining clinical samples for research purposes; publishing research papers obtaining grants; applying research findings in clinical practice, and conducting clinical research with the aim of creating new treatments. I therefore use academic outcome (AO) and clinical outcome (CO) as key dimensions defining SPP effectiveness. **Academic outcome** refers to the generation of conference abstracts and research papers, as well as research grants generated and awarded. **Clinical outcome** is defined as the generation of patents and new clinical applications of research findings. Both dimensions measure collaboration outcomes objectively.

*Satisfaction on process effectiveness (SPE)*: Collaboration research typically uses three types of measures to define the performance: financial, objective and subjective measures (Cooke-Lauder, 2006). In this study, grants-awarded is a financial measure of SPP effectiveness; Publications, patents and clinical applications of translational outcomes are objective measures of SPP effectiveness; satisfaction on process effectiveness of SPP is a subjective measure of SPP performance. Partnership satisfaction on the collaboration process is related to partnership performance and has been used as a measure of partnership success in many studies (Geringer & Hebert, 1989;
Hausman, 2001; Sriram & Stump, 2004). I define **satisfaction on process effectiveness** as the satisfaction partners perceived on collaboration performance. It includes if partners think their collaboration achieved desired objectives and whether they are satisfied with the collaboration process.

*Communication effectiveness (CE):* Communication plays a central role before and during collaboration. The effect of communication on collaboration and partnership has been well documented. For example, communication strategy influences financial performance (Koza & Dant, 2007). Inter-organizational communication has been shown to have an impact on the performance outcomes in collaborative buyer-supplier relationships (Paulraj, Lado, & Chen, 2007; Hunter & Perreault, 2007). Clinicians’ communication behavior has been shown to predict healthcare use and perceptions of quality of care (Clark et al., 2008). More frequent and higher caliber inter-professional communication and collaboration are associated with positive experiences of all healthcare providers in a care unit (Conn et al., 2012). A study by Kraut and colleagues (1988) also demonstrates the importance of the frequency and quality of communications in scientific collaboration. **Communication effectiveness** in this study is defined as effective and timely flow of information between partners to ensure the objectives of collaboration are achieved.

*Mutuality:* Thomson et al. (2007), who conducted an empirical study using interview, survey and field research to conceptualize and measure collaboration, conclude that mutuality and norms are key dimensions of collaboration. They point out that reciprocity, trust and reputation are three core relationships in norms, and commitment to collaboration is unlikely without the norms of trust and reciprocity. “Mutual respect is a
key component of mutuality in partnership. Mutual respect rests on an explicit recognition of the indispensability of each partner and its contribution. Partners are aware of each of their partner’s unique strengths and seek to effectively incorporate these into the partnership work” (Brinkerhoff, 2002:225).

However, “clinicians and basic science researchers have a fundamental difficulty in recognizing the merits of research from the other sphere…. This existing academic culture will have to change if collaborations between clinicians and laboratory-based investigators are to be successful” (Pober et al., 2001: 2309). “Without trust and respect, co-operation cannot exist. Assertiveness becomes threatening, responsibility is avoided, communication is hampered, autonomy is suppressed and co-operation is haphazard” (Norsen, 1995 cited in Way et al., 2000: 6).

My previous study also uncovered a lack of mutual respect and understanding between physicians and scientists. In this study, I use a mutuality scale to measure the quality of collaborative relationship between partners including reciprocity, fairness, commitment and trust.

**Independent Variables:** My previous research reveals that socio-cultural factors including professional language difference, perception of socio-cultural difference, social support and shared vision/goals inhibit or facilitate SPP. I therefore use these factors as exogenous variables to represent key dimensions of socio-cultural forces in this study.

**Perceived socio-cultural difference (PSCD):** Social influence is “the perceived expectation from family, relatives, friends, and peers for an individual to perform the behavior of interest.” (Hsieh et al., 2008). Culture is a “pattern of shared basic
assumptions learned by a group as it solved its problems of external adaptation and 
internal integration, which has worked well enough to be considered valid and, therefore, 
to be taught to new members as the correct way to perceived, think, and feel in relation to 
those problems” (Schein, 2010: 18). “Culture thus consists of language, ideas, beliefs, 
customs, taboos, codes, institutions, tools, techniques, and works of art, rituals, 
ceremonies, and symbols”(Merriam-Webster: http://www.merriam-webster.com/dictionary/culture)”. My previous study on SPP uncovered a significant 
culture difference between physicians and scientists; I refer to perceived socio-cultural 
difference in this study as the presence of socio-cultural difference between physicians 
and scientists in the dimensions of culture, social, economic and professional status 
perceived by individuals.

*Influence of professional language difference (PLD):* Language is one of 
multiple dimensions of culture (Schein, 2010). The professional language difference 
between physicians and scientists has originated from their trainings, the nature of their 
jobs and their different foci. Due to the PLD, “'knowledge brokers" or 
"translational scientists" are required to go between team members of different disciplines to overcome 
the problem of lacking of common language (Choi & Pak, 2008: E228). A previous study 
suggests that the professional language difference is associated with SPP. I define 
professional language difference as the degree to which the negative impact of 
professional language difference has on respondents' participation and engagement in 
SPP.

*Social support (SS):* Lack of time and funding were identified in my study as the 
main reasons why physicians do not participant in research actively. Despite the
organizational constrains in time and funding, many physicians still participate in research activities without organizational support. My qualitative data reveals that social support is crucial for the motivated physicians to engage in this research. Social support is “the overall emotional support that the adolescents felt they received from those around them, including their family, friends, and teachers” (Harker, 2001). I adopt the definition of Caplan et al. (1980) on social support in this study to include immediate supervisor and co-workers as potential sources of social support as well. Thus, social support is the support individuals receive from people around them including spouse/partner, friends and relatives, immediate supervisor and other co-workers.

**Shared vision/goals (SVG):** An extensive literature review by Choi and Pak (2007) identifies a common goal and shared vision as one of promoters of success in multidisciplinary, interdisciplinary and trans-disciplinary teams in the literature of health research, services, education and policy. Common goals and shared vision are key success factors emerged in my qualitative study as well. I define “shared vision and goals” in this study as the common view shared between collaborative partners on goals, objectives, future plans and strategic directions of the collaborative projects.

### 2.2 Hypothesis Development

Literature and my previous study suggest that professional language difference and socio-cultural difference may have a negative influence on SPP; and social support has a positive effect on SPP. I developed the following hypotheses accordingly.

#### 2.2.1 The effect of professional language difference (PLD) on SPP outcomes

The professional language difference (PLD) between physicians and scientists is a result of organizational and institutional arrangements. Language problem is a barrier of
interdisciplinary collaboration, because “experts from different disciplines and backgrounds usually speak different languages and use different jargon and acronyms” (Choi & Pak, 2007: E228).

The role of working professional language difference in SPP is not straightforward. While some respondents in my qualitative study said they want to collaborate with people who speak different professional languages for their expertise in their fields; some other respondents acknowledged that the professional language different is a concern in their initiation, engagement and continuation of inter-professional collaboration.

It is likely that individuals may be motivated to seek inter-professional collaboration to compensate the expertise they lack for academic and/or clinical purposes. Professional language difference, however, may discourage them from actively initiating and participating in collaboration with partners who speak a different professional language. Professional language difference may have a negative influence on communication due to the lack of common language. Non-effective communication would have a negative effect on the effectiveness of SPP. I therefore propose:

**Hypothesis 1: Professional language difference has a negatively influence on communication effectiveness (H1a), academic outcomes (H1b) and clinical outcomes (H1c).**

### 2.2.2 The effect of perceived social-cultural difference on SPP outcomes

Socio-cultural factors play critical role in collaboration (Unhelkar et al., 2010). My previous study uncovered a huge socio-cultural difference between scientists and physicians. For example, all interviewing respondents in the study acknowledged a “day
and night” cultural difference between physicians and scientists. They pointed out how physicians and scientists view the world and approach problems differently; how their work styles, value systems and learning styles and working languages are different. Physicians are described by researchers as non-linear thinkers, jumping around fast and randomly. Scientists, on the other hand, are viewed by physicians as having delayed gratification, and being slow in their responses, actions and decision making process. Physicians also perceived scientists as being logical, linear thinkers who focus on scientific method of perfect controlling and logic in an ideal world. Due to these differences, it is not surprising that many of the respondents reported the lack of mutual respect and understanding between physicians and scientists. In addition, the asymmetry in social status and income between scientists and physicians also influence the engagement and continuation of the SPP.

The level of perceived socio-cultural difference between physicians and scientists is likely linked with the level of the mutuality. If a person thinks the socio-cultural difference between scientists and physicians is small, it is likely that this person will treat collaborator(s) with respect. On the other hand, if a person thinks his/her own profession is superior to that of collaborator(s), s/he may not treat collaborator(s) with mutual respect and trust. Given the fundamental differences between scientists and physicians, it is reasonable to assume that the level of individuals’ perception of cultural difference is associated with the level of their willingness to participate in inter-professional collaboration and to the level of process and outcomes of collaboration. If an individual firmly believes and is deeply influenced by the difference between physicians and scientists in cultural, social and economic status, this perception could potentially have a
negative impact on this person’s participation and engagement in inter-professional collaboration. It may influence communication, mutuality and satisfaction on collaboration process and performance. Taken together, I hypothesize:

**Hypothesis 2: Perceived social-cultural difference negatively influences**

- *mutuality (H2a), satisfaction on process effectiveness of collaboration (H2b),
- *academic outcome (H2c) and clinical outcomes (H2d).*

### 2.2. 3 The effect of social support (SS) on SPP outcomes

The importance of social support was evident in my qualitative study. For example, both physicians and scientists said that “people are more helpful than organization”; they collaborate with friends, and they identified collaborators through friends and colleagues since “they (organizations) don’t have a department or an office that sort of tries to foster SPP”. Despite the organizational constrains on time and funding, many physicians do participate in research actively without organizational support. Social support is crucial for the motivated physicians to engage in the research. For example, a MD interviewee said that he was able to engage in research because he has been able to use family time to write grants and papers and to engage in other research activities. A MD told me that he was happy because he now can engage in research with his new fiancé’s full support.

Drawing on both my qualitative study and the literature, I reasoned social support from family members especially from spouse, from friends and other social relations as well as from co-workers and supervisors would help to overcome the constrains of social cultural factors and the institutional constrains such as lack of time, funding and other resources. In other words, social support is likely to promote the collaboration between
physicians and scientists; it would have a positive influence on the outcomes of collaboration. I hypothesized that:

**Hypothesis 3: Social support has a positive influence on SPP outcomes including both academic outcome (H3a) and clinical outcome (H3b).**

2.2.4 The effect of shared goals/vision (SVG) on SPP outcomes

Common goals and shared vision between scientists and physicians who have a collaborative relationship are key success factors that emerged in my qualitative interview study. Choi and Pak (2007) also found, through an intensive literature review, that a common goal and shared vision is one of promoters of success in multidisciplinary, interdisciplinary and trans-disciplinary teams.

The shared vision and agreed goals and objectives would promote effective communication among collaborators. It would promote partners to find ways to overcome social-cultural difference and professional language differences. It would promote mutually beneficial behaviors among the collaborators. It is highly likely that the more collaboration partners share in common in terms of goals, objectives, future plans and strategic directions of the collaborative projects, the better the collaboration outcomes will be. I propose:

**Hypothesis 4 shared goals/vision have a positive influences on communication effectiveness (H4a), mutuality (H4b), satisfaction on c collaboration process(H4c), and SPP outcomes including academic outcome (H4d) and clinical outcome(H4e).**
2.2. 5 The effect of mutuality

Mutual trust and respect is identified as one of seven essential elements including communication and coordination for successful collaboration in healthcare settings between physicians and nurses, and it is “common to and binds all of the other elements together. Each provider must be able to depend upon the integrity of the other as the foundation for their professional relationship” (Way et al., 2000: 6).

I also identified mutuality as a key process factors in successful SPP in my qualitative study. For example, lack of credit and respect from physicians are the main factor discouraging scientists from working with physicians and from working at clinical departments. The importance of mutual respect and understanding is reflected in the following account by a scientist when describing his successful partnership with a physician:

“It’s the realization of what each person brings and the appreciation of that. … even though he does his things differently, I don’t always agree with it, but I can see where he’s coming from. And that helps me – it makes me question my own thing and think about my own things that way. And I think the other way around, he appreciates my perspective and that it’s unique from his. And rather than saying, Vincent, do what I do, I think we have a give and take, and we both appreciate what the other has to bring”.

However, not all collaborators have mutual respect on each other. Many of the respondents reported the lack of mutual respect and understanding between physicians and scientists. For example, a MD-PhD said, “Too much arrogance on both sides. Cause “I certainly know better than this person does”. There’s a lot of that”.

Mutuality, including equality in decision making, reciprocity and resources exchange, is used to assess the degree of partnership (Brinkerhoff, 2002: 225). If partners treat each other with mutual respect and trust; if they are happy with their
relationship, they will be happy and willing to do what each other are supposed to do.

Being delighted with collaboration relationship and process will have a positive influence on collaboration outcomes. Drawing from literature and my interviews, I reasoned that:

**Hypothesis 5:** Mutuality has a positive effect on the satisfaction on process effectiveness of collaboration (H5a), on outcome of collaboration including both academic (H5b) and clinical (H5c) outcomes.

### 2.2.6 The mediating role of communication effectiveness

Literature is abundant on the importance of communication in partnership effectiveness (Amabile et al., 2001; Aiken, Bacharach, & French, 1980; Ansell & Gash, 2008; Sriram & Stump, 2003). I also identified communication as a key process factors in successful SPP. I found that communication effectiveness mediates the effect of academic promotion criteria, level of access difficulty to collaborators and organizational collaboration mechanism on academic outcome. In addition, my data reveals that communication effectiveness has a positive effect on satisfaction on process effectiveness of SPP.

Given the important role of communication effectiveness in mediating the effect of institutional factors on SPP effectiveness, I wondered if communication effectiveness also mediates the role of socio-cultural factors on SPP effectiveness.

People who speak the same language will communicate better than people who speak different languages. On the contrary, differing professional language may make the communication among professions difficult and ineffective. It is reasonable to assume that the level of professional language difference between scientists and physicians may correlate negatively with the level of communication effectiveness. Communication
effectiveness, in turn, has a positive effect on the outcomes of collaboration as found by previous studies (Mohr & Spekman, 1994; Conn et al., 2012). Given the links between professional language difference with CE, and the effect of CE on collaboration outcomes, I hypothesized:

**Hypothesis 6: Communication effectiveness mediates the effect of professional language difference on academic outcome (H6).**

In order to reach agreement on the comment goals and plans in the beginning, collaborators have to communicate effectively with each other. In order to achieve the agreed objectives and vision, partners have to continue to communicate effectively. In other words, shared vision/goals among collaborators would promote partners to communicate effectively with each other. Given the links between communication quality with successful partnership as noted in literature and as found in my earlier studies, I reasoned that shared vision/goals have a positive impact on communication effectiveness, which in turn will have a positive influence on both academic and clinical outcomes. Thus I hypothesized:

**Hypothesis 7: Communication effectiveness mediates the effect of shared vision/goals on both academic outcome (H7a) and clinical outcome (H7b).**

2.2.7 **The mediating role of satisfaction on collaboration process effectiveness (SPE)**

My previous data shows that satisfaction on process effectiveness of collaboration has a positive effect on both academic and clinical outcomes; satisfaction mediates the roles of institutional factor (academic promotion criteria) on academic outcome. In addition, SPE mediates the effect of CE on both AO and CO. I reasoned that SPE may also have a mediating role in the relationships between socio-cultural factors and SPP.
outcomes. Perception of social-cultural difference would influence communication effectiveness, and SPE; shared vision and goals would lead to SPE; SPE, in turn, is positively associated with collaboration outcomes including both AO and CO. I therefore reasoned satisfaction on collaboration process effectiveness would be the underlying mechanisms linking social-cultural factors and SPP effectiveness, which forms the rationale of my hypotheses on the role of SPE in mediating the effects of socio-cultural factors on SPP effectiveness.

*Hypothesis 8: Satisfaction on process effectiveness mediates the effect of perceived socio-cultural difference on academic outcome (H8a)*

*Hypothesis 9: Satisfaction on process effectiveness mediates the effect of shared vision/goals on both academic outcome (H9a) and clinical outcome (H9b).*

Previously, I found that SPE also fully mediates the positive effect of communication effectiveness on academic outcome and clinical outcome. Considering the importance of SPE on SPP outcomes, I suspect SPE may also mediates the effect of mutuality on outcomes of collaboration. I reasoned that mutual respect, trust and reciprocity would increase the satisfaction on collaboration; as a result, mutuality may have a direct or indirect effect on the outcomes of SPP effectiveness through SPE. Taken together with the positive effect of SPE on SPP effectiveness, I hypothesized:

*Hypothesis 10: Satisfaction on process effectiveness of collaboration mediates the effect of mutuality on both academic outcome (H10a) and clinical outcome (H10b).*
RESEARCH DESIGN AND METHOD

3.1. Methodology and Study Context

I carried out a quantitative psychometric study to test my hypotheses and validate the proposed research model. A structured survey was designed to measure the factors influencing scientist-physician partnership effectiveness by collecting response data from physicians and scientists who have collaborated with one another. SPSS was used to conduct basic statistical analysis (data screening), computing Cronbach’s alphas and exploratory factor analysis (EFA). AMOS (Arbuckle & Wothke, 1999; Amos user’s guide; Chicago: SPSS/SmallWaters) was used to conduct covariance based structural equation model analysis (CBSEM). Structural equation model (SEM) was chosen, because it offers many advantages over linear regression analysis including integration of the measurements and the hypothesized causal paths into a simultaneous assessment (Bollen, 1989). In addition, “SEM allows the creation and estimation of models with multiple dependent variables and their interconnections at the same time” (Gefen, Rigdon, & Straub, 2011: 4). AMOS software (CBSEM) was chosen because it brings the error terms into one unified model, therefore providing better protection from measurement errors (Gefen et al., 2011). The following sections detail the methods used including the development of survey instruments, sampling, data collection and statistical analysis.

3.2. Construct Operationalization

Measurement items of constructs were either adapted from existing scales when available and appropriate, or developed for the study based on the literature and a prior qualitative study. Appendix A lists the multi-item scales for each construct that were used.
to collect the data. A 5-point Likert-type scale is used because it is believed easy for respondents to master (Arya & Lin, 2007).

3.2.1. Adapted Scales

*Shared vision/goals (SVG):* Measures for SVG were adopted from Cooke-Lauder (2006). Four items were used to capture shared vision/goals in a 5-point Likert scale (1=strongly disagree and 5= strongly agree). This construct operationalized as a reflective construct, because the items reflect the construct they measured, and the causal directions are from construct to items and the items of each individual construct are interchangeable since they measure similar things that correlate with each other, and the items manifest instead of defining the construct they measure (Bollen, 1989; Jarvis et al., 2003). The Cronbach’s alpha for this construct is 0.881.

*Social support (SS):* this construct is adopted from Caplan et al (1980). Despite this is an established construct, not all four items loaded together as one factor in EFA, perhaps due to the factor that my study context is different from the original context where the construct was developed. In addition, this construct is a formative construct, because these items define the characteristics of the construct they measure, and each item reflects a unique aspect of the construct, therefore the items within the construct are not interchangeable (Jarvis et al., 2003). To account for all 4 dimensions of social support, I created an index of social support in the following way: first, the answers were assigned a numerical number as following: very much =5, somewhat=4, a little=3, not at all=0 and do not have such person=0. Then, the index of total social support was obtained by adding the numerical answers to all 4 items together. This is appropriate because these items are not mutually exclusive, and a higher number conveys a higher level of social
support as defined by the support from spouse, friends and family, co-work and immediate supervisor (Caplan et al., 1980).

**Mutuality:** Measures for mutuality were adopted from literature (Kauser & Shaw, 2004, Cooke-Lauder, 2006). This construct operationalized as a reflective construct. The Cronbach’s alpha for this construct is 0.915.

**Communication effectiveness (CE):** Measures for communication effectiveness were adopted from Judge and Douglas (2009). There are 4 items to measure communication effectiveness in a 5-point Likert scale (1=strongly disagree and 5= strongly agree). This construct operationalized as a reflective construct. The Cronbach’s alpha for this construct is 0.920.

**Satisfaction on process effectiveness (SPE):** Items for satisfaction on process effectiveness (SPE) of collaboration were adapted from Cooke-Lauder (2006) who adapted from literature (Saxton, 1997; Lui & Ngo, 2004). Three are four items measuring satisfaction on process effectiveness in a 5-point Likert scale. This construct operationalized as a reflective construct. The Cronbach’s alpha for this construct is 0.932.

### 3.2.2. Scales Developed for SPP

I used same measurements that I developed previously for academic and clinical outcomes of SPP.

**Dependent variables (outcomes of partnership):** In addition to measuring the perceptual understanding of partnership quality including satisfaction on process effectiveness of collaboration, I also measured the factual outcomes of collaboration. To this end I developed several items that reflect the results of SPP including generation of research abstracts, papers, research grants, patents and clinical applications. The
questions I asked were: (1) were paper(s)/meeting abstract(s) generated? (2) were grants generated? (3) were grants awarded? (4) did the collaboration lead to clinical application(s)? (5) did the collaboration generate patents (in preparation, pending or awarded)? The respondents were asked to choose between “Yes” or “No” to the above questions. A “no” answer was assigned as “0”, and a “yes” answer was assigned a numerical number based on the importance of the item in the outcome. The numerical numbers for first three items were added together to obtain the index of academic outcome. The index of clinical outcome was obtained by adding the numbers for last two items together. These constructs were operationalized as a formative construct.

3.2.3. New Scale Development

Due to the lack of available scales measuring perceived socio-cultural difference (PSCD) and professional language difference (PLD), I developed the measurements for perceived socio-cultural difference and professional language difference between scientists and physicians specifically for this study.

Perceived socio-cultural difference: as found in phase 1 study, both scientists and physicians agree “culturally they're incredibly different” and there is asymmetry in social status between scientists and physicians. This is in agreement with the socio-economic status index for scientist and physicians (Miller & Salkind, 2002). I developed four items to capture the difference: (1) There is a cultural difference between physicians and scientists; (2) There is a social and economic status difference between physicians and scientists; (3) Physicians have higher professional status than scientists; (4) Collaborating with physicians is more expensive than collaborating with scientists. The construct was measured in a 5-point Likert scale (1=strongly disagree and 5= strongly agree). This
construct was operationalized as a reflective construct. The last item was dropped because it did not load together with the first three items. The Cronbach’s alpha for this construct is 0.642

**Influence of professional language difference (PLD):** My prior qualitative inquiry indicates that the professional language difference between physicians and scientists maybe a barrier SPP. I therefore developed the following three items to measure the influence of professional language difference on SPP: (1) The professional language difference between physicians and scientists prevented me from collaborating with PhDs /MDs; (2) I would collaborate more with people who speak the same professional language as I do; (3) The professional language difference between physicians and scientists is the main reason that physicians and scientists do not collaborate with each other. The construct was measured in a 5-point Likert scale. To account for the negative influence in the items, I reverse coded the responses (i.e. 1=strongly agree and 5= strongly disagree). This construct was operationalized as a reflective construct. The Cronbach’s alpha for this construct is 0.654

### 3.2.4. Controls

I included income, age, academic title and gender as controls to account for their potential impact on collaboration and its outcomes. These variables reflect the demographic data of the respondents. They were operationalized as categorical variables as follows: gender (male=0, female=1); age (<31=1, 31-40=2, 41-50=3, 51-60=4, >60=5); academic title (postdoc=1; instructor=2; assistant professor=3, associate professor=4, full professor=5, physician without academic degree=6, other=7); income (less than 50K=1, 50K-100K=2, 100K-150K=3, 150K-200K=4, great than 200K=5).
3.3 Data Collection

*Pretesting of scales:* After interviewing and discussing with several scientists and physicians, the initial survey was tested with two physicians and two research scientists for content validity, face validity and comprehensibility (Bolton, 1993). The pretest did not reveal any conceptual issues. I modified a few questions clearer by adding “in above collaboration” to several questions. The refined survey was then distributed to the unit of my analysis—physicians, scientists and physician scientists with a MD, PhD or MD-PhD degree.

Data was collected using a carefully designed questionnaire and administered online using the assistance of survey software by Qualtrics (www.qualtrics.com/). Because scientist and physician collaboration is the focus of this study, I excluded MD and MD or PhD and PhD collaborations.

*Sample population:* Informed by the findings of my previous qualitative study, the study population was practicing physicians, research scientists, and physician scientists in the United States of America. The data was collected by invitation primarily through two methods: (1) email listings including both physicians and research scientists were compiled based on the contact information of potential respondents whose information are available on the websites of the research departments and research centers of top US hospitals and medical schools. Invitation e-mails containing brief description of research purpose and content, Internal Review Board (IRB) information and the survey link were emailed to the individuals on the e-mail listings. (2) The survey link was distributed to the members of several Clinical Translational Science Award (CTSA) centers through their local offices. The response rate is 8.2%, probably due to the
highly time sensitive nature of the unique survey population (physicians and scientists). This rate is similar to or higher than similar studies surveying physicians (Scott et al., 2008; Clark et al., 2008; Brewster, 2010).

**Non-response bias:** The analysis of demographics and main constructs showed no significant difference (Armstrong & Overton, 1977; Pavlou & El Sawy, 2006) between early and late responders or between completed or partial responders, suggesting non-response bias is not likely a threat in the study.

**Demographics of respondents:** A total of 440 responses that satisfy the analysis conditions (i.e. collaborated with physicians or scientists, and the collaboration partners are physicians and scientists with a MD or PhD) were obtained for further data analysis. Table D1 summarizes the demographics of respondents.

### TABLE D1
**Demographics of Respondents**

<table>
<thead>
<tr>
<th>Gender</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>63.2</td>
</tr>
<tr>
<td>Female</td>
<td>36.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;=30</td>
<td>5</td>
</tr>
<tr>
<td>31-40</td>
<td>20.7</td>
</tr>
<tr>
<td>41-50</td>
<td>29.5</td>
</tr>
<tr>
<td>51-60</td>
<td>30.5</td>
</tr>
<tr>
<td>&gt;60</td>
<td>18.9</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Professional Degree</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>PhD</td>
<td>30.9</td>
</tr>
<tr>
<td>MD</td>
<td>55.2</td>
</tr>
<tr>
<td>MD-PhD</td>
<td>13.9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Professional Degree of collaborators</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>PhD</td>
<td>38.0</td>
</tr>
<tr>
<td>MD</td>
<td>39.5</td>
</tr>
<tr>
<td>MD-PhD</td>
<td>20.9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Job category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientist</td>
<td>31.4</td>
</tr>
<tr>
<td>Physician</td>
<td>30.5</td>
</tr>
<tr>
<td>Physician Scientist</td>
<td>35.9</td>
</tr>
<tr>
<td>Other</td>
<td>2.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Affiliation</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>University alone</td>
<td>24.5</td>
</tr>
<tr>
<td>Hospital alone</td>
<td>6.1</td>
</tr>
<tr>
<td>Dual affiliation with both</td>
<td>68.9</td>
</tr>
<tr>
<td>university and hospital industry</td>
<td>0.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Income</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;=50K</td>
<td>3.0</td>
</tr>
<tr>
<td>50K-100K</td>
<td>14.5</td>
</tr>
<tr>
<td>100K-150K</td>
<td>16.4</td>
</tr>
<tr>
<td>150K-200K</td>
<td>24.1</td>
</tr>
<tr>
<td>&gt;200K</td>
<td>42.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Professional title</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postdoc</td>
<td>2.0</td>
</tr>
<tr>
<td>Instructor</td>
<td>4.3</td>
</tr>
<tr>
<td>Assistant Professor</td>
<td>30.0</td>
</tr>
<tr>
<td>Associate Professor</td>
<td>22.3</td>
</tr>
<tr>
<td>Full Professor</td>
<td>37.0</td>
</tr>
<tr>
<td>Physician without Academic Title</td>
<td>1.8</td>
</tr>
<tr>
<td>Other</td>
<td>2.5</td>
</tr>
</tbody>
</table>
3.4. Data Screening

**Missing values:** Among the 440 responses we analyzed, there were 4 missing values for income. I replaced these 4 missing values with median, which is acceptable given the missing value is below 5% as suggested by Tabachnick et al. (2001). There are no other missing values.

**Outliers:** Extreme outliers did not exist, because values for all reflective variables were based on Likert-like scales with five intervals or categorical values for categorical variables.

**Normality:** Only 7 items showed slight non-normal distribution. Visual inspection of the normality plots showed that the distributions are roughly normal except for one item asking for support from spouse/partners. The skewness for this item is -1.804 reflecting the true responses given the importance of support from spouse/partners. At variable levels, all the values for skewness (-0.899 to +0.274) and kurtosis (-1.546 to +1.765) are within acceptable range with good variance (Hair et al., 2010). It is possible more successful collaborators participated and finished the survey; therefore the slightly negative skewness of a few items is not surprising. This may account for the observed non-normal distribution for a few items. Because all variables are based on Likert-type scales, I did not exclude any variables with minor distribution issues.

**Linearity:** I conducted Deviation from Linearity Test to check linearity for all direct relationships in the model. I found that all relationships between IVs and DVs are linear with significance values all above 0.05, demonstrating all direct relationships are linear.
Homoscedasticity: I tested homoscedasticity by creating a simple scatter plot with the variables on X-axis and the variable’s residual on Y-axis. The scatter plots showed consistent non-problematic patterns indicating that the relationships between IVs and DVs are homoscedastic (Hair et al., 2010).

Multicollinearity: To check for multicollinearity, the Variable Inflation Factor (VIF) and tolerance tests were conducted for all exogenous variables simultaneously. Both VIF (range: 1.02-1.31) and tolerance (range: 0.764-0.977) values indicated no multicollinearity (Stine, 1995).

3.5. Statistical Analysis

3.5.1 Measurement model

Exploratory factor analysis (EFA):

EFA was carried out using Principle Axing Factoring (PFA) and Promax rotation in SPSS (21). PAF was chosen to determine unique variance among items and the correlation between factors. Promax was chosen to account for the correlated factors in a large data set (n=440). Six factors were extracted by setting the Eigen value great than 1. It showed to be a good solution as well when the number of extracted factors was constrained to six.

Pattern matrix (Table D2) shows that all the items loaded as expected after the deletion of two problematic items that caused Haywood Effect or no loading. Eigen values for all six factors extracted were above 1.0. The analyses for reliability, validity and data adequacy of EFA indicate a great factor solution (Hair et al., 2010): KMO=0.936, Chi-square =7467, df=276, p=0.000). Six factors explained 64.5% of variance, there were two (0%) on-redundant residuals with absolute values >0.05; no
problematic cross loadings; Cronbach’s Alphas for all factors were above or close (for perceived socio-cultural difference and professional language difference) to 0.7 (Nunnally, 1978).

**TABLE D2**  
Pattern Matrix

<table>
<thead>
<tr>
<th>Factor</th>
<th>Mutuality</th>
<th>SPE</th>
<th>CE</th>
<th>SVG</th>
<th>PLD</th>
<th>PSCD</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSCD1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.523</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.837</td>
</tr>
<tr>
<td>PSCD3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.516</td>
</tr>
<tr>
<td>PLD1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.692</td>
<td></td>
</tr>
<tr>
<td>PLD2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.732</td>
<td></td>
</tr>
<tr>
<td>PLD3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.472</td>
<td></td>
</tr>
<tr>
<td>SVG1</td>
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<td>.738</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SVG2</td>
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<td></td>
<td></td>
<td>.822</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SVG3</td>
<td>.274</td>
<td></td>
<td></td>
<td>.607</td>
<td></td>
<td>.838</td>
</tr>
<tr>
<td>SVG4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mut1</td>
<td>.793</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mut2</td>
<td>.805</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mut3</td>
<td>.954</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mut4</td>
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<td>Mut5</td>
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<tr>
<td>Mut6</td>
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</tr>
<tr>
<td>SPE1</td>
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<td></td>
</tr>
<tr>
<td>SPE2</td>
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<td>.994</td>
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<td></td>
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<tr>
<td>SPE4</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>CE1</td>
<td></td>
<td></td>
<td>.654</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CE2</td>
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<td>.820</td>
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<tr>
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<td></td>
<td>.836</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CE4</td>
<td></td>
<td></td>
<td>.977</td>
<td></td>
<td></td>
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</table>

**Confirmatory factor analysis (CFA)**

**Model fit:** The obtained EFA solution was then analyzed in a CFA model. In order to achieve a good model fit, the following error terms were covaried within constructs: between CE1 and CE4, CE3 and CE4 within communication; Mut2 and Mut3,
Mut5 and Mut6 for mutuality; SVG1 and SVG2 within shared vision/goals. The final measurement model has a great fit as indicated by the following fit parameters: CMIN/DF=1.95 (Chi-square=452, degrees of freedom=232), p=0.000, PLCOSE=0.812; GFI=0.923, AGFI=0.901, NFI=0.941, TLI=0.964; CFI=0.970, RMSEA=0.047, SRMR=0.040.

**Reliability and validity:** There are no convergent, discriminant or reliability concerns for mutuality, communication effectiveness, shared vision/goals and satisfaction on process effectiveness (Table D3). However, the AVE and CR indicate some minor validity concerns for perceived social cultural difference and professional language difference. Their CRs (reliability) are slightly less than 0.70; and their AVEs (convergent validity) are less than 0.50. Given the values are close to 0.7 and 0.5 respectively; plus these are the key constructs of this study, and their removal would eliminate key dimensions, therefore, a decision was made to kept them in the study and acknowledge and accept this as a limitation of the study.

**TABLE D3**

**Convergent and Discriminant Validity of Constructs**

<table>
<thead>
<tr>
<th></th>
<th>CR</th>
<th>AVE</th>
<th>MSV</th>
<th>ASV</th>
<th>PSCD</th>
<th>SVG</th>
<th>Mut</th>
<th>CE</th>
<th>PLD</th>
<th>SPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSCD</td>
<td>0.663</td>
<td>0.403</td>
<td>0.126</td>
<td>0.055</td>
<td>0.635</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SVG</td>
<td>0.878</td>
<td>0.644</td>
<td>0.621</td>
<td>0.342</td>
<td>-0.205</td>
<td>0.802</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mut</td>
<td>0.917</td>
<td>0.652</td>
<td>0.621</td>
<td>0.362</td>
<td>-0.216</td>
<td>0.788</td>
<td>0.807</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CE</td>
<td>0.915</td>
<td>0.73</td>
<td>0.615</td>
<td>0.371</td>
<td>-0.222</td>
<td>0.759</td>
<td>0.784</td>
<td>0.855</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PLD</td>
<td>0.68</td>
<td>0.422</td>
<td>0.126</td>
<td>0.081</td>
<td>-0.355</td>
<td>0.231</td>
<td>0.24</td>
<td>0.35</td>
<td>0.649</td>
<td></td>
</tr>
<tr>
<td>SPE</td>
<td>0.934</td>
<td>0.779</td>
<td>0.49</td>
<td>0.286</td>
<td>-0.103</td>
<td>0.647</td>
<td>0.684</td>
<td>0.7</td>
<td>0.21</td>
<td>0.883</td>
</tr>
</tbody>
</table>

**Common Method Bias (CMB):**

The “common latent factor” method recommended by Podsakoff et al. (2003) for studies that do not explicitly measure a common factor (as in this study) was used to test
for CMB. I conducted a test using the unmeasured latent factor method as recommended by Podsakoff et al. (2003). I compared the item loadings of CFA without and with a common latent factor (CLF, all paths from CFL to observed items were constrained to be equal to reflect the commonly shared variance). All the differences of loadings on same item between with and without CLF is below 0.2, indicating that CMB is not a significant threat (Podsakoff et al., 2003).

3.5.2 Structural Equation Model

Due to the inclusion of variables represented by indices (SS, CO and AO) that are not amenable for CBSEM, I transformed all item level reflective variables into composites. These composite variables were created based on the CFA model in AMOS.

The controls were tested only for their effect on endogenous variables (dependent variables, communication effectiveness, mutuality and SPE). The mediation analysis for the significance of indirect effects was carried out using bootstrapping with 2000 samples and setting “bias-corrected confidence intervals” to 95%. The presence of mediation effects was evaluated using Baron and Kenny method (1986).

The final SEM was created by trimming all non-significant paths off. Meanwhile, a few regression lines were added after consulting modification indices. For example, a regression line from academic outcome to clinical outcome was added, because it made both statistical and theoretical sense and improved the model fit. This final model yielded a very good model fit as indicated by the following parameters: Chi-square=69.5, degrees of freedom=38, CMIN/DF=1.829, p value=0.001, PLCOSE=0.733; GFI=0.975, AGFI=0.948, NFI=0.969, TLI=0.975; CFI=0.986, RMSEA=0.043, SRMR= 0.0713. Table D4 shows the correlation among the constructs in the final SEM model.
TABLE D4
Descriptive Statistics and Correlation of Constructs

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>SPE</th>
<th>PSCD</th>
<th>PLD</th>
<th>CE</th>
<th>Mutuality</th>
<th>SVG</th>
<th>SS</th>
<th>AO</th>
<th>CO</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPE</td>
<td>3.20</td>
<td>0.54</td>
<td>0.932*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSCD</td>
<td>1.81</td>
<td>0.51</td>
<td>-0.128</td>
<td>0.642</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PLD</td>
<td>2.25</td>
<td>0.43</td>
<td>0.253</td>
<td>-0.452</td>
<td>0.654</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>CE</td>
<td>4.17</td>
<td>0.77</td>
<td>0.739</td>
<td>-0.269</td>
<td>0.413</td>
<td>0.920</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mutuality</td>
<td>3.49</td>
<td>0.61</td>
<td>0.723</td>
<td>-0.260</td>
<td>0.291</td>
<td>0.829</td>
<td>0.915</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SVG</td>
<td>4.07</td>
<td>0.65</td>
<td>0.695</td>
<td>-0.250</td>
<td>0.285</td>
<td>0.813</td>
<td>0.844</td>
<td>0.881</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SS</td>
<td>11.45</td>
<td>4.61</td>
<td>0.190</td>
<td>-0.152</td>
<td>0.087</td>
<td>0.218</td>
<td>0.253</td>
<td>0.241</td>
<td>NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Academic Outcome</td>
<td>4.90</td>
<td>2.39</td>
<td>0.345</td>
<td>0.066</td>
<td>0.094</td>
<td>0.259</td>
<td>0.204</td>
<td>0.214</td>
<td>0.118</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Clinical Outcome</td>
<td>5.78</td>
<td>5.91</td>
<td>0.317</td>
<td>-0.072</td>
<td>0.150</td>
<td>0.283</td>
<td>0.259</td>
<td>0.278</td>
<td>0.091</td>
<td>0.242</td>
<td>NA</td>
</tr>
</tbody>
</table>

*: Values on diagonal are Cronbach’s alpha; NA: not applicable

RESULTS AND FINDINGS

The path standardized coefficients and their p values within the final model are presented in Figure D2. The R-squares of endogenous variables are included in Figure D2 as well. The results for all hypothesis tests are summarized in Table D5 (H1, H2, H3, H4 and H5), Table D6 (H6, H7), Table D7 (H8, H9, H10). All regression weights reported are standardized.
1. The Effects of Socio-Cultural Factors (hypotheses H1, H2, H3, H4, H5)

Table D5 shows the results of hypotheses (H1, H2, H3, H4, and H5) tested on the direct effects of independent variables on endogenous variables.

1.1 The role of professional language difference (PLD):

In the presence of CE, mutuality and satisfaction on collaboration process effectiveness, PLD does not have a significant direct relationship with either academic outcome or clinical outcome. However, PLD has a positive not negative influence on both communication ($\beta=0.191$, $p<0.001$) and mutuality ($\beta=0.047$, $p=0.08$), which influence both academic outcome and clinical outcome through their effect on SPE. In other words, although PLD does not have a direct effect on academic outcome or clinical outcome, it influences academic outcome and clinical outcome through its effect on
communication and mutuality. In addition, although PLD has no direct relationship with satisfaction, it influences SPE through its effect on mutuality and CE. In the absence of communication, mutuality and satisfaction, PLD does have a modest negative effect on academic outcome ($\beta = 0.086$) at 90% confidence level ($p=0.099$).

1.2 The role of perceived social-cultural difference (PSCD)

To my surprise, PSCD does not influence communication effectiveness or mutuality negatively, and it has no significant relationships with either of them. PSCD has a positive relationship with satisfaction on collaboration process ($\beta = 0.093$, $p=0.003$). Satisfaction on collaboration process effectiveness has a positive effect on both academic outcome ($\beta = 0.342$, $p<0.001$) and clinical outcome ($\beta = 0.178$, $p=0.005$). In addition, PSCD has a direct positive relationship with academic outcome (AO) ($\beta = 0.113$, $p=0.011$), which is opposite to the negative relationship I hypothesized. Although PSCD does not have a direct influence on clinical outcome as I hypothesized, it affects clinical outcome through its influence on satisfaction on process effectiveness of collaboration and AO.

1.3 The role of social support (SS)

In the absence of mutuality, communication effectiveness and satisfaction on collaboration process effectiveness, social support has a modest but significant positive influence on academic outcome ($\beta = 0.086$, $p=0.07$); in the presence of mutuality, CE and SPE, it only has an effect on mutuality ($\beta = 0.074$, $p=0.042$), but not on academic outcome directly. Mutuality has a direct effect on SPE ($\beta = 0.286$, $p<0.001$), and SPE influences both academic outcome ($\beta = 0.342$, $p<0.001$) and clinical outcome ($\beta = 0.187$, $p=0.005$).
Therefore, although social support has no directly significant relationship with either academic or clinical outcome, it influences academic outcome and clinical outcome indirectly through its effect on mutuality.

1.4 The role of shared vision/goals (SVG)

As hypothesized, SVG has a strong positive influence on CE ($\beta=0.756$, $p<0.001$) and mutuality ($\beta=0.818$, $p<0.001$) supporting H4a and H4b. SVG also has a positive effect on satisfaction on process effectiveness (SPE) ($\beta=0.143$, $p=0.019$) supporting H4c. Importantly, SVG has a direct positive effect on clinical outcome ($\beta=0.106$, $p=0.081$) supporting my hypothesis (H4e). Although SVG has no direct relationship with academic outcome, it influences academic outcome through its effect on communication effectiveness, mutuality and satisfaction on collaboration process. Indeed, in the absence of communication effectiveness, mutuality and satisfaction, SVG does have a direct positive effect on academic outcome ($\beta=0.193$, $p<0.001$).

1.5 Other significant relationships:

Communication effectiveness (CE) has a positive impact on satisfaction on process effectiveness (SPE) ($\beta=0.407$, $p<0.001$). Mutuality also has a positive influence on SPE ($\beta=0.286$, $p<0.001$). SPE, in turn, has a positive effect on both academic outcome ($\beta=0.342$, $p<0.001$) and clinical outcome ($\beta=0.178$, $p=0.005$).

The combination of mutuality, communication effectiveness, shared vision and goals, PSCD explains 59% of variance in SPE. The combination of shared vision and goals and professional language difference explains 69% of variance in communication effectiveness. The combination of shared vision and goals, professional language
difference and social support explains 72% of variance in mutuality. These data indicates that this is a very good model predicting communication effectiveness, mutuality and satisfaction on process effectiveness of collaboration.

### TABLE D5
Summary of Hypothesis Test on Direct Relationships

<table>
<thead>
<tr>
<th>ID</th>
<th>Hypothesis</th>
<th>Evidence (beta/p value)</th>
<th>Hypothesis Supported?</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1a</td>
<td>Professional language difference has a negatively effect on communication effectiveness</td>
<td>0.191/p&lt;0.001</td>
<td>No, Negative</td>
</tr>
<tr>
<td>H1b</td>
<td>Professional language difference has a negatively effect on academic outcome</td>
<td>NS</td>
<td>Not directly</td>
</tr>
<tr>
<td>H1c</td>
<td>Professional language difference has a negatively effect on clinical outcome</td>
<td>NS</td>
<td>Not directly</td>
</tr>
<tr>
<td></td>
<td>Professional language difference has a negatively effect on mutuality</td>
<td>0.047/0.08</td>
<td>No, negative</td>
</tr>
<tr>
<td>H2a</td>
<td>Perceived social-cultural difference negatively influences mutuality</td>
<td>NS</td>
<td>No</td>
</tr>
<tr>
<td>H2b</td>
<td>Perceived social-cultural difference negatively influences satisfaction on process effectiveness</td>
<td>0.093/0.003</td>
<td>No, negative</td>
</tr>
<tr>
<td>H2c</td>
<td>Perceived social-cultural difference negatively influences academic outcome</td>
<td>0.113/0.011</td>
<td>No, negative</td>
</tr>
<tr>
<td>H2d</td>
<td>Perceived social-cultural difference negatively influences clinical outcome</td>
<td>NS</td>
<td>Not directly</td>
</tr>
<tr>
<td>H3a</td>
<td>Social support has a positive influence on academic outcome</td>
<td>NS</td>
<td>Not directly</td>
</tr>
<tr>
<td>H3b</td>
<td>Social support has a positive influence on clinical outcome</td>
<td>NS</td>
<td>Not directly</td>
</tr>
<tr>
<td></td>
<td>Social support has a positive influence on mutuality</td>
<td>0.042/0.074</td>
<td>Yes, supported</td>
</tr>
<tr>
<td>H4a</td>
<td>Shared goals/vision has a positive influences communication effectiveness</td>
<td>0.756/ p&lt;0.001</td>
<td>Yes, supported</td>
</tr>
<tr>
<td>H4b</td>
<td>Shared goals/vision has a positive influences on Mutuality</td>
<td>0.818/ p&lt;0.001</td>
<td>Yes, supported</td>
</tr>
<tr>
<td>H4c</td>
<td>Shared goals/vision has a positive influences on satisfaction on collaboration process effectiveness</td>
<td>0.143/0.019</td>
<td>Yes, supported</td>
</tr>
<tr>
<td>H4d</td>
<td>Shared goals/vision have a positive influences on academic outcome</td>
<td>NS</td>
<td>Not directly</td>
</tr>
<tr>
<td>H4e</td>
<td>Shared goals/vision has a positive influences on clinical outcome</td>
<td>0.106/0.081</td>
<td>Yes, supported</td>
</tr>
<tr>
<td>H5a</td>
<td>Mutuality has a positive impact on satisfaction on collaboration process</td>
<td>0.128/ p&lt;0.001</td>
<td>Yes</td>
</tr>
<tr>
<td>H5b</td>
<td>Mutuality has a positive impact on academic outcome</td>
<td>NS</td>
<td>Not directly</td>
</tr>
<tr>
<td>H5c</td>
<td>Mutuality has a positive impact on clinical outcome</td>
<td>NS</td>
<td>Not directly</td>
</tr>
</tbody>
</table>

Note: the values are from the final model; NS: not significant.
2. The Mediating Effect of Communication Effectiveness (CE) (H6 and H7)

Mediating test in the absence and presence of mutuality and satisfaction on collaboration were performed to test the mediating role of CE. Table D6 summarizes the results of the tests. In the absence of mutuality and satisfaction on process effectiveness of collaboration, CE fully mediates the effect of professional language difference and shared vision and goals on academic outcome as hypothesized (H6, H7a). It partially mediates the positive effect of shared vision and goals on clinical outcome supporting H7b. In the presence of mutuality and satisfaction on collaboration process effectiveness, however, CE only mediates the effect of SVG on clinical outcome.

**TABLE D6**

**Summary of the Mediating Role of Communication Effectiveness**

<table>
<thead>
<tr>
<th>Hypothesis Supported?</th>
<th>Direct w/o CE w/o Mutuality w/o SPE</th>
<th>Direct with CE</th>
<th>Indirect with CCE</th>
<th>Hypothesis Supported?</th>
</tr>
</thead>
<tbody>
<tr>
<td>H6 Diff. on AO</td>
<td>0.086/0.099</td>
<td>0.037/0.472</td>
<td>0.049/0.005</td>
<td>Full</td>
</tr>
<tr>
<td>H7a Shared Vision/Goals on AO</td>
<td>0.193/&lt;0.001</td>
<td>0.008/0.885</td>
<td>0.184/0.008</td>
<td>Full</td>
</tr>
<tr>
<td>H7b Shared Vision/Goals on CO</td>
<td>0.206/&lt;0.001</td>
<td>0.152/0.064</td>
<td>0.096/0.091</td>
<td>Partial</td>
</tr>
</tbody>
</table>

3. The Mediating Effect of Satisfaction on Process Effectiveness (SPE) (H8, H9, H10)

Mediating tests in the absence and presence of CE and mutuality were conducted to illustrate the mediating role of SPE. Table D7 summarizes the results of the tests. In the absence of mutuality and CE, SPE partially mediates the positive effect of PSCD on
academic outcome and the effect of SVG on CO; it fully mediates the effect of shared vision and goals on academic outcome. In the presence of CE and mutuality, SPE partially mediates the effect of PSCD on academic outcome, fully mediates the effect of shared vision and goals on clinical outcome, but does not mediate the relationship between SVG and AO. Since there is no relationship between mutuality and AO or CO, my hypotheses of SPE mediating the roles of mutuality on AO (H10a) and CO (H10b) are not supported.

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Socio-cultural Diff. on AO</th>
<th>Shared Vision/Goals on AO</th>
<th>Shared Vision/Goals on CO</th>
<th>Mutuality on AO</th>
<th>Mutuality on clinical outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>H8</td>
<td>0.170/&lt;0.001</td>
<td>0.193/&lt;0.001</td>
<td>0.206/&lt;0.001</td>
<td>-0.036/0.764</td>
<td>0.01/0.9</td>
</tr>
<tr>
<td>H9a</td>
<td>0.138/0.006</td>
<td>-0.048/0.542</td>
<td>0.106/0.088</td>
<td>-0.137/0.211</td>
<td>-0.043/0.598</td>
</tr>
<tr>
<td>H9b</td>
<td>0.033/0.013</td>
<td>0.242/0.001</td>
<td>0.147/0.001</td>
<td>0.101/0.002</td>
<td>0.048/0.091</td>
</tr>
<tr>
<td>H10a</td>
<td>Partial, Yes</td>
<td>Full, Yes</td>
<td>Partial, Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>H10b</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TABLE D7**

The Mediating Effect of Satisfaction on Process Effectiveness

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Socio-cultural Diff. on AO</th>
<th>Shared Vision/Goals on AO</th>
<th>Shared Vision/Goals on CO</th>
<th>Mutuality on AO</th>
<th>Mutuality on clinical outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>H8</td>
<td>0.165/0.002</td>
<td>0.025/0.758</td>
<td>0.147/0.096</td>
<td>0.01/0.9</td>
<td>0.165/0.002</td>
</tr>
<tr>
<td>H9a</td>
<td>0.132/0.008</td>
<td>n-0.024/0.866</td>
<td>0.123/0.154</td>
<td>-0.043/0.598</td>
<td>0.132/0.008</td>
</tr>
<tr>
<td>H9b</td>
<td>0.033/0.007</td>
<td>0.218/0.008</td>
<td>0.129/0.037</td>
<td>-0.043/0.598</td>
<td>0.033/0.007</td>
</tr>
<tr>
<td>H10a</td>
<td>Partial, Yes</td>
<td>No</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H10b</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. **Controls:** Among the controls tested including sex, age, income and academic title, income has a modest positive relationship with both communication ($\beta = 0.069, p=0.009$) and mutuality ($\beta = 0.062, p=0.014$). Age positively influences clinical outcome ($\beta = 0.213, p<0.001$). Academic Title is positively associated with academic outcome ($\beta = 0.118, p=0.008$). Not surprisingly, age and income is significantly correlated ($\beta = 0.57,$
DISCUSSION

I. The Impact of Socio-Cultural Factors on SPP Effectiveness

The Influence of Scientist and Physician Difference on SPP

SPP faces many challenges similar to those of other inter-professional collaboration such as difference in structure, professional agenda, project aim, career progression and institutional pressure (Freeth, 2001: P44; Harris et al., 2008). Language problem, unequal power, and lack of guidelines for multiple authorship of research publications, are barriers to inter-disciplinary collaborations (Choi & Park, 2007; Choi, 2008).

My qualitative study also suggests that PSCD and profession difference may negatively affect SPP, and lacking of understanding in other’s profession may lead to lacking of mutual respect between difference professions. For example, as a MD commented in the interview:

“There’s a lot of name calling (between physicians and scientists) …Physicians should not regard PhD’s with arrogance and PhD’s should not regard physicians as idiots …Many times physicians feel like PhDs don’t understand their world. A lot of times there will be a disconnect and sometimes PhDs think physicians don’t understand their world. A physician will say you haven’t figured that out yet, and the PhD will say, what, are you nuts? You have absolutely no idea how hard that is”.

This suggests that professional language difference may have a negative influence on mutuality. To my surprise, professional language difference does not have a negative but has a positive influence on mutuality and a positive effect on CE as well, which in turn have a positive effect on both academic outcome and clinical outcome through their
effect on SPE. Similarity, perceived socio-cultural difference does not have a negative effect on academic outcome or clinical outcome as I hypothesized; instead, it has a direct positive effect on AO and on SPE. These findings are opposite to the conventional beliefs on the effect of the difference in professional language and social-cultural and economic status on communication, collaboration and the effectiveness of collaboration.

The unexpected positive effects of perceived socio-cultural difference and professional language difference on SPP effectiveness in this study context (i.e. voluntary participants who have collaborated) are important and exciting. It shows that the desire and determination of collaboration can overcome the professional language difference, overcome the socio-cultural difference. Indeed the difference and the limits of one’s own profession actually promote not inhibit the SPP, because people collaborate for each other’s expertise and strength.

In responding to my question asking the influence of PLD on their collaboration, less than 4% of the respondents agreed with the following statement: “the professional language difference between physicians and scientists prevented me from collaborating with PhDs /MDs”; 85% of them disagree with this statement; the remaining 11% neither agree nor disagree. This is consistent with what was discovered in my qualitative study where the respondents stated that they are not discouraged by the difference between physician and scientists, because they want to collaborate with people who have different set of skills, and the most exciting break-through discoveries usually occurs in collaboration across different disciplines and professions.
The Importance of Shared Vision and Goals (SVG)

SVG has a direct influence on CO, CE, mutuality and SPE, demonstrating the importance of SVG. Shared vision/goals are strong predictor of both communication effectiveness ($\beta=0.745$, $p<0.001$) and mutuality ($\beta=0.779$, $p<0.001$). SVG between partners would make them overcome the difference that different professions may experience such as difference in language and in socio-cultural status by showing respect and mutual understanding for each other’s perspectives and profession.

The fact that SVG has a direct positive effect on CO is particular interesting. Among all the institutional and socio-cultural factors I tested, it is the only independent variable that has a direct influence on CO. Other factors affect CO indirectly through their effect on AO and/or on collaboration facilitators such as CE, SPE and mutuality. This finding indicates that for a successful SPP, it is critical to identify collaborators who are common in the goals, agenda and process, roles and functions to be performed, the strategic direction and vision.

The Role of Social Support (SS)

The qualitative phase study identifies a role of social support in SPP. As a MD stated and many agreed “people are more helpful than organization”. The role of social support is confirmed in this quantitative study by our finding that social support has a positive effect on mutuality. Although the influence of SS on mutuality is weak, social support, especially support from spouse/partner is very important in SPP. This is reflected in our survey with 440 respondents, we asked the degree that “their spouse/partners would find their ways to do things to make their work life easier”. Sixty three percent of respondents responded with “very much”, and 21% with “somewhat”. This is supported
by an MD-PhD experience who stated that it would be impossible for him to do research without his wife’s support; because doing research carries a financial loss for physicians due to the lower income as a scientist compared to a physician.

II. Collaboration Processors

The importance of communication:

I found in study 3 that communication effectiveness (CE) fully or partially mediates the effect of organizational collaboration mechanism on academic outcome; academic promotion criteria and level of access difficulty to collaborators on academic outcome. This current study also demonstrates a crucial role of CE in mediating the effects of social-cultural factors on outcomes of collaboration. CE fully mediates the effect of professional language difference, social support, shared vision and goals on academic outcome and partially mediates the positive effect of perceived socio-cultural difference on academic outcome. In addition, CE predicts SPE ($\beta=0.442$, $p<0.001$).

Given the central and crucial role communication in mediating the effects of social-cultural and institutional factors on SPP effectiveness, strategies and mechanisms to promote and enhance communication effectiveness are highly recommended in order to improve SPP and collaboration outcomes.

The role of mutuality:

The level of commitment to collaboration is a critical variable in explaining success or failure of collaboration, and commitment requires mutual recognition or joint recognition (Ansell & Gash, 2008). Honesty, trust and respect are essential to the interdisciplinary structure (Satin, 1987 cited by Freeth, 2001: 39). Many other studies discuss the important function of mutuality in collaboration (Brinkerhoff, 2002; Thomson
However, despite the fact that our model adequately predicts mutuality ($R^2=0.715$), the role of mutuality in SPP is limited. Mutuality only has a positive effect on SPE; it has no direct impact on AO or CO; therefore, it does not mediate any relationships between IV and DV. This is an unexpected finding, because we reasoned, based on literature and our qualitative study, that mutuality would be the key collaboration processor in successful collaboration. It is possible that mutuality is not very important in a strong results-driven and goal-oriented collaboration like SPP. CE plays a more important role than mutuality does. This makes sense. In reality, people who communicate better can get the job done regardless if mutual respect or trust between physicians and scientist exists or not. Communication skills and power-influence may play a bigger role than mutuality in this type of collaboration.

**The effect of satisfaction on process effectiveness (SPE) of collaboration:**

Study 3 reveals that SPE mediates the positive effect of CE on both academic outcome and clinical outcome in addition to mediating the effect of academic promotion criteria on academic outcome (Wang, 2013). The model in this study adequately measures the satisfaction on process effectiveness (SPE) of physician and scientist collaboration ($R^2=0.570$). My data reveals a predicting role of SPE on physician and scientist collaboration effectiveness including both clinical ($\beta=0.164, P<0.05$) and academic outcomes ($\beta=0.338, p<0.001$). In addition, SPE mediates the effects of PSCD and SVG on AO, and the effect of SVG on CO. These findings agree with our earlier study (Wang 2012) and literature on the correlation between satisfaction and successful partnership (Geringer & Hebert, 1989).
III. A Good Model Measuring CE, Mutuality and SPE

My previous study focusing on institutional factors shows that the combination of collaboration mechanism, access difficulty and academic incentive only explains 13.0% of variance in communication. In this study focusing on socio-cultural factors, the combination of shared vision/goals and professional language difference explains 69.4% of variance in CE proving this is a good model predicting CE. In addition, shared vision and goals, professional language difference and social support together explain 71.5% of variance in mutuality indicating that this is a great model predicting mutuality between scientists and physicians. Among all the factors, shared vision/goals is the strongest predictor for both CE ($\beta=0.456, p<0.001$) and mutuality ($\beta=0.818, p<0.001$).

Furthermore, my model also adequately measures the satisfaction on process effectiveness (SPE) of physician and scientist collaboration ($R^2=0.570$).

**Predicting academic outcome (AO) and clinical outcome (CO):**

My model investigating the roles of organization factors on the outcomes of SPP shows a $R^2$ of 0.182 for academic outcome, and $R^2$ of 0.159 for clinical outcome. In this study focusing on the influence of social-cultural factors, the model shows that the social factors I tested including professional language difference, socio-cultural difference, social support and shared vision and goals explains only 13% of variance in AO and 15% variance in CO.

Given the complexity of SPP, it is not surprising to see the low predicting power of socio-cultural influence or institutional influence alone on SPP outcomes. Other factors such as personal attributes including motivation and personality may play important roles in SPP. In addition, factors such as randomness of discovery, funding and
regulatory have influence on both AO and CO as well. Study including these factors could potentially increase the power of predicting AO and CO.

CONCLUSIONS

I. Summary of Main Findings

This study was aimed to investigate the influence of socio-cultural factors on scientist-physician partnership (SPP) and collaboration outcomes. Contrary to traditional beliefs and the literature, my data reveals that professional language difference does not have a negative, but a positive effect on both communication and mutuality. Mutuality has a positive effect on SPE. Perceived socio-cultural difference has no relationship with either communication effectiveness or mutuality; it actually has a positive not negative effect on satisfaction on collaboration process effectiveness; it does not inhibit but promotes academic outcome (AO).

As predicted, shared vision and goals have a positive effect on communication effectiveness, mutuality and satisfaction on process effectiveness of collaboration. These factors in turn positively influence both academic outcome and clinical outcomes. Strikingly, SVG has a direct effect on CO. Social support influences academic outcome and clinical outcome through its direct impact on mutuality.

Communication effectiveness fully mediates the effects of professional language difference and shared vision and goals on academic outcome, and it partially mediates the effect of SVG on CO. Satisfaction on process effectiveness of collaboration partially mediates the role of perceived socio-cultural difference and SVG on academic outcome. It also mediates the effect of shared vision and goals on academic outcome.
II. Implications for Managerial Practice

My study uncovers the roles of social support, perceived socio-cultural difference, professional language difference and shared vision and goals on CE, Mutuality, SPE and academic outcome and clinical outcome. The data would be of interest to the academic community, medical centers, government and funding agencies. It has several implications for practice. Specifically, socio-cultural factors should be taken into consideration when designing a structure and mechanism to promote the effectiveness of SPP and other inter-professional collaboration.

1. This study demonstrates that people in different professions should not be discouraged to collaborate inter-professionally due to the concerns for the difference in professional languages or socio-cultural status, because PLD and PSCD do not inhibit but promote collaboration for determined collaborators. People at different professions should actively participate in inter-professional collaborations like SPP, because ground-breaking discoveries come out of most unlikely collaborations among different professions and disciplines as stated by a physician scientist.

2. To ensure successful and productive inter-professional collaboration, it is important to identify potential collaborators who share same vision and goals; it is important to communicate the plans, roles of individuals involved and objectives effectively among collaborators. In addition to its effect on communication, mutuality and satisfaction, SVG has a direct positive effect on CO demonstrating its critical role in inter-professional collaboration like SPP.
3. While the support from non-organizational sources is something out of organizational control, organizations can cultivate a supportive working environment by having supportive supervisors and co-workers. In addition, organizations should provide other supportive mechanisms such as the ones I identified earlier to provide an environment for effective communication between collaborators to foster a successful inter-professional collaboration.

III. Contribution

The important influence of socio-cultural factors on inter-disciplinary collaboration has been recognized but tends to be ignored (Unhelkar et al., 2010). I have developed new scales to capture the influence of PLD and PSCD quantitatively. I establish a model to measure the influence of social-cultural difference and professional language difference on CE, mutuality and SPE adequately. This is the first study to my knowledge to use psychometric measurement to investigate the relationships quantitatively between PSCD, PLD and outcomes of inter-professional collaboration such as SPP.

In addition to contributing to the literature of socio-cultural difference on collaboration, the surprising findings on the influence of difference in professional language and socio-cultural status between scientists and physicians provide new insights for inter-professional and inter-disciplinary collaborations. The surprising positive influence of PLD and PSCD, and the limited role of mutuality I found in this study will likely promote further research.

In conclusion, my study provides new insights and practical implications on the influence of social and cultural factors on inter-professional collaborations like SPP.
LIMITATIONS OF THIS RESEARCH

As with all research, this study has several limitations: 1) this study is based on single resource and single method obtained self-reported data. Nevertheless, CMB checks do not reveal any concerns. In addition, I have both subjective and objective outcomes in the study; 2) the data is from voluntary participants who have collaborated; this may at a certain degree bias the findings; 3) it is possible that the unexpected effect of professional language difference might be a result of construct specification; 4) the findings on the relationships between socio-cultural factors and the outcomes of scientist-physician partnership may be specific to the research field. Its generalizability to other cross-boundary and cross-disciplinary collaborations may need to be validated at other contexts.

FUTURE WORK

There are many lines of research that warrant further investigation: (1) Investigate the effect of personal attributes on SPP and academic and clinical outcomes. (2) Obtain data from non-collaborators. (3) Study the effects of other institutional arrangements such as government regulations, insurance policy, funding agencies and regulation, and hospital operations. (4) Conduct a longitudinal study by obtaining objective collaboration outcomes from non-self-reporting data resources such as public records on papers, grants, patents and clinical applications.
### Construct Table

<table>
<thead>
<tr>
<th>Construct</th>
<th>Items</th>
<th>Factor loading</th>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Perceived Socio-Cultural Difference (PSCD)</strong></td>
<td>1. There is a cultural difference between physicians and scientists</td>
<td>0.556</td>
<td>This study</td>
</tr>
<tr>
<td></td>
<td>2. There is a social and economic status difference between physicians</td>
<td>0.774</td>
<td></td>
</tr>
<tr>
<td></td>
<td>and scientists.</td>
<td>0.548</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Physicians have higher professional status than scientists.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Influence of Professional Language Difference (PLD)</strong></td>
<td>1. The professional language difference between physicians and scientists is the main reason that physicians and scientists do not collaborate with each other.</td>
<td>0.672</td>
<td>This study</td>
</tr>
<tr>
<td></td>
<td>2. The professional language difference between physicians and scientists prevented me from collaborating with PhDs/MDs.</td>
<td>0.756</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. I would collaborate more with people who speak the same professional language as I do.</td>
<td>0.492</td>
<td></td>
</tr>
<tr>
<td><strong>Social Support (SS):</strong></td>
<td><strong>How much does each of these people go out of their way to do things to make your work life easier for you?</strong></td>
<td></td>
<td>Caplan et al., 1975; 1980</td>
</tr>
<tr>
<td></td>
<td>1. Your spouse/partner</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Friends and relatives</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Your immediate supervisor</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Other people at work</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Shared Goals/Vision (SGV)</strong></td>
<td><em>My collaborator (in the above collaboration) and I had/have a common view of:</em></td>
<td></td>
<td>Cooke-Lauder 2006; Kaiser &amp; Shaw 2004</td>
</tr>
<tr>
<td></td>
<td>1. Goals and objectives of the project.</td>
<td>0.702</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Future plans and prospects.</td>
<td>0.748</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Roles and functions to be performed.</td>
<td>0.852</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. The strategic direction of the project.</td>
<td>0.893</td>
<td></td>
</tr>
<tr>
<td><strong>Mutuality</strong></td>
<td><em>My collaborator (in the above collaboration) and I did:</em></td>
<td></td>
<td>Cooke-Lauder 2006; Kaiser &amp; Shaw 2004</td>
</tr>
<tr>
<td></td>
<td>1. Could always rely on each other when it counted.</td>
<td>0.856</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Did not take advantage of each other.</td>
<td>0.618</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Were always ready and willing to support one other.</td>
<td>0.898</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Made every effort to keep to the commitments we made.</td>
<td>0.870</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Had a close relationship.</td>
<td>0.797</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. The degree of trust between my collaborator (in above collaboration) and I was (is)</td>
<td>0.774</td>
<td></td>
</tr>
<tr>
<td><strong>Communication Effectiveness (CE)</strong></td>
<td>1. Information flowed effectively between me and my collaborator(s).</td>
<td>0.898</td>
<td>Cooke-Lauder 2006; Judge &amp; Douglas 2009;</td>
</tr>
<tr>
<td></td>
<td>2. Information flowed effectively in a timely fashion.</td>
<td>0.923</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Both parties kept each other informed about the events that may affect the other.</td>
<td>0.913</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. I am proud of the collaborative project.</td>
<td>0.790</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. I learned new skills and competencies through this collaborative project.</td>
<td>dropped</td>
<td></td>
</tr>
<tr>
<td><strong>Satisfaction on Process Effectiveness (SPE)</strong></td>
<td>1. The goals of the collaborative project were achieved.</td>
<td>0.906</td>
<td>Cooke-Lauder 2006 who adapted from Saxton, 1997; Lui and Ngo, 2004</td>
</tr>
<tr>
<td></td>
<td>2. I would rate the collaborative project as a success.</td>
<td>0.847</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. I am very satisfied with the performance of this collaborative project.</td>
<td>0.799</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. There was strong two-way communication.</td>
<td>0.863</td>
<td></td>
</tr>
<tr>
<td><strong>Academic Outcome (AO)</strong></td>
<td>1. Were paper(s)/meeting abstract(s) generated?</td>
<td>Not applicable</td>
<td>This study</td>
</tr>
<tr>
<td></td>
<td>2. Were grants generated?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Were grants awarded?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Clinical Outcome (CO) | 1. Did the collaboration lead to clinical application(s)? | Not applicable | This study
| 2. Did the collaboration generate patents (in preparation, pending or awarded)? |

APPENDIX E
Interview Protocol

Introduction

Good morning/afternoon! Dr. NAME! I really appreciate your willingness to take the time to talk with me today. As I stated in my email to you, I plan to record the interview if it is fine with you. This is the consent form that I emailed you. Could you please sign it for me? If there are moments that you don’t want to be recorded, please let me know and I will turn off the recorder. Can we start now?

Questions:

Q1: Could you please tell me a little bit about yourself? Such as where did you go to school and how did you come to this point in your career?

Q2: Could you please think about a specific experience that you have had during the last 2-3 years in which you have worked with physician(s)/research scientist(s) on a research project or on transferring research findings into practice.

- Please tell me more as detailed as possible.
- Could you please give me examples?
- Can you elaborate on that?
- Please explain that.
- What motivated you to work with physician(s)/ research scientist(s)?
- What was the result of your collaboration?
- What knowledge, skills, habits or attitude helped or hindered the collaboration?
- What were the advantages, drawbacks and challenges of your collaboration with physicians/ research scientists?
- What did your organization do to encourage or discourage your collaboration with physicians/ research scientists?
- Were there any tensions and conflicts? How did you resolve them?
- What were the high points and low points in this experience?
- Did you enjoy it? Would you do it again?

**Q 3:** Did you have any other experiences in which you worked with physician(s)/scientist(s)? Perhaps a bad one for my learning purpose if you do not mind? An experience where the outcome was the opposite of what you planned or hoped for?

**Q4:** Were there any other significant experience(s) you would like to share with me regarding physician-researcher partnership and transfer of medical research into practice.

**Q5:** Is there anything else you would like to mention about your experience or opinion on the topics we talked today?

**Closing**

I think we covered the questions I have today. I may have additional questions when I review our conversation later. Is it possible for me to contact you again to clarify? Thanks again! I appreciate your time and help very much!
APPENDIX F
Survey Instrument

Q1. To what extent do you agree with the following statements?

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I do not know how to identify potential collaborator(s).</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I do not have access to the potential collaborator(s).</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td></td>
<td>○</td>
</tr>
<tr>
<td>There is limited time to collaborate with physicians/scientists.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td></td>
<td>○</td>
</tr>
<tr>
<td>I have received promotions because of the grants I obtained as the Principal Investigator.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td></td>
<td>○</td>
</tr>
<tr>
<td>I was promoted because of the papers I published as primary (first or last) author.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td></td>
<td>○</td>
</tr>
<tr>
<td>I restrain from collaborating because I need independent work to get promoted.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td></td>
<td>○</td>
</tr>
<tr>
<td>My organization does not encourage collaborative work.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td></td>
<td>○</td>
</tr>
</tbody>
</table>
Q2. Which of the following collaborative contexts exist in your organization?

<table>
<thead>
<tr>
<th></th>
<th>YES</th>
<th>NO</th>
<th>NOT SURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supportive leader(s) in a department /school /hospital</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collaboration office</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regular meetings with potential collaborators</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seminars</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organizing happy hours</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q3. Do you agree with the following statements on the differences between physicians and scientists?

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>There is a cultural difference between physicians and scientists.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>There is a social and economic status difference between physicians and scientists.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Physicians have higher professional status than scientists.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>The professional language difference between physicians and scientists is the main reason that physicians and scientists do not collaborate with each other.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>The professional language difference between physicians and scientists prevented me from collaborating with PhDs /MDs.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Collaborating with physicians is more expensive than collaborating with scientists.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I would collaborate more with people who speak the same professional language as I do.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Q4. Have you collaborated with a physician or a scientist?

- ○ Yes
- ○ No
**Q5.** Thinking about a recent collaborative experience, how much do you agree with the following statement?

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Our collaborative relationship was very satisfactory.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Some aspects of our working relationship could have been better. (R)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>My collaborator treated me well.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I really liked working with the collaborator.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>The goals of the collaborative project were achieved.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I would rate the collaborative project as a success.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I am very satisfied with the performance of this collaborative project.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I have learned new skills and competencies through this collaborative project.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I am proud of the collaborative project.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Information flowed effectively between me and my collaborator(s).</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Information flowed effectively in a timely fashion.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I met regularly with my collaborator.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Both parties kept each other informed about the events that may affect the other.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
There was strong two-way communication.

Q6. Thinking about the outcomes of the above collaboration, answer Yes or No to each question.

<table>
<thead>
<tr>
<th>Question</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Were paper(s)/meeting abstract(s) generated?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Were grants generated?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Were grants awarded?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did the collaboration lead to clinical application(s)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did the collaboration generate patents (in preparation, pending or awarded)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did you establish a sustainable collaborative relationship?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q7. What is the degree of your collaborator (in the above collaboration)?
- PhD
- MD
- MD-PhD
- Other

Q8. My collaborator (in the above collaboration) and I had/have a common view of

<table>
<thead>
<tr>
<th>Topic</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goals and objectives of the project.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Future plans and prospects.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roles and functions to be performed.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The strategic direction of the project.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q9. My collaborator (in the above collaboration) and I

<table>
<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Could always rely on each other when it counted.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Did not take advantage of each other.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Were always ready and willing to support one other.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Made every effort to keep to the commitments we made.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Had a close relationship.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
Q10. To what extent do you agree with the following statements on your career and goals?

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Neither Agree nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am willing to put a great deal of effort in order to be successful in this profession.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>I am proud to tell others that I am part of this profession.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>I am glad that I chose this profession.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>I really care about the fate of this profession.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>I enjoy trying to solve complex problems.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>I enjoy tackling problems that are completely new to me.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>The more difficult the problem is, the more I enjoy trying to solve it.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>I consider the primary purpose of my job is to make money.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>I am strongly motivated by the money I can earn through my job.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>I am keenly aware of the income goals I have for myself.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>I am strongly motivated by the recognition I can earn from other people.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>I want other people to find out how good I really can be at my work.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>To me, success means doing better than others in my organization.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

Q11. How much does each of these people go out of their way to do things to make your work life easier for you?
<table>
<thead>
<tr>
<th></th>
<th>Very much</th>
<th>Somewhat</th>
<th>A little</th>
<th>Not at all</th>
<th>Don't have any such person</th>
</tr>
</thead>
<tbody>
<tr>
<td>Your spouse/partner</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Friends and relatives</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Your immediate supervisor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other people at work</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q12. Please tell us more about yourself.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neither Agree nor Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am reserved.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am quiet sometimes.</td>
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<td>I am sometimes shy.</td>
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<td>I am inhibited.</td>
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<tr>
<td>I have a forgiving nature.</td>
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<tr>
<td>I am generally trusting.</td>
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<tr>
<td>I am considerate and kind to almost everyone.</td>
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<tr>
<td>I am a reliable worker.</td>
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<tr>
<td>I am persistent until the task is finished.</td>
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<td>I am efficient.</td>
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<tr>
<td>I am good at making and executing plans.</td>
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<td>I am ingenious.</td>
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<tr>
<td>I am imaginative.</td>
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<tr>
<td>I am inventive.</td>
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<tr>
<td>I am a deep thinker.</td>
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</table>

Demographic information about you

Q13. What is your gender?

- Male
- Female
Q14. Your age
- <30
- 31-40
- 41-50
- 51-60
- >60

Q15. Your academic title
- Postdoc
- Instructor
- Assistant Professor
- Associate Professor
- Full Professor
- Physician without Academic Title
- Other

Q16. Your degree(s) and year obtained
- MS ________________
- PhD ________________
- MD ________________
- MD-PhD ________________
- Other ________________

Q17. Your job category (primary career)
- Scientist
- Physician
- Physician Scientist
- Other

Q18. Your affiliation
- University alone
- Hospital alone
- Dual affiliation with both university and hospital
- Industry

Q19. Your income
- <50K
- 50K-100K
- 100K-150K
- 150K-200K
- >200K
REFERENCES


Baethge, C. 2008. Publish together or perish: The increasing number of authors per article in academic journals is the consequence of a changing scientific culture. Some researchers define authorship quite loosely. *Deutsches Arzteblatt International*, 105(20): 380.


Conn, L. G., Reeves, S., Dainty, K., Kenaszchuk, C., & Zwarenstein, M. 2012. Interprofessional communication with hospitalist and consultant physicians in

Cooke-Lauder, J. 2006 Social change–making the improbable possible through collaboration: Barriers and enablers to NGOs working together in South Africa to tackle hiv/aids. [https://library.case.edu/digitalcase](https://library.case.edu/digitalcase).


Kumar G 2009 *Unraveling adaptive selling: an empirical analysis of underlying relational behaviors*. Digital case at https://library.case.edu/digitalcase


Wang, Y. 2012. The valley of death in medicine is not only a knowledge translation but also a socio-cultural and institutional problem. Digital Case at https://library.case.edu/digitalcase/.


