Utilizing Control in Emergency Medical Services: Expertise in Paramedics

DISSERTATION

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By
Michael William Smith
Graduate Program in Industrial and Systems Engineering

The Ohio State University
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Dissertation Committee:
Professor David Woods, Advisor
Professor Philip Smith
Professor Sharon Schweikhart
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Abstract

Paramedics provide pre-hospital care by virtue of demonstrating competency (in terms of knowledge and skills) and following protocols. At the same time, they serve as a major bridge between the hospital where emergency care is provided, and the complex world where a diversity of people, health problems, and environments interact to bring about emergency situations. As such, paramedics must manage complex, ambiguous, and novel situations under dynamic time and resource constraints.

Expertise develops to fill in the gap between the protocols and associated competencies on one side, and the demands of the complex world on the other side.

The expertise developed by paramedics reflects the nature of the challenges they confront. Given the increasing interdependency between components in the health care system, and the greater breadth and complexity of cases confronting paramedics, it is important to conduct systematic exploration of paramedics’ capabilities in responding to the demands of the complex world.

To investigate these issues, a two-phase cognitive systems engineering research study was conducted. The first phase used knowledge elicitation methods with a focus group panel of subject matter experts to clarify the challenges and trends.
affecting EMS work, and to define specific challenge cases that highlight expert
performance in paramedics. The second phase was a staged-world study,
incorporating two of these challenge cases into scenarios (a chest pain diagnosis
scenario and a multiple patient management scenario). New paramedics (twelve
months or less of experience) and very experienced paramedics (identified by
supervisors as experts) went through these scenarios in a mixed-fidelity
simulation.

For the chest pain diagnostic scenario, half of the less experienced paramedics
correctly determined that it was not a cardiac issue, but none of them pursued
alternate explanations very thoroughly. The more experienced paramedics went
beyond standard procedures for determining whether chest pain is a heart attack
or not. They explored more alternate explanations, and were more likely than the
less experienced paramedics to identify the issue (pulmonary embolism) without
additional cues.

In the multiple patient scenario, the more experienced paramedics switched
focus of attention from one patient to the other more frequently, and used their
Emergency Medical Technician (basic level) partner to perform a greater variety
of tasks than did the less experienced paramedics.

In both scenarios, the expert paramedics were able to modify their approaches to
respond to the demands of the situations, whereas the less experienced
paramedics were relatively more static in their approaches.
These results highlight important aspects of performance that are not captured by traditional concepts of competency, nor by protocols. Furthermore, the adaptive capacities of these experts, and their abilities to employ broader means of control, have implications in the context of distributed care. These facets of expertise enable greater control of patient disposition and utilization of resources in the service of care for that particular patient, and the future capabilities of the paramedic unit.
To Adriana and my father
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**Vita**

1993......................................................... B.A. Psychology, New College of Florida

1993–1994 .............................................. Research Assistant, University of North Carolina at Chapel Hill

1998......................................................... M.S. Ergonomics, University of Miami

1998–2001 .............................................. Human Factors Engineer, Hewlett-Packard (contract), Clearwater Research

2001–2006 .............................................. Senior Research Associate/Usability and Performance Researcher, Stein Gerontological Institute

2006 to present ...................................... Research Associate, Cognitive Systems Engineering Laboratory, The Ohio State University

**Publications**


Fields of Study

Major Field: Industrial and Systems Engineering
Specialization in Cognitive Systems Engineering
Minor Field: Health Systems
Minor Field: Information Analysis
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Chapter 1: Introduction

1.1 Research Problem

As a way of managing the quality of care provided by paramedics, Emergency Medical Services (EMS) require that paramedics follow particular protocols, designed to guide assessment and care processes. Paramedics are also required to possess the knowledge and skills necessary for competent performance. However, the challenges and opportunities posed by the complex world where medical emergencies happen can exceed the space defined by the competencies and protocols.

Important forms of expertise are developed and utilized as paramedics go beyond competencies and protocols in managing complex, ambiguous, and novel situations under dynamic time and resource constraints.

This research study explores this expertise, focusing on cognitive challenges common to complex domains. Scenarios are used to replicate particular sets of challenges, such as: the “garden path” problem (in which people may fail to properly revise initial hypotheses in light of new information), change blindness (in which an important event develops slowly and subtly against a noisy background), and managing multiple demands with limited resources.
Expertise is developed and expressed in the context of work. For paramedics, the immediate environments they work in, and the larger context of the EMS system, contribute to the difficulties, but also provide the means of accomplishing the work. Systematic observations of paramedic performance in an appropriately representative environment can yield insight into the ways sharp-end practitioners go beyond textbook knowledge and generic protocols, and utilize resources to exert control in achieving goals.

1.2 CSE Approach

Cognitive Systems Engineering (CSE) is a well-suited approach for exploring the performance of paramedics in Emergency Medical Services. CSE is focused on how people deal with complexity in their work (Hollnagel & Woods, 2005). It can facilitate explorations of trends and future states, which enables these factors to be considered in short-term systems development cycles — unlike more time-consuming and retrospective research approaches (Nemeth, 2008). Because the CSE approach involves not only domain-specific details, but also more abstract patterns observed in multiple domains (Woods & Hollnagel, 2006), it enables research and design-concepts from other complex domains to help inform descriptions of and solutions for EMS — and vice-versa.

A set of core values and associated fundamental activities from Woods & Hollnagel (2006) lays the basic framework of the CSE research approach:
• Obtain an authentic portrayal of work as practiced in the domain by working with practitioners in the domain, observing work in its context, and striving to understand the system in which work takes place.

• Extract maximum value from these observations through abstraction to cross-domain patterns of adaptation in complex work.

• Generate explanations of those patterns.

• Generate insight about the work of the domain, and auspicious innovations for adapting to complexity.

• Influence systems development as researchers and designers with hypotheses, in the context of dynamic organizations of multiple stakeholders.

1.3 **Objective I: Identify Cognitive Challenges in Paramedic Work**

1.3.1 **Complexity in EMS**

The domain of EMS is complex. There are many interdependent parts at multiple levels that affect the constraints and opportunities confronting the paramedic — patient physiology and psychology, family dynamics, other emergency medical technicians and paramedics, other public safety and medical providers. All of these elements can influence one another, and in inconsistent and disproportionate manners. The paramedic has limited time and resources with which to comprehend and influence the state of these elements.
The requirements of managing the components of the EMS system, and providing responses to calls, are distributed among multiple actors, fulfilling various roles in different locations and organizations. The work of these actors must happen in coordination. Managing shared resource and synchronizing interdependent tasks are themselves additional cognitive demands.

The time window in which paramedics have access to the patient is a critical one, in which there are unique opportunities to reduce the harm resulting from acute medical problems or trauma. Decisions about stroke or heart attack care are made during this time. The decision about which hospital to deliver the patient (which can have significant consequences) is made during this time. During this time window, paramedics must simultaneously protect the patient’s vital functions and address the patient’s pain and emotional condition; assess the signs and symptoms, and form presumptive accounts for the patient’s condition; and plan for the transport and transfer of the patient to the most appropriate of many possible receiving institutions.

Trends affecting EMS suggest that the complexity of the work will continue to increase. The scope of work continues to move from implementation of protocols and transport, to more complex problem solving, assessment and treatment (Ball, 2005; O'Meara, 2009). Demographic shifts mean that more patients will be geriatric, with co-morbidities, multiple medications, and greater dependencies (McGinnis, Moore, & Armstrong, 2006). New technologies are being introduced (McGinnis et al., 2006), bringing with them new opportunities and constraints to be managed.
Various EMS improvement efforts proposed by the Institute of Medicine (2007) all involve new attention and workflow patterns (the drive for coordination and communication among safety and health workers); new stake-holders and risk-management factors to be considered (the drive for accountability); and/or new information analysis and sensemaking steps (the drive for evidence-based protocols).

1.3.2 Means of management

The ambulance crew performs these tasks with no direct supervision. They have guidelines and protocols to follow, but there is a shortage of research on best practices in emergency pre-hospital care, and the recommendations necessarily address idealized, simplified cases, and often do not provide clear instructions for the wide range of complex circumstances confronting paramedics.

Given these demands and responsibilities, EMS, like other areas of health care, and other high-stakes industries, relies on making sure the people filling the role of paramedic (or other emergency medical technician) meet certain criteria regarding their knowledge and skills — the competency of the practitioner to perform as a paramedic.

As one aspect of protecting quality of care, limiting authority to practice based on a well-researched set of knowledge and skills is a widely accepted method with many benefits. But as a framework to understand how paramedics successfully manage the complexity of their work, it is insufficient.
As discussed, paramedics are confronted with such a wide range of situations that established guidelines – or established requisite knowledge and skills – may not be adequate in specifying the range of appropriate responses. Additionally, the set of challenges, tools, and protocols is changing. More patients are obese (presenting challenges with handling and access). More patients are older, and on more medications. Call volumes are increasing. New technologies are being introduced. There is generally a time-lag between when new problems or opportunities are presented, and when research provides reasonably clear indications of the proper response with respect to the range of patients in the real world.

Nonetheless, paramedics successfully cope with the challenges of their work. They adapt to unanticipated situations. Based on experiences, feedback, and reflection, they develop emergent strategies to manage challenges. The concept of expertise provides the framework for exploring the processes by which paramedics are able to manage the cognitive challenges in their work.

1.4 Objective II: Develop and Apply Methods to Assess Patterns of Cognitive Performance

1.4.1 Limits of “pencil and paper” methods

Particular methods are required to study cognitive patterns in complex, high-stakes, fast-tempo work. The approaches used elsewhere for exploring health care provider performance are not suited for exploring cognitive adaptations to
complexity. The knowledge- and skill-assessment methods used for certification testing necessarily focus on unambiguous problems (Kane, 1992), while in practice paramedics are confronted with situations which could not be part of standardized tests, such as: missing required information, situations in which different responses are justifiable, and even situations for which mutually exclusive guidelines apply.

Some assessment and research methods [e.g., scripts concordance test (Charlin, Roy, Brailovsky, Goulet, & Van der Vleuten, 2000)] examining diagnostic reasoning use text or other self-paced presentations of case information. The examinee is presented with a sequence of information, rather than actively searching for desired information. The environment is devoid of information or memory cues. The examinees are presented only with problem to be solved, as opposed to a failing dynamic system that needs to be actively managed while simultaneously trying to solve the problem. Even if a time limit is set, the tempo is independent of any interventions.

Observations of paramedics on the job are essential in understanding the domain, but by themselves will not expose the patterns of cognitive work paramedics use to manage complexity. The adaptations may be executed with such fluency that the challenges are undetectable (as per the “Law of Fluency”, Woods & Hollnagel, 2006, p. 171). Field observations will not allow for repeated measures, or for comparisons between different sets of practitioners, such as
novices and experts (which is important for seeing which behaviors are expert adaptations).

1.4.2 Requirements for a Staged-World study

In using the CSE approach, developing the methods essentially involves creating a “tentative model of practice” (Woods & Hollnagel, 2006, p. 47), incorporating insightful problems and meaningful contexts. Identifying and verifying these problems and contexts requires iterative consultations with domain experts and other resources, and deliberate application of patterns of cognitive complexity.

The staged-world research method (Woods & Hollnagel, 2006) was developed to support observation of cognitive strategies used by practitioners as they cope with the challenges in their domain. Scenarios are scripted which involve challenging problems. The scenarios are then staged via a mixed-fidelity simulation, in which participants interact with the elements of the simulation similar to their interactions with the elements in their work.

Face validity is indispensable for participant practitioners to feel engaged and valued in what is necessarily a collaborative endeavor. Meaningful decisions and actions, along with physical interactions with artifacts, and social interactions with other people (partners, patients), are important for making the participants’ plans, actions, and conclusions observable.

Functional analyses are used to ensure that the simulation presents the requisite information and means of interaction in the appropriate fidelity. Appropriate
affordances and limits are integrated into the simulation. Information and artifacts are distributed in space; movement and searching is required to acquire them, but they are present in the environment to serve as cues and memory aids. Demands of immediate and longer-term time frames are presented. Interventions by the participant are incorporated into the flow of the scenario. The mixed-fidelity simulation balances out some of the issues involved in low- or high-fidelity simulations. Important aspects are realistic enough to elicit authentic responses from the participants, yet it also supports greater adaptability and flexibility on the part of the researcher/administrator, and easier detachment and reflection on the part of the participant. The cognitive challenges, and the means by which they are presented, are designed to support generalizability from the testing situation to the world of the target domain.

1.5 **Objective III: Develop an Understanding of Expertise in Paramedic Work**

1.5.1 **Need for enriched understanding of paramedic performance**

Most research on paramedic performance looks at patient outcomes, or competencies, or looks at narrow slices of work with methods designed for medical students or other office- or hospital-based providers. These approaches
do not address the means by which paramedics wield their expertise by utilizing strategies to manage the cognitive challenges in their work.

Concepts of how paramedics perform work influence organizational, training, and systems design. It is important that these designs are informed by an understanding of paramedic performance that includes the patterns by which paramedics handle complexity.

The opportunities for new information and communication technology in EMS are already being explored. The increasing call volumes in EMS, the wider scope of patients utilizing EMS, and the issue of crowding in Emergency Departments all point to the need for enabling greater adaptability, and broader and deeper coordination mechanisms, in EMS. Paramedic expertise is central in these processes of adaptation and coordination.

1.5.2 Exploration of patterns of cognitive performance

This enriched understanding of paramedic performance is generated by exploring patterns in terms of both the domain-specific factors of the cases (what they did as paramedics), and the abstract patterns of cognitive strategies (what they did as cognitive agents) (Woods, 1993; Woods & Hollnagel, 2006, Ch. 5).

The patterns are explored relative to the problem-space defined by the scenario (in terms of specific cognitive challenges, and in terms of a priori canonical paths), and relative to the patterns displayed by other sets of participants. The
classic psychology method of comparing “novice” (or less experienced) and “expert” (or more experienced) practitioners can make the expert strategies apparent.

Seeing these patterns in terms of the facets of expertise observed in other naturalistic studies (see Charness & Tuffiash, 2008; Norman, Eva, Brooks, & Hamstra, 2006) shows how these facets present in paramedic work. This understanding of paramedic expertise, compared to definitions of paramedic competency, highlights important hidden processes, and provides useful guidance for systems design.

1.6 **Expertise in Context**

Given the authority of public safety incident commanders in the field, and of emergency medical physicians in the ED, the paramedic’s envelope of authority is fairly constrained. Furthermore, as extensions of the authority of the EMS medical director, they are in principle limited to following specific protocols. However, as this research shows, paramedics can and do develop expertise. Experienced paramedics are able to utilize their own knowledge, people and other resources to manage patient care in complex situations and pursue their goals.

Examining expertise in this rich context presents a picture of expertise that touches on multiple levels: the required propositional knowledge and psychomotor skills of the paramedic; the material resources and the people on scene; and the various stake-holders and social resources in the distributed
system (including EMS resources, ED resources, and the paramedic his-or herself as an agent in the system).

As the paramedic experiences and learns from more and more cases, his or her relationships with these elements change. The people, and the other elements, are understood more in terms of functions and capabilities relative to types of situations and goals. Expertise lies in the degree to which the paramedic can utilize these elements.

To explore this expertise in context, two studies were conducted: a knowledge elicitation study, and a staged-world study. The knowledge elicitation study was conducted with a panel of experts. Cognitive challenges, and characteristics of expertise, were identified. The staged-world study included two challenge scenarios presented to two groups of paramedics (less and more experienced) with the use of a mixed fidelity simulator.

The tactics of experts elicited in these scenarios include: more fluid attention management; use of resources in a greater variety of ways; and broader and deeper hypotheses exploration. Additionally, the contrast of the knowledge elicitation study and the staged-world study illustrates how different methods can focus on different aspects of cognitive work.
Chapter 2: Background and Literature Review

2.1 Domain of EMS

Emergency Medical Services (EMS) systems in the US developed from military programs; initiatives providing first aid training to fire-fighters; advanced care “heart-mobiles” and similar programs; and standardized training overseen by the Department of Transportation (Pozner, Zane, Nelson, & Levine, 2004). The initial role of transporting critically ill or injured patients to hospitals expanded to include limited medical intervention, with care providers acting as remote agents under the authority and license of a medical director.

Emergency Medical Services can refer to the whole set of organizations, facilities, etc. that provide care or transportation for treatment for medical emergencies. This includes emergency departments, trauma centers, dispatch, various ambulances, and first responders. More typically (and how it is used here) EMS refers just to the system of mobile care providers and transportation resources that serve people outside of the hospital.

EMS systems differ widely across locations, due to differences in medical direction, population density and characteristics, financial resources, and other
factors. Most systems are managed as part of the fire department, but many are run as independent public safety services (private or public), or out of hospitals. Emergency Medical Technicians (EMTs) are trained and certified specialists who can provide certain medical treatments under the authority of their EMS system’s medical director. They can do more than first responders or ambulance drivers. Paramedic-level EMTs (EMT-Ps, henceforth paramedics) are the highest general level of EMTs in the US. Training is around two years, and their scope of practice includes Advanced Life Support (ALS) procedures such as administering certain medications and performing intubations. Basic-level EMT’s (EMT-Bs) have less training, and can only perform Basic Life Support (BLS) procedures. EMT without further specification refers to Basic-level EMTs.

2.2 Control of Performance in EMS

Competency, as the basis for permitting an individual to practice work of a particular level of risk, arose as a contrast to assessment or certification based solely on exposure to training (Albanese, Mejicano, Mullan, Kokotailo, & Gruppen, 2008; Carraccio, Wolfsthal, Englander, Ferentz, & Martin, 2002). Discussions of competency have extended this further, recognizing the importance of more emergent capabilities. Epstein and Hundert (2002) discuss ‘habits of mind’ (including reflection and personal knowledge) and dealing with ambiguous problems as aspects of competency. This broad scope describes the capabilities of a good paramedic, but it does not shed any light on the nature of those capabilities and the processes and work environments that give rise to
them. Unlike an approach oriented on expertise, approaches oriented on competency use (in principle if not in practice) a static picture of the domain of work. The requirements for performing work are defined in terms of sets of propositional knowledge and procedural skills.

The limitations of current concepts of competency are recognized by educators, researchers, and certification bodies (G. Margolis, personal communication; Albanese et al., 2008; Carraccio et al., 2002). Understanding practitioner capability in complex, dynamic systems requires more a binary value (competent or not) based on limited measures of a subset of propositional knowledge and procedural skill.

In principle, the work of paramedics is bound by protocols. However, protocols are limited in how well they support work in ambiguous, unpredictable situations (Klein, 2009), such as those involved in much of paramedic work. Furthermore, the clinical studies providing an evidence-base for pre-hospital care protocols are few in number and narrow in scope (Smith et al., 2007). Paramedic work often involves challenges for which there is no unambiguous right way to proceed.

### 2.3 Expertise

The dimensions of work that are not well supported by protocols (e.g., handling novel situations, exploiting new opportunities, practicing reflection and recognizing limitations, developing new strategies, and managing uncertainty)
are the types of emergent cognitive patterns that characterize expertise (Charness & Tuffiash, 2008; Crandall, Klein, & Hoffman, 2006).

The literature on medical expertise is focused heavily on diagnostic reasoning (Norman et al., 2006), at the expense of research on expertise in care planning, treatment, etc. For practitioners engaged in safing acts simultaneously with diagnostic reasoning, the two are not independent, and interact with the process of (re)planning as well (Woods & Hollnagel, 2006). While pathologists (for example) may be able to focus solely on diagnosis, paramedics have the burden (and opportunity) of performing therapeutic interventions while updating care plans and attempting to generate and evaluate presumptive diagnoses.

Furthermore, there is a shortage of research on cognition in EMTs and paramedics (Feufel, Lippa, & Klein, 2009; Shaban, Wyatt-Smith, & Cumming, 2004). A few studies have explored paramedic decision-making with regards to following protocols for specific types of cases. Examples include: assessment and disposition of psychiatric patients (Shaban, 2006); endotrachial intubation (Wang & Katz, 2007); resuscitation (Grudzen et al., 2009); and disposition of elderly patients who fell (Halter et al., 2010).

Only a very few studies look at paramedic cognition more broadly. One study (Jensen, 2010; Jensen, Croskerry, & Travers, 2009) used a Delphi study with paramedics and medical directors to identify important decisions made by paramedics, followed by a small pilot study using text scenarios of two cases to
elicit reasoning patterns from experienced and newer paramedics. Findings stress the number of important decisions occurring during the on-scene treatment phase of responses, and the variety of reasoning strategies that paramedics employ. The only difference between the novice and expert paramedics was the greater number of decisions explicitly made by the experts. An important limitation of this and other studies which use scenarios or similar representations of cases presented in text-based, self-paced format is the lack of fidelity for the nature of the information provided, and lack of any tempo pressures. The perception of informative patterns in stimuli, and the awareness and management of time, are important attributes of expertise in dynamic, physical domains (Shalin, Geddes, Bertram, Szczepkowski, & DuBois, 1997).

Campeau (2008a, 2008b) used in-depth interviews with paramedics and a grounded theory analysis to explore the nature of what distinguishes paramedic work from that of other providers. The findings emphasize the importance of being able to manage the social and physical environment of the scene. Turning an uncontrolled scene into a space for providing medical care is a valued skill. The cognitive tasks include social negotiations, anticipating constraints, and making trade-offs.

Another study (Wyatt, 2003) involved interviews and observations of a small number of experienced paramedics. The focus is on tacit knowledge and its role in facilitating judgment. These expert paramedics were able to manage routine
cases by utilizing case-based reasoning. Non-routine cases required the addition of more general problem solving heuristics. Other findings include the ability to use multiple sources of information concurrently, and an openness with proceeding with cases without narrowing down the diagnosis.

An acknowledge limitation with this study (Wyatt, 2003) is the dependence on external field observations and interviews to gain insight into tacit processes. Even for those who debate the problem of tacit knowledge in knowledge elicitation (Hoffman & Lintern, 2006), an ethnographic approach is insufficient.

In exploring the cognitive strategies that have become manifest in the experts’ management of complexity, observations (and potentially interviews) will be insufficient. The adaptations may be executed with such fluency that the challenges are undetectable (as per the “Law of Fluency”, Woods & Hollnagel, 2006, p. 171).

As a means of exploring expertise, these latter two studies do not benefit from between-participant comparisons – in particular comparisons between less and more experienced practitioners, which are important for highlighting which behaviors are adaptations to complex challenges.
Chapter 3: Study I—Knowledge Elicitation

3.1 Background

3.1.1 Goals

The panel discussion was conducted at the National Registry for Emergency Medical Technicians (NREMT) on December 14 and 15, 2009. The goals were to validate the research team’s initial understanding of the current and future challenges in EMS, to identify in more detail some of the main cognitive challenges in the work of paramedics and how competence and expertise influence management of those, and to generate candidate scenario ideas for further exploration of expertise in paramedics.

3.1.2 Methods

The method of using a focus group approach for knowledge elicitation was useful for this study as the participants were able to discuss commonalities and differences across their EMS systems, and share stories indicative of the challenges in pre-hospital care and EMS operations. General preparation work included researching current issues and trends in EMS (e.g., (Institute of Medicine, 2007), interviewing paramedics, and observing paramedic work in stations and in the field. Paramedics affiliated with different
organizations were consulted, to ensure that more than one perspective on controversial issues were captured. Potential areas of challenges, relating to patterns of distributed work, interaction among agents, and issues of communication, were identified with the use of a work structure map (Figure 3.1).

A list of complexity factors (from Patterson, Roth, & Woods, 2010) was developed to use in detecting and probing for examples of challenges. Examples of complexity factors include:

- Multi-threaded work
- Interdependency among roles
- Attention demands
- Fixation
- Change blindness
- Hidden side-effects
- Multiple hypotheses (large differential diagnosis)

Tactics for managing engagement were identified, including cues for eliciting stories (e.g., “When was the last time you...?”), for shifting away from lecturing to more sharing (e.g., “What would it mean for X to be different?”), and for eliciting comparisons (e.g., “How would a nurse, as opposed to a paramedic, have handled the case?”, “What would an expert have done differently compared to a novice”?).
The session began with an explanation of the research goals, and a “round-the-table” session on what each participant wanted to get out of the activity. This helped the important goal of the panelists being treated as partners in the research effort. Periodically, the panelists were asked to reflect on how the session was going, and to what extent their goals were being met.
The sequence of topics was arranged so that topics of common knowledge and interest, with concrete components, were at the beginning, in order to facilitate engagement and building of rapport. The first day was somewhat open, with a few topic ideas (technology, coordination, training), but primarily driven by the issues raised by the panelists. The second day was more structured and focused. General requirements for the scenarios were shared, and specific scenario ideas were discussed.

The author led the facilitation effort, with other research team members contributing. The discussions were audio-recorded. An extended summary was generated by the author, based on observation notes from multiple research team members, and the author’s transcription of the audio recordings. Additional sources were consulted to confirm and clarify items as necessary. See Appendix B: Expert Knowledge Elicitation Findings Summary.

### 3.1.3 Panelists

There were five panelists – all highly experienced paramedic supervisors and trainers, representing diverse geographical areas and EMS system types. The organizations the panelists had been with most recently for an appreciable length of time are listed below:

- Huge city, fire-based service
- Multi-city region, private service
- Large city, fire-based service
- Medium city, third service
- National certification organization

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They had been paramedics for an average of 25.2 years (ranging from 21 to 30), and had been going on calls (as 1st responder, EMT, or paramedic) for an average of 28.4 years (range from 25 to 39).

Table 3.1: Panelists' Experience with Different Types of Services

<table>
<thead>
<tr>
<th>Type of Service</th>
<th># with MAIN or CURRENT Experience in each service type</th>
<th># with ANY experience in each service type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire-based</td>
<td>2</td>
<td>All 5</td>
</tr>
<tr>
<td>Private</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>3rd service</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Hospital</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td>1 (volunteer EMT rescue)</td>
</tr>
</tbody>
</table>

3.2 Challenges in Paramedic Work

Less access to social services and non-emergent medical services increases dependence on Emergency Medical Services (EMS). Medical calls are more complicated for EMS than are trauma calls. Public health and demographic trends mean that more EMS calls involve patients who are elderly, obese, and/or have multiple chronic health problems. Dispatch algorithms and evidence-based protocols are not always suited to managing complex cases.

Due to political pressures, many municipalities have only Advanced Life Support (ALS) units, staffed by paramedics. The effect of this is that more responders become paramedics, and that these paramedics spend most of their time on Basic Life Support (BLS) calls. Because they do not get much practice with ALS techniques, they may not develop expertise as quickly as in other configurations.
However, in tiered systems (with both BLS and ALS units), there can be pressures in the opposite direction, with ALS units cautious about overuse, and BLS units cautious about unnecessary handoffs to ALS units, leading to patients being under-served.

The cognitive work of EMTs/paramedics on a call begins with assessing the scene, and with the team lead of the unit assuming command of the incident, as applicable. The initial assessment and planning for the patient is generally made very quickly, with modifications being incorporated as more information is uncovered. In calls that initial present as stereotypical cases, it can be difficult to revise the initial impressions and plans.

For medical calls in particular, assessment involves distinguishing between the person’s normal state, and the change that precipitated the call for EMS. Family members can be a resource for identifying what is different. Assessment instruments, such as EKGs, can provide a great deal of information about the state of the patient. However, it is easy to overlook other important cues when focusing on simple indicators in the EKG tracing. In addition to signs and symptoms directly observable in the patient, there are important but subtle cues in the full set of patterns in the 12-lead EKG tracing. Knowing when a simple assessment algorithm may not be applicable, when a particular treatment protocol may warrant modification, and knowing when one’s own knowledge and capabilities are insufficient for a situation, are all aspects of competency.
Much of the knowledge involved in the decision about patient disposition is specific to the given EMS system (and thus not something that is part of standard training or certification). It involves an understanding of hospital capabilities and current status, in addition to patient preference and insurance coverage, and the nature of the medical issues. Of course, for some systems, disposition protocols or a very small number of hospitals within a given region mean that little or no decision-making is required.

The hospitals rely on the EMTs/paramedics to bring in patients, who are a source of revenue. When the EMS units begin to utilize or otherwise value a particular procedure or technology for particular conditions, they will have a preference for taking patients with those conditions to hospitals that use that particular procedure or technology. This drives other hospitals to adopt the new procedure or technology.

In many systems, paramedics have a variety of options other than taking the patient to an ED (catheter lab, surgery, observation unit, and even treating without transporting). However, utilizing these options typically involves negotiations with other stakeholders, such as the medical director or ED staff. Maintaining credibility with these stakeholders enables the paramedics to gain access to resources for their patients, and thereby have a greater influence on the outcome of patients. Avoiding extended negotiations, and entrapment in crowded EDs, enables the paramedics to return to service more quickly.
However, coordination with ED staff regarding patient disposition is often challenging, given the differences in perspectives and incentives between paramedics/EMTs and ED staff. Triage nurses have protocols to follow, and have a responsibility to allocate care resources for the incoming patient as well as the other patients in the ED. Paramedics want to make sure that their patients are going to get proper care, and to make sure that they are available to for other people in the field in need of emergency care.

There are differences between stakeholders in the field as well. Other responders, including police and fire, have their own perspectives and incentives. The common dual-role of fire-fighter/paramedic can sometimes lead paramedics and fire commanders to utilize their fire-fighting capabilities despite a need for having available paramedics on hand.

These differences in the perspectives of stakeholders can occur at higher organizational levels as well. Most EMS systems do not have a medical director who has special training in overseeing an EMS. Some EMS’s have medical directors who are not even emergency medicine physicians. For some fire-based EMS systems, decisions impacting the EMS are made by fire chiefs who have outdated or no paramedic experience. While the role of EMS specialists in medical direction and in public safety is increasing, there are many systemic issues currently confronting EMS in need of attention at high levels.
See Appendix B: Study 1 Summary for a more detailed summary of the panel discussions.

3.3 **Challenging Scenarios**

On Day 2, the panelists were asked to suggest scenarios that would help distinguish expert and novice paramedics. A list of scenario concepts, and some generic requirements for staged-world scenarios, was presented to the panelists to guide the discussion. This list was developed by the research team the previous evening, based on the discussions of Day 1, and the relevant cognitive complexity factors.

The panelists discussed various challenges, and a consensus formed around three particular scenarios, which were then explored in more depth. For each of the three scenarios, the panel and the research team determined the general flow of events, the decision points, the information required by the paramedic, the likely courses of action for both experts and novices, and the consequences of those courses of action.

3.3.1 **Two trauma patients**

The paramedic is presented with two patients – a head shot victim and a chest shot victim. The paramedic must make a prioritization decision. A novice may become fixated on one patient, and neglect to manage the larger situation. The paramedic must recognize that the head shot patient is dying and should not
consume all the resources (thereby threatening the life of the chest shot patient). He or she must not fixate on implementing interventions.

Once in route, the paramedic must be aware that patient status is not static, and requires reassessment. He or she must recognize the unintended side-effect of an earlier intervention (the occlusive dressing on the bullet wound traps air in the chest, preventing lung expansion during breathing), and respond.

3.3.2 **Elderly patient fainting**

The paramedic is presented with an elderly patient who (upon initial examination) has the symptoms of a not-uncommon and non-urgent problem – fast but inefficient heart beat (tachycardic) associated with low blood pressure and fainting. The paramedic should suspect that this is the problem, but continue to do a full assessment (and not become fixated on the initial most likely diagnosis – i.e. “following the garden path”). If the paramedic tries to treat this problem, the patient will not respond as they expect – providing further opportunity to break out of the cognitive fixation.

If the paramedic does further assessment, symptoms indicative of another problem will be revealed, including a pulsating mass in the abdomen, suggesting a very urgent and critical problem – abdominal aortic aneurism.

3.3.3 **Extrication from motor vehicle accident**

In this scenario, the participant will be asked to comment on the actions of a hypothetical paramedic from an independent EMS responding to a single vehicle
accident (outside of the services normal jurisdiction). The patient was trapped in the car, and needed urgent medical treatment. A fire engine unit was on-scene. The commander was following a detailed, systematic process for opening the vehicle in a very safe manner. However, extrication of the patient in a more rapid manner was possible. The participating paramedic should recognize the trade-off between speed and safety, including the threat to the patient resulting from the slower extrication method, and recognize that this should have been presented to the commander. In addition to exploring revision and re-planning issues, this scenario incorporates issues of authority gradients, and differences between organizations and professions.
Chapter 4: Study II—Staged World

4.1 Methods

4.1.1 Scenarios

Two of the scenarios proposed by the panel of experts are used in this study: A multiple patient shooting case, and a chest pain case. The details of each scenario are presented in the sections for each case below, and in Appendices D: Chest Pain Case Materials, and F: Multiple Patients Case Materials.

The chest pain case was modified from the original aortic abdominal aneurism to a pulmonary embolism, as diagnosis of the former is heavily dependent on assessment via palpation. A reasonable fidelity palpation simulation was not feasible, and representing the pivotal finding in an indirect and abstract way would undermine the engagement of the participants. Pulmonary embolism is less dependent on hard-to-simulate findings, and was repeatedly mentioned in interviews and in the panel discussion as a challenging case to diagnosis.

The scenarios were designed to have good face validity with paramedics, yet to also include constraints and challenges which can expose the strategies that paramedics use to manage complexity in their domain. See section 4.1.3 on Probes.
Both scenarios involve all the steps in a paramedic going on an emergency call: arriving on the scene, assessment and treatment of the patient, deciding which hospital to take the patient, and reporting to the emergency department. The space of different likely responses (for a range of experienced and new paramedics) was defined, by consulting with experts and consulting differential diagnoses and their associated management protocols. Vitals signs for each of the patients over time, and in response to various interventions, were defined. Responses to likely questions from the paramedics were created. The behavior of the patient and the EMT, in relation to the actions of the paramedic, was defined. Thus, each scenario includes responses to a variety of paramedic history-taking questions, assessments, and actions, including medical responses to likely counter-indicated interventions.

Iterative reviews of each scenario were conducted, with a physician, one of the expert panelists, and a paramedic member of the research team. This, plus the original involvement of the expert panelists, helps assure the validity of the scenarios.

4.1.2 Staged-World simulation

A mixed-fidelity simulation was developed to run the two scenarios. A functional analysis for each scenario was developed to determine what information and tools were required to implement the scenario (including all the likely paths and problem spaces that might be encountered). See Figure 4.1. The goals (in bold) are supported by tasks (in normal black text) which require tools (in red) and
information (in blue). The means of providing the information in a realistic way are identified in green text.

Figure 4.1: Example of Functional Analysis for Simulation

The simulation was designed to represent the different components of the
situation at levels of fidelity that would provide the necessary information, given the assessment methods and the main cognitive and perceptual aspects of the specific assessments. The modality of the information was maintained as much as was feasible. Space was used to require reorientation and movement as in the real world. The simulation incorporated the relevant affordances and limitations of the real world.

Paramedics always work with partners, so in this simulation the participant paramedic was paired with an EMT-Basic partner (henceforth EMT), who would follow the directions issued by the paramedic. Two of the research team members who are experienced, certified paramedics, took turns portraying the EMT partner. With the exception of a small set of specific behaviors in the Multiple Patient case, the EMT partner took no initiative. The participants knew that the “EMT partner” was a paramedic and a member of the research team.

In addition to helping to maintain the validity of the simulation, having a partner involved means that, as part of coordination, the paramedic verbalizes his or her intentions, but in a way that is natural and not disruptive of the task.

Because subtle visual information is of key importance to a paramedic evaluating a patient, the patients were represented with life-sized photographs (from the pelvis up). The images were developed by a medical illustrator and media development team associated with a medical college. Professional models depicted the patients. See Figure 4.2. Relevant visual cues (for example, bullet wounds, jugular venous distension, and cyanic complexion) were photo-shopped
in. See Figures 4.6 (Chest Pain patient) and 4.21 (Patients in Multiple Patients Case). Multiple images of each patient were made, at a minimum a front and back image (for examination when the patient is rolled over), and more images for one patient (the Chest-shot Patient in the Multiple Patient case) whose condition changes dramatically over the course of the scenario.

![Image](image_url)

Figure 4.2: Development of Images

These images were presented on a large [36 x 21 inch (66 x 53 cm)] monitor, positioned horizontally at stretcher level (on part of a large conference room table), similar to an actual patient. See Figure 4.3. This enabled the Simulation Administrator to change the images rapidly and, as necessary, discretely (without unduly cuing the participant to a change in patient status). The patients’ legs...
were represented with lower resolution images, clothed and unclothed, positioned as an extension of the upper-body image.

Figure 4.3: Life-sized Presentation of Images

For the Multiple Patients case, the patient not being directly attended by the paramedic was represented by the same life-sized images, printed on posters. When performing actions on this patient, the EMT interacted with these posters. In order to maintain some spatial fidelity, the posters used by the EMT in the
Multiple Patients case were several feet from the large flat-screen display attended by the paramedic—close enough to see general activity and gross information, but too far to see any detail.

Verbal responses from the patient were voiced by the Simulation Administrator. Initial responses to the paramedic, for each case, were voiced with the tempo and breathing pattern that the patient would be speaking with [in the case of the two verbal patients (the Chest-shot Patient, and the Chest Pain Patient) short statements in-between rapid breaths, indicating difficulty breathing and shortage of oxygen].

For the breathing pattern of the Head-shot Patient, an audio loop of agonal breathing was played when the paramedic first assessed that patient.

The vital sign values that would be presented on the EKG monitor were presented on a separate computer display, requiring the same visual reorientation as would occur in an actual field situation.

Being able to dynamically change the values and pictures, as well as controlling the arrival of the backup unit, and the arrival at the ED, enabled control of the pacing of the simulation, ensuring that the tempo was realistic.

Maps of the incident location and the nearby hospitals (with travel times) were provided on papers, as were the EKG tracings.

As the emphasis of the study is on cognitive strategies for diagnosis and management, not on physical performance of specific technical tasks, high fidelity representation of the instruments were not necessary. Artifacts serving as
lower fidelity representations were used in the scenario. Cards with pictures and
names of the items in a standard complement of equipment and supplies in an
ALS ambulance were laid out on poster-boards, grouped similar to how the
equipment is packaged in different bags or compartments on the ambulance. The
groupings were:

- General equipment
- Safety and protective equipment
- Respiratory (oxygen, intubation kits, etc.)
- Monitor with Pulse Ox sensor
- Obstetrical Kit
- Immobilization equipment
- Bandages and dressings
- IV needles, tubes, and fluids
- Medicines

The paramedics would grab an item (such as a bag valve mask) and place it on
the flat-screen, as if they were applying the item to the patient. This served
several purposes. It encouraged the paramedics to be engaged in performance of
care, rather than simply comment and speculate on the case. It required
reorientation to acquire the item. It supported external memory and recognition,
as it is available in the real world. It made the actions of the paramedic
observable, without requiring the disruption of having the paramedic tell us what
he or she was doing.

Figures 4.4 and 4.5 show the layout of the components of the simulation,
conducted in a large conference room.
The paramedics were able to engage in the simulation, and run through the scenario as if they were on the call. They told the EMT what to do. They examined the image of the patient, placing items on it, and putting their hands on it to palpate or stop bleeding. A few of the paramedics volunteered that they found the life-sided pictures on the flat-screen display, with the pictures changing in response to events (putting on a bandage, flipping over) to be very effective.

The granularity with which paramedics engaged the simulation varied. For example, for one paramedic the actions involved in starting an IV were: attach the tubing to the 18 gauge needle, find a good vein, get alcohol swab and clean the site, etc. For another paramedic, the action was more compressed: start an IV, 18 gauge. This is discussed more in the Analysis section of the Chest Pain Scenario. The consequence of this variety is that number of minutes marked on the clock does not correspond exactly to the passage of time in the scenario. In order for events in the scenario to happen on schedule (decline of the patient, arrival of backup, etc), the actions to be performed by the paramedics were given rough time values, based on time estimates from various paramedic protocols. Time in the scenario was estimated based on the time values for the actions performed.
Figure 4.4: Layout of Simulation

Figure 4.5: Photo of Simulation Setup

More detail is provided in Appendix C: Staged-World Study Materials.
4.1.3 **Probes**

Multiple means were incorporated into the scenarios and the simulation to make the cognitive patterns of the paramedic more observable. Already mentioned above is the use of an inexperienced EMT partner, with whom the paramedic has not worked before. This requires the paramedic to verbalize intentions as part of coordination. Similarly, having the paramedic interact with the ED staff brings forth his or her understanding of the patient’s condition in a natural manner.

Also discussed above is the use of physical artifacts for the paramedic to interact with in a natural manner, making his or her actions visible.

Requiring the paramedics to make assessments and ask questions to get information makes their hypotheses and strategies more observable.

Presenting the paramedics with challenging cases means that responses are not limited to standard, well-practiced scripts—in which adaptations are hidden by expert fluency (Woods & Hollnagel, 2006). Adaptations to constraints provide insight into cognitive strategies (Crandall et al., 2006).

Comparing the performance of two groups with different levels of experience is a standard method in studying expertise (Chi, 2006), and provides a baseline against which to detect the adaptations of more experienced practitioners.

Reviewing each case immediately after performance supplemented the embedded probes. The review served to elicit reflections from the paramedic about the case.
It also served as a mini-debriefing, allowing the paramedic, as a stakeholder in the research, to ask questions of, and to instruct, the researchers. These responses, along with the observations of performance, composed the data used in the process tracing analysis.

4.1.4 Protocol

The paramedics participated in a set of research activities, including interviews, two mixed-fidelity simulations (presented here), and two paper-and-pencil walk-through scenarios.

Informed consent was obtained from each participant. Prior to the start of the scenarios, the paramedic was given an opportunity to ask any questions. He or she was show the different components of the simulation (without any picture or values present), introduced to the paramedic researcher portraying the EMT partner, and given time to become familiar with the layout of the equipment cards.

The first case was the Multiple Patient case (chosen to be the first case because it was the most physically engaging, and held the most potential for getting paramedics immersed in the simulation). In going through the scenario, the Simulation Administrator would provide initial information, the paramedic would respond with actions and questions, and the Simulation Administrator would update values and pictures, and answer questions based on what information would be available given the assessment actions of the paramedic.
After completion of the Multiple Patient scenario (which lasted between 15 – 20 minutes), the participant paramedic, the Simulation Administrator, the observing research team member, and the paramedic “EMT” research team member reviewed the scenario and the paramedic’s actions.

When the paramedic was ready and the materials for the next scenario were ready, the Chest Pain case began, and was conducted in the same manner as the Multiple Patient case (except there was only one patient, so no posters of a second patient were necessary). It also lasted between 15 – 20 minutes. Afterwards, the scenario was reviewed.

The session continued with two other cases (paper-and-pencil walk-through scenarios, not reported here) with breaks in-between. The session completed with an interview and debriefing. The whole session lasted two hours.

There were two groups of participating paramedics (More Experienced and Less Experienced; see Participants below). Due to scheduling and logistic constraints, most of the More Experienced paramedics were run early in the sequence, and most of the Less Experienced paramedics were run later in the sequence.

4.1.5 Execution

The staged-world sessions were run in such a way as to maintain the status of the participant as a partner in the research (and status as an expert or journeyman in
the domain), while utilizing opportunities to get more information about the cognitive work of paramedics.

The paramedics were encouraged and supported in engaging the scenarios, and interacting as if they were on real calls. On occasion, minor modifications from the original plan were made in real-time in order to keep the paramedic engaged and to get more information about how the paramedic is managing the challenges. For example, when one paramedic asked about police officers being available to help, the Simulator Administrator said that they looked busy. Later in the scenario, the paramedic said he was recruiting a police officer to assist him, and this was not contradicted, because 1) it would have harmed the engagement and the face validity for this paramedic who has been able to recruit police officers for help in real life, and 2) it permitted the paramedic to do other, more informative, activities.

After the staged-world session with each paramedic, he or she was asked about the scenarios and simulation, and what he or she thought about how the session went. The research team members present were also consulted after each session. Other research team members, observing remotely via video camera, were consulted periodically.

4.1.6 Analysis

Background data for the paramedics were collected via paper surveys and personal interviews.
The sessions (including the case run-through and the case review) were audio-taped and video-taped (from two angles), and notes were taken by a research-team member. The recordings sessions for these two cases were transcribed by the author.

The transcriptions were reviewed iteratively, starting with reviews of specific actions, events, and decisions based primarily on the details of the scenario; the post-case reviews, as well as information about intervention and assessment methods, were used to help interpret paramedic actions. Later reviews focused on more general patterns, based more on general patterns of cognitive adaptations to complexity (Woods & Hollnagel, 2006). Each iteration was done in a short, continuous period of time. The order in which the paramedics’ performances were reviewed was deliberately varied for each iteration, in order to avoid any systematic effects of review sequence.

Once the final process tracings for each paramedic were generated, they were reviewed against the notes taken by the research-team member, to verify that the process tracings were congruent with these independent observations of the paramedic performance.

Due to the complexity of EMS care situations, the shortage of empirical studies of pre-hospital care methods, and the specific complexities of these cases, the canonical path is a wide space with fuzzy boundaries. This (in addition to the emphasis on engagement and immersion in the simulation as a means of
bringing about adaptive responses) means that each paramedic’s performance (including the impact to the patient’s trajectory) is evaluated against the set of responses (and impacts) as a whole, in addition to the canonical path/region.

At both domain-specific, concrete levels, and more general levels, the actions or strategies demonstrated by the whole set of paramedics were identified. Specific paramedics, and the two groups of paramedics, are compared relative to which sub-set of actions, hypotheses, strategies, etc. they demonstrated.

4.2 Participants

4.2.1 Screening

All of the participants were certified as paramedics (EMT-P) by the National Registry of Emergency Medical Technicians, currently working as paramedics and going on calls.

Two types of paramedics were recruited: very experienced, and fairly new paramedics. Multiple criteria were used to distinguish the two groups (Hoffman, Feltovich, & Ford, 1997). Each of the Less Experienced (LE) paramedics had one year or less experience as a paramedic. In discussions with the expert panelists and other paramedics, and in literature (Metz, 1982) one year of full-time work in as a paramedic in a busy EMS is mentioned as a boundary point, after which there is a feeling of competency. However, no one with less than a few months of on-the-job was recruited, in order to guarantee that the participants had some
experience beyond an initial orientation period. In addition to having less than a year as a paramedic, each of the LE group considered him- or herself among the newer, less experienced paramedics in his or her system.

Each of the More Experienced (ME) paramedics had multiple years as a paramedic, and had were considered to be an expert paramedic by a supervisor in his or her system.

### 4.2.2 Participant Characteristics

Table 4.1: Staged–World Study Participants

<table>
<thead>
<tr>
<th></th>
<th>More Experienced</th>
<th>Less Experienced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Participants</td>
<td>6 (A, B, C, D, E, F)</td>
<td>4 (G, H, I, J)</td>
</tr>
<tr>
<td>Years just as Paramedic</td>
<td>Avg. 10.5 (3.5–24)</td>
<td>Avg. 0.7 (0.5–1.0)</td>
</tr>
<tr>
<td>Total Years as EMT (B, I or P)</td>
<td>Avg. 13 (5.5–25)</td>
<td>All had 3 years</td>
</tr>
<tr>
<td>Other Selection Criteria</td>
<td>Recommended as expert by supervisor</td>
<td>Considered themselves newer in their EMS</td>
</tr>
<tr>
<td>Types of EMS</td>
<td>Both groups contained a mix of EMS types (fire, private, hospital-based).</td>
<td></td>
</tr>
<tr>
<td>Urban/Rural</td>
<td>Both groups included urban and rural.</td>
<td></td>
</tr>
</tbody>
</table>

The code letters assigned to the participants (A–J) are in order of experience (years as EMT-B/I plus a heavier-weighted years as paramedic), with A having the most experience, and J having the least.

One of the ten participants is female, compared to 28% of paramedics nationally. Eight of the ten are non-Hispanic White, compared to 86% of paramedics nationally. Four are based in fire departments [compared to 38% of EMTs (all
types) nationally. Two are from hospital-based services (compared to 16%). Four are from private services. National figures are from McGinnis et al. (2006).

Three of the participants are based in large cities. Four are from suburbs or otherwise just outside large cities. Three are from smaller towns in rural areas.

The paramedics are from seven different states from different regions of the US, including South, Midwest, West, and East Coast.

Two of the More Experienced (ME) serve as field supervisors in their systems.

Neither the participants themselves nor the researchers were blind to the experience grouping.

### 4.3 Chest Pain Case

#### 4.3.1 Chest Pain scenario

##### 4.3.1.1 Scenario Details

In the Chest Pain scenario, the paramedic receives a call at 5 am, Monday morning for a middle-aged man with chest pain. Several indicators suggest that the pain is caused by a heart attack (MI, or Myocardial Infarction), a very common event for paramedics.

Early on, the patient’s wife refers to the event as a heart attack. The patient has a visible scar on his chest from past heart valve surgery. He has a family history of heart problems. The problem occurred early on a Monday morning.
However, the MI diagnosis is the “garden path” in this scenario. With further assessment, it is possible for the paramedic to learn that the problem is unlikely to be a heart attack. The EKG tracing contains no strong indicators for a heart attack. The description and location of the pain are atypical for a heart attack (sharp and stationary, as opposed to a dull, crushing pain that radiates). The pain did not start until after he was awake. Nitroglycerin does not relieve the pain. With yet further investigation, it is possible to learn that the problem is respiratory in nature. The lung sounds are diminished, his skin is cyanic, and the saturated O2 readings are lower than would be expected assuming the patient is on high-flow oxygen. He is breathing rapidly, and cannot be calmed down. With still further investigation, it is possible to identify the problem as a pulmonary embolism (PE, the entrapment of a blood clot in a lung, preventing blood from circulating in the lung and getting oxygenated). The pain and shortness of breath started after he was up and moving around. The patient has a swollen leg, which started soon after he returned from Hawaii via a long airplane flight.

Pulmonary Embolisms are associated with deep vein thrombosis (DVT). A DVT is a blood clot, typically in a leg, often resulting from long periods of sitting and immobility, such as long airplane flights. The clot can break free from the leg, and travel to the lungs.

The hospitals available for patient disposition included: an emergency department 4 minutes away, an ED with a catheter lab (providing rapid, best
practice treatment for MIs) 7 minutes away, and a Level 1 trauma center with a catheter lab 8 minutes away.

Vital signs were adjusted in response to therapeutic actions. Over time, IV fluid raised the blood pressure, and oxygen raised the O2 saturation and decreased the respiratory rate. Administration of nitroglycerin dropped the blood pressure; administration of nebulizers caused a slight increase in pulse.

More details and materials are available in Appendix D: Chest Pain Case Materials. Figure 4.6 shows the image of the patient.
Figure 4.6: Chest Pain Patient
4.3.1.2 Cognitive Work in Chest Pain Scenario

This case was designed as a “garden path” or “false prime explanation” case (Johnson, Moen, & Thompson, 1988; Patterson et al., 2010). Initial information (appropriately) suggests a particular hypothesis (here, a heart attack or similar cardiac episode), causing activation of the associated set of knowledge structures. Additional information, inconsistent with the initial hypothesis, may not lead to activation of other knowledge structures, or exploration of other parts of the problem space. In failing to revise the hypothesis in light of evidence supporting a different hypothesis (and undermining the original hypothesis), the practitioner is in a state of fixation (Rudolph, 2003). However, as discussed below, there was very little of the expected fixation on the heart attack hypothesis.

Unlike typical studies of diagnostic reasoning, in this case the practitioner is simultaneously engaging in safing or therapeutic actions in order to keep the patient’s life-essential processes functioning, while making assessments and exploring hypotheses. These three types of activities interact with one another. Hypotheses guide therapeutic and assessment actions, and influence the interpretation of observations. Assessments can provide evidence to support or to undermine different sets of hypotheses. Safing or therapeutic interventions can change the state of the system (possibly introducing new problems), and produce meaningful information. These activities occur in a larger context of ongoing planning, coordination, and resource management activities. Managing such a
case is a much broader task than simply diagnosing the problem (Woods & Hollnagel, 2006, chap. 8).

A further difference is that arriving at a final diagnosis is not a requirement for providing emergency care. In providing care, paramedics have the option of simply responding to the patient’s conditions in order to prevent further damage (by providing oxygen, pain relief, and circulatory support) while transporting to an ED. In some systems, just transporting the patient is good enough. In the distributed system of EMS, the additional diagnostic work can be shifted downstream to the ED staff.

4.3.2 Analysis

As part of the process tracing, behaviors were identified as particular types of therapeutic or assessment actions. In order to facilitate comparisons across different participants’ engagement in the simulation, sets of actions were converted to the coarsest granularity (for example, one paramedic placing the stethoscope on various fields of the lungs and listening, and another paramedic saying “I’m checking the lung sounds” are both counted as a lung sound assessment).

On the other hand, if a specific assessment was not indicated somehow, it was not counted, even if it is considered part of a standard procedure. For example, talking with the patient is a practical way to quickly assess airway, breathing, and level of consciousness; but for this analysis, talking with the patient was not
assumed to constitute assessments of airway, breathing, and level of consciousness. Indications of assessments could occur during the post-case review.

It should be noted that the granularity of the actions as reported here fail to capture distinctions that undoubtedly have clinical significance in many circumstances.

Nonetheless, all relevant assessments were incorporated into the analysis, because: 1) observation and review of the actions were informed by knowledge of what assessments were diagnostically important; and 2) if an assessment was important or meaningful, a reference to it was made—if not during the planning or execution, or in interpreting the results, then it was brought up during the post-case review.

The paramedics performed assessments and treatments based upon hypotheses they considered regarding the cause of the patient’s problem. The various assessment and therapeutic actions indicate what possible causes they are considering. For example, having the patient sit up to see if that helps the breathing is an assessment of fluid in the lungs, associated with Congestive Heart Failure. Specific hypotheses and their associated treatments are identified in the Chest Pain Management Chart in Appendix D: Chest Pain Case Materials.

Figure 4.7 shows categories of safing actions, assessments, and hypotheses (generated after initial analysis of the paramedics’ performances, representing the range and nature of the full set of therapeutic actions, assessments, and
hypotheses from all of the paramedics). Figures 4.10 and 4.18 show examples of
the sequences of safing actions, assessments, and hypotheses from an ME
paramedic (A) and an LE paramedic (H), respectively.

![Safing, Assessment, Hypotheses/Expectations Diagram]

**Figure 4.7: Post-hoc Categories of Safing, Assessment, and Hypotheses**

Some hypotheses were explicitly voiced by the paramedics. As part of the post-
case review, there paramedics were asked what they were expecting upon hearing
the “chest pain” call from dispatch. These **expectations** are identified as such in
Figure 4.8 (Coarse Sequences of Responses to Chest Pain Case).
Other hypotheses were explicitly mentioned during the simulation, either in situ as part of a report to the receiving ED, or in response to a question from the Simulation Administrator. When the paramedic explicitly stated what he or she thought was going on, that is considered a **presumptive diagnosis (PDx)**, the term used by the expert panelists. Technically, only physicians can make official medical diagnoses. However, nurses and paramedics routinely use abductive reasoning, including the generation and evaluation of hypotheses about the causes of signs and symptoms, to guide their work. The presumptive diagnosis constitutes the paramedic's best explanation for the current set of evidence, whereas other hypotheses may simply be models of possible causes, used to guide assessments and construct expectations about results.

When a paramedic updated a primary hypothesis based on information he or she found, that is considered a **revision**. Changes in hypotheses resulting from hints are not included in the count.

**Hints** are pieces of information provided by the Simulation Administrator that may not have been discovered by the participant in an equivalent real-world situation. When it was apparent that the paramedic had exhausted his or her line of inquiry, and was unlikely to refine or update his or her hypothesis, then the Simulation Administrator incorporated a hint into the information provided. This was done in order to maximize the information space to which each participant
was exposed (relative to the structure of the scenario), and thereby gain further understanding of the cognitive processes of the participants.

In this scenario, the main relevant hints concern the patient’s swollen leg, its history, and the patient’s history of a recent long flight. This patient (as most patients experiencing chest pain, and having a family and personal history of heart problems) does not associate his leg or his recent travels with his current chest pain. Giving a piece of information (such as leg history) is not a hint if this patient would have volunteered that information in response to the paramedic’s inquiry.

If it was likely that the paramedic would have come across the answer, in response to his or her line of questioning, from a patient who was more forthcoming about any and all signs, symptoms, and factors, then giving that piece of information is considered a generous response. Example: When paramedic J asks the patient about other medical problems, the patient mention’s his leg.

If it was not a piece of information that the paramedic would have gotten in response to his or her questions from even a more forthcoming patient, then giving that piece of information is considered a directive cue. Example: When paramedic E is told that a long airplane flight preceded the swollen leg.
4.3.3 Findings

4.3.3.1 Overview

All of the participants responded satisfactorily, providing therapeutic measures and planning transport sufficient to save the life of the patient. Within this set of results, there are differences between how the More Experienced (ME) and Less Experienced (LE) paramedics dealt with the case. Both groups were, for the most part, successful in determining that the problem was not cardiac. The LE did not go much further than that without additional prompting; they focused more on treatment and transportation at that point. Compared to the ME, they required more cues (see the “Hints” column of Table 4.2). The ME went further, using assessments to guide consideration of other hypotheses, and thereby respond to new findings by revising their approaches to the patient (see “Revisions” column of Table 4.2).
### Table 4.2: Summary of Chest Pain Case Performance

<table>
<thead>
<tr>
<th>Revisions</th>
<th>PDx Prior to Cues</th>
<th>Hints</th>
<th>Final PDx</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ME</strong></td>
<td>Mean 1.6 (1–4)</td>
<td>PE: 2/6 Cardiac: 2/6</td>
<td>generous responses: 3/6 DIRECTIVE CUES: 3/6</td>
</tr>
<tr>
<td>A</td>
<td>MI &gt; PE</td>
<td>PE</td>
<td>air flight</td>
</tr>
<tr>
<td>B</td>
<td>MI &gt; Respiratory</td>
<td>PE</td>
<td>None</td>
</tr>
<tr>
<td>C</td>
<td>MI &gt; Respiratory &gt; Musculoskeletal &gt; MI &gt; Other</td>
<td>Unknown, possibly septic; transport to ED with Cath Lab</td>
<td>Leg, AIR FLIGHT</td>
</tr>
<tr>
<td>D</td>
<td>MI &gt; Other/PE</td>
<td>Standard cardiac care</td>
<td>air flight</td>
</tr>
<tr>
<td>E</td>
<td>MI &gt; Musculoskeletal &gt; Respiratory</td>
<td>CHF</td>
<td>Recentness of leg, AIR FLIGHT</td>
</tr>
<tr>
<td>F</td>
<td>Respiratory &gt; MI &gt; Other</td>
<td>Not cardiac</td>
<td>AIR FLIGHT</td>
</tr>
<tr>
<td><strong>LE</strong></td>
<td>Mean 0.75 (0–1)</td>
<td>PE: 0/4 Cardiac: 2/4</td>
<td>generous responses: 1/4 DIRECTIVE CUES: 6/4</td>
</tr>
<tr>
<td>G</td>
<td></td>
<td>Standard cardiac care; transport to ED with Cath Lab</td>
<td>LEG, AIR FLIGHT</td>
</tr>
<tr>
<td>H</td>
<td>Maybe MI &gt; Yes MI</td>
<td>MI</td>
<td>LEG</td>
</tr>
<tr>
<td>I</td>
<td>MI &gt; Not MI</td>
<td>Not MI</td>
<td>LEG, AIR FLIGHT</td>
</tr>
<tr>
<td>J</td>
<td>MI &gt; Not MI</td>
<td>Not cardiac; respiratory/CHF</td>
<td>Leg; AIR FLIGHT</td>
</tr>
</tbody>
</table>

#### 4.3.3.2 Actions and Hypotheses

Tables 4.3 – 4.5 compare the assessments, therapeutic interventions, and hypotheses across the More Experienced and Less Experienced groups.

In these tables, the spacing of the (mono-spaced) characters in the ME and LE columns has been adjusted, so that the six ME letters and the four LE letters take
up the same space, so comparisons can be made by looking at the comparative lengths of the black regions.

For assessments, lowercase letters indicate that the paramedic received the assessment information as the result of a directive cue (vs. searching for it on their own, indicated by Uppercase letters). For treatments, lowercase letters indicate that the Simulation Administrator, either in situ playing the role of the medical director, or as part of a hint, made a suggestion or direction that the paramedic perform that particular treatment.

Gray letters indicate that the assessment occurred in the sequence after a directive cue was given (indicating that they would not have made it that far without earlier intervention from the Simulation Administrator).
Table 4.3: Chest Pain Case Assessments

<table>
<thead>
<tr>
<th>Assessment</th>
<th>ME</th>
<th>LE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cardiac</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulse</td>
<td>ABCF</td>
<td>G</td>
</tr>
<tr>
<td>BP</td>
<td>ABCD</td>
<td>GHI</td>
</tr>
<tr>
<td>EKG</td>
<td>ABCDEF</td>
<td>GHI J</td>
</tr>
<tr>
<td><strong>Respiratory</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Airway</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>RR</td>
<td>ACF</td>
<td>GJ</td>
</tr>
<tr>
<td>Lung sounds</td>
<td>ABCDEF</td>
<td>HJ</td>
</tr>
<tr>
<td>Sat O2</td>
<td>ABCDEF</td>
<td>GHI</td>
</tr>
<tr>
<td><strong>Pain/Mental</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOC</td>
<td>A</td>
<td>J</td>
</tr>
<tr>
<td>Anxiety</td>
<td>J</td>
<td></td>
</tr>
<tr>
<td>Pain description</td>
<td>ACD</td>
<td>HI J</td>
</tr>
<tr>
<td>Pain location</td>
<td>A</td>
<td>I</td>
</tr>
<tr>
<td>Pain level</td>
<td>ACEF</td>
<td>GHI</td>
</tr>
<tr>
<td>Pain movement</td>
<td>DE</td>
<td>HI</td>
</tr>
<tr>
<td>Pain &amp; breath</td>
<td>ACEF</td>
<td>J</td>
</tr>
<tr>
<td>After Nitro</td>
<td>ACD</td>
<td>GJ</td>
</tr>
<tr>
<td>After other</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td><strong>Body</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skin</td>
<td>ACD</td>
<td></td>
</tr>
<tr>
<td>Scar</td>
<td>BF</td>
<td>GHJ</td>
</tr>
<tr>
<td>Fever</td>
<td>BF</td>
<td></td>
</tr>
<tr>
<td>Blood sugar</td>
<td>BC</td>
<td></td>
</tr>
<tr>
<td>Palpate chest</td>
<td>CE</td>
<td></td>
</tr>
<tr>
<td>Palpate abdomen</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Leg view</td>
<td>BCEF</td>
<td>GJ</td>
</tr>
<tr>
<td>Leg history</td>
<td>BCEG</td>
<td>GHi</td>
</tr>
<tr>
<td>Pedal edema</td>
<td>BE</td>
<td></td>
</tr>
<tr>
<td><strong>Event History</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Event</td>
<td>ABCDEF</td>
<td>GHI J</td>
</tr>
<tr>
<td>Recent surgery</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Trip</td>
<td>acdef</td>
<td>gij</td>
</tr>
<tr>
<td>Recent leg injury</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Recent illness</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Eating/Food</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td><strong>Past History</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heart</td>
<td>ACDEF</td>
<td>GHI</td>
</tr>
<tr>
<td>Respiratory</td>
<td>AF</td>
<td></td>
</tr>
<tr>
<td>Last MD visit</td>
<td>ADF</td>
<td></td>
</tr>
<tr>
<td>Smoking</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Aspirin</td>
<td>AE</td>
<td></td>
</tr>
<tr>
<td>Sedentary job</td>
<td>A</td>
<td></td>
</tr>
</tbody>
</table>
Cardiac assessments were frequent, with all paramedics getting EKG tracings. Pain assessments were also frequent. These are standard assessments for assessing the occurrence of a heart attack.

Proportionally more respiratory assessments were done by the ME group than the LE group. Additionally, the more detailed body assessments and histories were performed by ME paramedics.

Table 4.4: Chest Pain Case Treatments

<table>
<thead>
<tr>
<th>Treatment</th>
<th>ME</th>
<th>LE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac</td>
<td>IV</td>
<td>ABCDEF</td>
</tr>
<tr>
<td></td>
<td>1st Nitro</td>
<td>GHIJ</td>
</tr>
<tr>
<td></td>
<td>2nd Nitro</td>
<td>ABCDF</td>
</tr>
<tr>
<td></td>
<td>3rd Nitro</td>
<td>G</td>
</tr>
<tr>
<td></td>
<td>Aspirin</td>
<td>ECDGF</td>
</tr>
<tr>
<td>Respiratory</td>
<td>O2</td>
<td>ABCDEF</td>
</tr>
<tr>
<td></td>
<td>Nebulizer</td>
<td>GHIJ</td>
</tr>
<tr>
<td>Other</td>
<td>Calming</td>
<td>EHI</td>
</tr>
<tr>
<td></td>
<td>Sit up</td>
<td>EJ</td>
</tr>
<tr>
<td></td>
<td>Call for Backup</td>
<td>E</td>
</tr>
<tr>
<td>Transport</td>
<td>Call ED</td>
<td>AE</td>
</tr>
<tr>
<td></td>
<td>Move to Truck</td>
<td>HIK</td>
</tr>
<tr>
<td></td>
<td>ED w/ Cath Lab</td>
<td>ABCDF</td>
</tr>
<tr>
<td></td>
<td>Level 1 w/ Cath</td>
<td>G</td>
</tr>
<tr>
<td></td>
<td>General</td>
<td>EF</td>
</tr>
</tbody>
</table>

Just as with the cardiac assessments, the cardiac treatments were frequent in both the ME and LE groups, the exception being that the second and third doses of nitroglycerin were administered by proportionally more of the LE group.

No LE paramedic administered a nebulizer.
No paramedics decided to take the patient to the closest ED (4 minutes away). They all decided to go to one with a catheter lab, explaining that 1) a PE can precipitate a cardiac event, especially in a patient with a history of heart issues, and 2) a PE itself is serious enough to warrant going to an ED with lots of sophisticated capabilities.

Table 4.5: Chest Pain Case Hypotheses

<table>
<thead>
<tr>
<th>Hypotheses/Framing</th>
<th>ME</th>
<th>LE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac</td>
<td>MI</td>
<td>G J</td>
</tr>
<tr>
<td></td>
<td>CHF</td>
<td>BE</td>
</tr>
<tr>
<td>Respiratory</td>
<td>COPD</td>
<td>ABE</td>
</tr>
<tr>
<td></td>
<td>PE</td>
<td>ABCDEF</td>
</tr>
<tr>
<td></td>
<td>Respiratory</td>
<td>G H J</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B J</td>
</tr>
<tr>
<td>Body</td>
<td>Pedal Edema</td>
<td>BDEF</td>
</tr>
<tr>
<td></td>
<td>DVT</td>
<td>HJ</td>
</tr>
<tr>
<td></td>
<td>Muscular-skeletal</td>
<td>C J</td>
</tr>
<tr>
<td></td>
<td>Abdominal rupture</td>
<td>C J</td>
</tr>
<tr>
<td></td>
<td>Leg inflammation</td>
<td>C J</td>
</tr>
<tr>
<td></td>
<td>Septic</td>
<td>C J</td>
</tr>
<tr>
<td>Other</td>
<td>Anxiety</td>
<td>F I J</td>
</tr>
<tr>
<td></td>
<td>Not cardiac</td>
<td>F I J</td>
</tr>
<tr>
<td>Pre-arrival Expectations</td>
<td>MI</td>
<td>AC</td>
</tr>
<tr>
<td></td>
<td>Many causes</td>
<td>BE</td>
</tr>
<tr>
<td></td>
<td>Something bad</td>
<td>J</td>
</tr>
<tr>
<td></td>
<td>Ride to hospital</td>
<td>DF</td>
</tr>
</tbody>
</table>

Proportionally more of the ME paramedics considered Congestive Heart Failure and pedal edema (swelling of the lower extremities related with CHF). No LE paramedics considered the possible role of Chronic Obstructive Pulmonary Disorder, but half of the ME paramedics did.
No LE paramedic considered abdominal rupture.

4.3.3.3 Sequences

The individual assessments and treatments, and the generation and revision of hypotheses, occur in the context of the sequence of events. Looking at the sequence of activities, and how assessment, treatment, and hypotheses interact, enables a better understanding of the dynamics of cognition in paramedics.

Figure 4.8 presents the sequences of the actions and hypotheses for all of the paramedics. Figures 4.9 – 4.20 present the sequences for each individual paramedic (followed by summaries of each paramedics performance). As explained in the key, hypotheses are in bold; therapeutic actions are in italics; assessments are in gray cells; generous responses are in light gray cells; directive cues have dark highlighting; and revisions are indicated by wavy lines in the table.
## More Experienced

<table>
<thead>
<tr>
<th>A</th>
<th>Likely MI</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Many things</td>
</tr>
<tr>
<td>C</td>
<td>Likely MI</td>
</tr>
<tr>
<td>D</td>
<td>Something serious</td>
</tr>
<tr>
<td>E</td>
<td>Many things</td>
</tr>
<tr>
<td>F</td>
<td>Something serious</td>
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<table>
<thead>
<tr>
<th>G</th>
<th>Cardiac</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>N/A</td>
</tr>
<tr>
<td>I</td>
<td>Many things</td>
</tr>
<tr>
<td>J</td>
<td>Many things</td>
</tr>
</tbody>
</table>

### Key
- **Expectation re: “Chest Pain” call**
- **Assessments Taken**
- **Therapeutic action**
- **Action directed by Scenario Administrator**
- **Hypothesis**
- **generous response**
- **directive cue**
- **Revision**

---

**Figure 4.8: Coarse Sequences of Responses to Chest Pain Case**
4.3.3.4 **Summaries**

<table>
<thead>
<tr>
<th>A</th>
<th>Likely MI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Event History</td>
<td></td>
</tr>
<tr>
<td>Heart History</td>
<td></td>
</tr>
<tr>
<td>Pain Description</td>
<td></td>
</tr>
<tr>
<td>Oxygen</td>
<td></td>
</tr>
<tr>
<td>Med History</td>
<td></td>
</tr>
<tr>
<td>Skin</td>
<td></td>
</tr>
<tr>
<td>Lung Sounds</td>
<td></td>
</tr>
<tr>
<td><strong>COPD factor</strong></td>
<td></td>
</tr>
<tr>
<td>Respiratory History</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td></td>
</tr>
<tr>
<td>EKG</td>
<td></td>
</tr>
<tr>
<td>Nitroglycerin</td>
<td></td>
</tr>
<tr>
<td>Reassess Pain</td>
<td></td>
</tr>
<tr>
<td>O2 Sat</td>
<td></td>
</tr>
<tr>
<td>PE?</td>
<td></td>
</tr>
<tr>
<td>PE Risk Factors</td>
<td></td>
</tr>
<tr>
<td>recent flight</td>
<td></td>
</tr>
<tr>
<td>PE</td>
<td></td>
</tr>
</tbody>
</table>

Figure 4.9: Paramedic A Sequence for Chest Pain Case

**A**: Starts with general assessment and determining if it is an MI or not.

Motivated in part by patient’s smoking history, shifts to respiratory history and assessment. Proceeds with standard cardiac treatment, but negative response to nitroglycerin and low saturated O2 reading lead to suspicion of respiratory issue. Asks about PE risk factors. Is told of recent flight, which confirms suspicion of PE.
Figure 4.10: Paramedic A Safing, Assessment, and Hypotheses Sequence

Figure 4.10 shows examples of the interaction between safing, assessment, and hypothesis exploration. The information about the pain being related to breathing (item 5 in the figure) is followed by administration of oxygen (6). As mentioned above, the safing actions of oxygen (6) and nitroglycerin (14) provide information in the form of the maintenance of pain levels after nitroglycerin (15) and the low O2 saturation (16) that lead to the suspicion of a respiratory problem (17), specifically PE (18).
Figure 4.11: Paramedic B Sequence for Chest Pain Case

**B**: Begins with history and general assessment. Based on EKG and lung sounds, concludes respiratory more likely than cardiac, but still administers nitroglycerin. Asks about CHF and COPD history, and looks for pedal edema in legs. Sees legs, asks about leg history, and suggests possibility of DVT/PE.
### Figure 4.12: Paramedic C Sequence for Chest Pain Case

**C:** Starts with general and cardiac assessments, then shifts to respiratory. Hears clear bilateral lungs, and excludes PE. Explores other (non-cardiac, non-respiratory) possibilities. Defaults to cardiac protocol, but continues to examine and take history. Prompt about leg leads to leg examination and concerns about pedal edema and infections. Cue about the recent flight leads to conclusion of PE.

<table>
<thead>
<tr>
<th>Likely MI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulse &amp; BP</td>
</tr>
<tr>
<td>Oxygen</td>
</tr>
<tr>
<td>EKG</td>
</tr>
<tr>
<td>Pain Description</td>
</tr>
<tr>
<td>Lung Sounds</td>
</tr>
<tr>
<td><strong>Clear lung = unlikely pulmonary</strong></td>
</tr>
<tr>
<td><strong>Musculo-skeletal or aortic aneurism?</strong></td>
</tr>
<tr>
<td>Palpation</td>
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<tr>
<td>Medical History</td>
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<td>Nitroglycerin</td>
</tr>
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<td>Reassess Pain</td>
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<td>Other History</td>
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</tr>
<tr>
<td>Leg History</td>
</tr>
<tr>
<td>Reassess EKG</td>
</tr>
<tr>
<td>Reassess Lungs</td>
</tr>
<tr>
<td>Take to ED</td>
</tr>
<tr>
<td>recent flight</td>
</tr>
<tr>
<td>PE</td>
</tr>
</tbody>
</table>
Figure 4.13: Paramedic D Sequence for Chest Pain Case

**D**: Starts with general assessment and history. Proceeds with standard cardiac care, including two instances of administering nitroglycerin and finding no lessening of pain. The requested backup unit arrives and begins to load patient. Utilizes opportunity to get more history, learning of recent flight. Concludes that DVT/PE is a risk in addition to cardiac issue.
Figure 4.14: Paramedic E Sequence for Chest Pain Case

E: Begins with general and cardiac assessment, shifting to exploration of respiratory and other possibilities. Considers COPD and CHF, and examines legs. Considers both pedal edema/CHF and DVT/PE, even after being told of leg history. Cue of recent flight leads to conclusion of DVT/PE.
Figure 4.15: Paramedic F Sequence for Chest Pain Case

**F:** Begins with respiratory-focused assessment, followed by administration of nebulizer to break up fluid in lungs. Negative response, plus history of heart surgery lead to shift to standard cardiac protocol. Pain description leads to exploration of non-cardiac possibilities. Prompt about recent flight leads to leg assessment and conclusion of DVT/PE.
**Figure 4.16: Paramedic G Sequence for Chest Pain Case**

**G**: Begins with a general assessment, including EKG. Proceeds with standard cardiac care, including three instances of administering nitroglycerin and finding no lessening of pain. Initial cues about sat O2 and patient’s leg do not lead to revisions, but cuing about recent flight leads to suspicion of PE.
Figure 4.17: Paramedic H Sequence for Chest Pain Case

**H**: Starts with determining if it is an MI or not; is unsure. Calls ED to request direction on cardiac protocol or not. Learns of past heart surgery, and infers that MI is likely. Prompts about failure of nitroglycerin to lessen pain lead to suggesting that it is a very large MI. Cues about the patient’s leg history lead to conclusion of DVT/PE.
Figure 4.18: Paramedic H Safing, Assessment, and Hypotheses Sequence

Figure 4.18 shows examples of the interactions between safing, assessment, and hypotheses exploration. The planning for transport (11) presents the dilemma of whether it is an MI or not (12 and 13), which prompts the call for medical direction (14). After seeing the patient’s chest scar, and asking about past heart surgery (18), H is more aggressive in managing the case as cardiac, administering a second nitroglycerin (19), and interpreting the lack of any response (20) as evidence of a large MI (21).
Figure 4.19: Paramedic I Sequence for Chest Pain Case

I: Starts with determining if it is an MI or not; suspects it is not. Sends 12-lead to Cath lab anyway to see if they recommend cardiac protocol. Prompts of failure of nitroglycerin to lessen pain lead to suggestions of alternate treatment methods. Cues about the patient’s legs and recent flight lead to hypotheses about the legs themselves, independent of the chief complaint.
Figure 4.20: Paramedic J Sequence for Chest Pain Case

**J:** Starts with determining if it is an MI or not; concludes it is not. Investigates more, and finds out about legs. Suspects CHF. With prompting and cuing about leg history and flight, concludes that it is a DVT/PE.

The sequences of hypotheses and their associated actions show that diagnostic reasoning in these situations is not always a simple, straightforward matter of ongoing exclusion and refinement. Paramedics C, F, and H all went from not suspecting MI, to considering MI, to discounting it.

Paramedic C quickly assessed for and discounted MI, then assessed for and discounted other possibilities (including interpreting the lung sound findings, as presented by the Simulation Administrator, as ruling-out PE). Having ruled out other possibilities, C reluctantly returned to standard cardiac protocol, until the negative response to nitroglycerin prompted further exploration.
Paramedic F initially focused on respiratory issues, narrowing in on COPD. The negative response to the nebulizer led to discounting that hypothesis, and shifting to standard cardiac protocol (which was revised after the negative response to nitroglycerin).

Paramedic H was unsure if it was cardiac or not, after performing the cardiac assessment, and wanted the receiving ED to decide whether or not to follow cardiac treatment protocol. H then noticed the chest scar and learned of the past heart history. H then maintained MI as the primary hypothesis until learning of the patient’s leg history.

The pattern of administering nitroglycerin and then reassessing pain levels is an example of the interactions between treatments and assessments. The ME paramedics used nitroglycerin as both a treatment and as a diagnostic tool, checking to see if the pain level decreased, which would support the hypothesis of heart attack. Paramedics A, C, D, and F all reassessed pain levels after administering nitroglycerin, and upon seeing the negative results, revised their hypotheses away from MI towards alternatives.

This pattern was not observed in the LE paramedics. G and H reassessed pain after the administration of nitroglycerin, but did not revise the primary hypothesis of MI.
In addition to the example of the absence of a response to nitroglycerin being noticed and used, negative responses were noticed and used with nebulizers (F), calming (I), and sitting the patient up (J).

Resources can play a part in the dynamics of hypotheses exploration. Paramedic D was using standard cardiac procedures to manage the patient (not convinced it was an MI, but leaning towards that out of caution). Early on, D requested backup (the only paramedic to do so). When the backup arrived, D had them prepare the patient for transport. While they were doing that, D was freed up from hands-on patient care responsibilities, and used that opportunity to change the line of inquiry, getting some new history, leading to new information (the recent flight) and a shift in the primary hypothesis.

Goals guide the process as well, and one important goal is preventing damage to the heart muscle. Even though most paramedics were suspecting that the problem was non-cardiac early on (due largely to the atypical presentation of pain), there was a high use of standard cardiac care measures (nitroglycerin, aspirin). This is because there is little risk from these treatments (when properly managed) for non-cardiac patients, but they are very important for MI patients. Likewise, all of the paramedics took the patient to a hospital with a catheter lab. Other goals and risk-management issues were in operation as well. For example, paramedic J considered taking the patient to the Level 1 trauma center (with catheter lab) that was 8 minutes away, but decided to go to the ED with catheter
lab that was 7 minutes away. J was concerned that taking the patient to a hospital which was twice as far as the nearest hospital (4 minutes away) might look bad if there were any sort of review. Taking the patient to the second closest hospital, only 3 minutes further, would be more easily justified.

4.3.4 Preliminary Discussion

The fixation on the heart attack hypothesis did not happen to the extent expected. Most of the paramedics followed a process to determine if the pain was cardiac or not, and interpreted the results of the assessments as suggesting a non-cardiac cause. A common chest pain protocol, designed to help identify heart attacks, was referenced by almost all of the paramedics. This protocol, plus the experience and training of the paramedics, enabled them to use the information in this case to keep a larger portion of the problem space active and under consideration. They did not even initially focus exclusively on MI.

There was little evidence that most of the paramedics even initially considered MI to be the only hypothesis. The assumption that a large portion of the paramedics would be fixated on an initial hypothesis of MI grew from a failure to appreciate the familiarity of non-cardiac chest pain cases and the activation of the wide range of associated knowledge structures in response to a chest pain case.

For the three that demonstrated some fixation on the cardiac hypothesis, only one (G) did not diverge from following a standard cardiac care protocol. Paramedic D seemed to recognize that this was not a typical MI, but D never stopped considering the possibility of a cardiac event, at least partially as a
conservative risk management stance. After initial assessment, paramedic H was unsure if it was an MI or not. It was after learning about prior heart surgery that H concluded it was an MI, maintaining that hypothesis even after negative nitroglycerin results.

Unlike other allied health providers, paramedics are in a position of responsibility and authority regarding the treatment and disposition of the patient. But unlike the experience of emergency physicians, paramedics do not have to reach much of a diagnosis regarding their patients. They only need to have enough of an idea about what might be happening in order to select the proper protocol. In the case of chest pain, simply following the standard chest pain protocol (aspirin and nitroglycerin) is the ideal response if it is an MI, and relatively harmless if it is not. The primary job of paramedics is to stabilize the patient if possible and to maintain the basic processes required for life (airway, breathing, circulation). Nevertheless, all of the paramedics in this scenario took effort to determine the cause of the patient’s chest pain.

The LE paramedics did not explore as many alternative hypotheses as did the ME paramedics. When given hints about the unexplored hypothesis of PE, most of the LE paramedics responded by mentioning the planning or status of treatment and transportation measures. The ME paramedics were able to go beyond the procedure for confirming/disconfirming an MI, and to utilize other assessment procedures to actively explore a wider variety of possible causes.
The fact that the ME paramedics pursued the diagnostic process further than did
the LE paramedics may be related to goals regarding the care of the patient after
handoff at the ED, and the credibility of the paramedic (and by extension, the
EMS staff) for the ED staff. As discussed by the expert panelists in study 1,
quickly getting the most appropriate hospital treatment for the patient depends
on knowing which ED or specialty lab the patient should go to, and being able to
alert the staff. Determining that the destination is appropriate, and being able to
justify that decision, will also enable faster turn-around.
Beyond that particular patient, establishing and maintaining a good record of
decision-making with the EDs will help with negotiations with future patients. If
the catheter lab is activated for a patient who actually turns out to have a non-
cardiac issue, this will not only cause problems for that particular patient, but it
will hurt the credibility of the paramedic, and his or her ability to control patient
disposition and mobilize resources in the future. Thus, the motives for
determining what was really going on with the chest pain patient involved
multiple goals at different levels. The context of work distributed across multiple
organizations, conducted by agents in roles with different goals and stances,
increases the importance of deliberate management of these relationships.
4.4 Multiple Patients Case

4.4.1 Multiple Patients scenario

4.4.1.1 Scenario Detail
In the Multiple Patients scenario, the paramedic is called for a shooting (the police are there and have already secured the scene). Upon arrival, he or she is presented with two shooting victims; one is shot in the head, the other in the chest. This is presented via pictures showing both patients from a distance. The paramedic can request a backup unit, but it will not arrive for a few minutes. In the meantime, he or she has responsibility for both patients.

While being responsible for hands-on management of multiple unstable patients is atypical for other health care providers, this is not an especially uncommon situation for paramedics. One of the calls observed by the author during preparatory work included two patients at once. This multiple patient scenario is based on an actual case handled by one of the expert panelist paramedics. All of the paramedics in the study reported having experience with multiple patient calls, though for most of the paramedics, especially the urban ones, there are usually more resources.

The man shot in the chest is initially presented sitting up and talking. He is breathing somewhat fast, and holding his chest. The man shot in the head lying down, unresponsive. The paramedic must decide what to do – who to approach, and how to use the EMT partner.
The patients are several feet from one another. To observe the vital signs of a patient, the paramedic must put the patient on an EKG monitor with O2 sensor, or take vital signs manually, or have the EMT take vital signs manually. The paramedic must go over and look at a patient to make visual assessments. Similarly, the paramedic must be at a patient in order to perform interventions, or else direct the EMT to perform interventions (within the EMT’s scope of practice) upon the patient.

The Head-shot Patient has a low chance of survival. His posture (decerebrate) and his breathing pattern (agonal) indicate significant swelling of the brain, causing pressure on the brainstem and spinal cord. His vital signs are poor, and without intervention, slowly get worse.

Administration of oxygen, IV fluids, and interventions to his airway and breathing have effects on these vital signs. Some of these interventions can only be done by a paramedic (e.g., IV, full intubation). Some, such as the full intubation, usually require two people to perform safely. Some interventions, such as use of a bag valve mask, are ongoing manual tasks that tie someone up, making them unavailable for other manual tasks.

The Chest-shot Patient gets worse over time. As he breathes, air gets sucked into his chest-cavity. Instead of escaping, the air forms a continuously growing bubble in his chest (a tension pneumothorax), blocking his left lung from expansion, and causing some displacement. This causes lower sat O2, faster respirations, slightly
faster pulse and slightly lower blood pressure. He becomes less alert, but also visibly distressed. His face becomes more cyanic, and his neck shows signs of tracheal deviation and jugular vein distension (from the pressure of the bubble).

Oxygen, IV fluids, and covering the wound affect his vital signs somewhat, but they do not prevent the decline caused by the tension pneumothorax. Alleviating the tension pneumothorax involves decompressing the chest by inserting a large syringe, or “burping” the wound, to release the trapped air. This results in improved vital signs, appearance, and responsiveness.

Two hospitals (a level 3 trauma center, and a level 1 trauma center) were both nearby, each 3 minutes away.

More details and materials are available in Appendix F: Multiple Patients Case Materials. Figure 4.21 shows the images of the patients (Head Shot on left, Chest Shot on right).
4.4.1.2 **Cognitive Work in Multiple Patients Case**

This case incorporates time pressures, resource limits, and attentional demands that should make it impossible for a paramedic to execute the considerable work required to thoroughly respond to both patients. Providing adequate treatment for one patient should mean neglect of the other patient. However, as discussed below, many of the paramedics were able to provide considerable care to both
patients. For these paramedics, the case did not serve as the over-constrained task it was designed for.

The attentional demands come from the changing status of the two patients, and the need to coordinate with backup resources and the ED. The workload demands come from the criticality of the patients’ conditions (in addition to assessment, there are requirements for management of circulation, airway, breathing, and wounds).

Additionally, there is a stereotype violation, in that the patient who more severely injured warrants less attention and effort than the one who is less injured. Compounding this is the change in the Chest Shot patient’s condition over time. This change happens slowly, against a noisy background. Understanding the rational for prioritizing the Chest Shot patient over the Head Shot patient requires integrating information distributed across the two patients, and over time.

4.4.2 Analysis

The results for paramedics B and D are not included in this analysis, as problems occurred during the simulation such that the results are not easily comparable with the other participants. Thus, there are 4 More Experienced (ME) and 4 Less Experienced (LE) paramedics in this analysis.

Paramedics A and F did not handoff their patients, so they had more time with both patients. For measures dependent on duration of exposure to both patients
simultaneously, aggregate figures for all ME paramedics, as well as for just C and
d (excluding A & F) are presented.

Paramedics C and H chose to handoff the Chest-shot patient (CP) to the backup unit, and continue treating the Head-shot patient (HP). After finishing with HP, the Simulation Administrator had them continue with CP, starting at the handoff point. Thus, they had more exposure to HP than did the other paramedics (D, G, I, J). Post-handoff actions with HP are identified as such.

The focus of the analysis is on how the paramedic managed the two patients simultaneously, and the impact to that process of the different saliencies of the risks experienced by the two patients.

While the paramedics did direct interventions and assessments on both patients, most of the actions for one of the patients (either CP or HP) were done via the EMT. This was the patient to which the EMT was delegated, while the other patient was the one the paramedic attended.

One aspect of managing the two patients is to what extent the paramedic focused on one patient versus frequently attending to each one alternately. This is measured by the number of times the paramedic switched focus from one patient to the other. When the paramedic was working on, asking or talking about one patient, then stopped that and began focusing on the other patient, it is counted as a switch between patients. External triggers other than the patients (such
as alerts from the EMT, the arrival of the backup unit, or arrival at the ED) are excluded.

When the paramedic switched from focusing on one patient to focusing on planning, backup, general resources, scene, etc. (something not specific to one patient), it is not counted as a switch across patients. If the paramedic focused on one patient, then on the status of the backup (for example), then on the other patient, it is counted as one switch.

The rational for this is that the different potential targets of focus not related to a specific patient (e.g., planning, evaluation of the scene, etc.) were not defined in the simulation, and therefore reflect the paramedic’s scope, granularity, and specificity in his or her particular approach to the simulation. For example, paramedics A and F did not utilize backups, and so were not checking on backup status. For paramedic G, reference to backup was paired with reference to the EMT’s patient – checking on backup was part of G’s approach to assure care for the EMT’s patient. Thus, as it is with therapeutic and assessment actions, it is necessary to measure attention at the level of coarsest granularity in order to facilitate comparisons across participants.

As the patients’ conditions were changing over time, it is possible that while the paramedic was focused on one patient, the other patient’s status changed. If the other patient was being attended by the EMT, and the paramedic had neglected to check on the status of that patient, the EMT would alert the paramedic to the change in status.
If enough time in the scenario had passed such that the EMT’s patient would experience a change in status, and the paramedic had not recently checked the status of that patient, the Simulation Administrator would cue the EMT to call out to the paramedic with the new status (e.g., “Hey, this guy is looking pale and anxious. His breathing is more rapid”). These information pushes from the EMT are another indicator of the attention management processes used by the paramedics. Note that, as discussed in the Simulation section above, the passage of time in the scenario is estimated based on the typical (real-world) duration of the actions performed by the paramedic, as opposed to clock-time.

Comparing the thoroughness or intensity of the care provided to the two patients, with different needs, is done by looking at the whole set of interventions provided to each patient by all the paramedics. (As in the Chest Pain case, actions are converted to the coarsest granularity.)

The main landmark for managing blood pressure in the patients is the introduction of an IV. For managing the airway and breathing of the patients, there are various interventions, ranging from less costly (in terms of time and effort) and effective to more costly and effective. For the Chest-shot patient, these landmarks (in order) are: placing an occlusive dressing over the wound; administering oxygen; and decompressing the tension pneumothorax. For the Head-shot patient, these landmarks are: administering oxygen; opening the airway with an airway adjunct (such as an oropharyngeal airway); and controlling the airway with endotracheal intubation.
The extent of interventions achieved upon each patient by the time handoff occurs is one indicator of the effort applied to each patient (see the CP pre-handoff Rx status and the HP pre-handoff Rx status columns in Table 4.6).

In addition to decompression, there are other intervention and assessment actions that related to the tension pneumothorax. Some (primarily the use of a 3-sided occlusive dressing in covering the wound) are intended to decrease the likelihood of a tension pneumothorax developing (see the Try to Prevent Tension Pneumothorax column). There are also assessment actions (looking for jugular venous distention or deviation of the trachea) that are performed to in response to patient decline to evaluate for a developing tension pneumothorax (see the Suspect Tension Pneumothorax column).

### 4.4.3 Findings

#### 4.4.3.1 Overview

As with the Chest-pain case, all of the paramedics responded to this challenging situation adequately, providing care and transport that would improve the patients’ chances of survival. Because of the resource limitations, providing ideal care to both patients was not possible, but some paramedics were closer to that than others.

The More Experienced paramedics managed to perform more advanced and effective interventions, especially with the Head-shot patient. All of the ME paramedics responded to the tension pneumothorax in the Chest-shot patient,
whereas only three of the four Less Experienced performed a decompression on CP. The ME paramedics also utilized their EMT partner in a greater variety of ways than did the LE paramedics. Compared to the LE paramedics, the ME switched attention across the two patients more, and required fewer pushed updates from the EMT. The most experienced paramedics were also able to progress with their interventions in a somewhat balanced fashion, taking care of the basics for one patient before proceeding to advanced interventions on the other. The least experienced paramedics were either balanced or thorough, but not both.

Most of the paramedics handed off HP to the backup units. Two (C and H) handed off CP instead, and two (A and F) did not handoff either patient, instead taking both to the ED.
Table 4.6: Summary of Multiple Patient Case Performance

<table>
<thead>
<tr>
<th></th>
<th>Switches between patients</th>
<th>Pushes from EMT</th>
<th>Paramedic attended</th>
<th>CP pre-handoff Rx status</th>
<th>HP pre-handoff Rx status</th>
<th>Try to Prevent Tension Pneumothorax</th>
<th>Suspect Tension Pneumothorax</th>
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<td>2/4: CP</td>
<td>3/4 (1/2)*: Decompression</td>
<td>3/4 (1/2)*: Intubation</td>
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</tr>
<tr>
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<td>Mean 6.5 (C &amp; D)</td>
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<td>2/4: HP</td>
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<tr>
<td>A</td>
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<td>CP</td>
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<tr>
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<td>1</td>
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<td>Decompression + IV*</td>
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</tr>
</tbody>
</table>

‡ Data for B and D are not included in the Multiple Patient case.
* A & F did not hand-off either patient, instead staying with both until arrival at ED.

4.4.3.2 Interventions

Figure 4.22 illustrates the sequences of landmark interventions upon each patient. The paths start in the lower left corner of each grid. Growth upward occurs through interventions for CP, whereas growth towards the right occurs through interventions for HP.
Figure 4.22: Prioritization of Patients (Based on Landmark Interventions)

For all but two paramedics (C and J), HP received the initial effort of interventions. As the decline of CP was noticed, the focus shifted.

For the most part, the ME paramedics took care of the basics with one of the patients, then switched to the other. They did not proceed to the maximum intervention with one patient while ignoring the other. The exception is F, the least experienced ME paramedic.
The ME paramedics progressed further along the path, particularly with regards to intubation for HP. Of the ME group, 3/4 (1/2 excluding A and F) performed intubations, whereas no LE paramedic intubated HP. All of the ME paramedics decompressed CP (one decompression was post-handoff). Three of the LE paramedics decompressed CP (one decompression was post-handoff).

Table 4.7 show the actions performed with each patient in more detail. In the ME and LE columns, the black regions show actions prior to handoff. Post handoff actions are indicated by paramedic letter codes in normal text. Lowercase letters indicate that the action was performed by the EMT. Mono-spaced font is used to facilitate comparison via horizontal length.
### Table 4.7: Multiple Patient Case Interventions and Assessments

<table>
<thead>
<tr>
<th>Chest Patient</th>
<th>ME</th>
<th>LE</th>
<th>Head Patient</th>
<th>ME</th>
<th>LE</th>
</tr>
</thead>
<tbody>
<tr>
<td>*</td>
<td>Before Handoff</td>
<td>After Handoff</td>
<td>Before Handoff</td>
<td>After Handoff</td>
<td></td>
</tr>
<tr>
<td>Airway/Breathing</td>
<td>Occlusive dressing</td>
<td>O2</td>
<td>Decompression</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Circulatory</td>
<td>Trendelenburg</td>
<td>IV</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Assessment</td>
<td>Suspcion of Tension Pneumothorax</td>
<td>JVD noticed</td>
<td>Lung sounds</td>
<td>Other assessment</td>
<td></td>
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</tbody>
</table>

*Only C & D (of the ME’s), and all of the LE’s, had CP after handoff. All had CP before handoff. A & F did not handoff.

† Only D & H had HP after handoff. All had HP before handoff. A & F did not handoff.

Most of the interventions, especially the earlier ones, were done by the EMT. Few interventions on HP were done by the EMT.

As indicated earlier, the ME paramedics did more intubations. More ME’s suspected tension pneumothorax, and all ME’s performed decompression (as opposed to three of the LE paramedics).

The LE paramedics were more frequent in explicitly indicating assessments for other wounds on CP. One ME paramedics (C) made a point of assessing for...
abdominal trauma, suspecting that since the bullet did not exit, it may have traveled into the abdomen and caused damage there.

In addition to the assessments of HP to see if he needed treatment or was non-viable, CP was assessed by one paramedic (G) to see if he needed treatment or not, suspecting (based on the initial photo) that he may not have serious injuries (e.g., he was punched instead of shot).

4.4.3.3 Sequences

Figure 4.23 illustrates the sequences of actions across the two patients far all paramedics. Figures 4.24 – 4.31 repeat the illustrations for each paramedic individually. Icons represent various actions. Landmark interventions are in color. Those actions directed towards CP are on the top row of the figure for each paramedic, those directed towards HP are on the bottom row, and those that are not specific to one patient or the other are in-between or across the rows. The outlines of the icons indicate if it was performed directly by the paramedic, or indirectly via the EMT. The line connecting the actions illustrates the (simplified) flow of attention of the paramedic.

Without interventions, the patients’ conditions decline. This baseline is represented by the bottom edge (going diagonally from top left to bottom right) of the light gray area stretching across each patient’s row.

Different therapeutic interventions have different impacts on the patients’ conditions. The change in each patient’s condition resulting from the
intervention is represented by a rise in the top edge of the grey area, starting at the point of the intervention. For example, placing the occlusive dressing results in a slight change in the angle of the top edge, indicating a slight improvement in CP relative to his trajectory without intervention. Performing the decompression on CP results in a greater rise in the angle of the top edge. Thus, the space of the gray area is a rough indicator of how much improvement, relative to the baseline of no interventions, the paramedic brought about in the condition of the patient.
Figure 4.23: Sequences of Actions Across Patients
4.4.3.4 Summaries

Figure 4.24: Paramedic A sequence for Multi-Patient

**Summary:** A first established need for immediate transport of HP and had EMT manage HP’s airway. A called for backup for CP, then changed plans and decided to transport both. The patients were packaged and loaded and resources for transportation were obtained. A treated CP’s tension pneumothorax, and provided basic measures (O2, IV) for both patients, and reassessed. A intubated HP prior to arrival at ED.

**Prioritization:** A re-planned after seeing the risk with CP. A took care of the basics with HP, and was responsive to CP.

**Resources:** A had EMT manage HP airway, help package HP; help evaluate tracheal deviation in CP. A recruited a police officer to drive ambulance. A did not wait for backup.
Summary: C decided HP is more critical, and focused treatment on HP. Had EMT manage CP. Intubated HP. CP is given to the backup unit, and HP is packaged for transport.

Prioritization: C took care of the basics with CP before doing an early intubation with HP.

Resource: C had EMT assess CP, provide O2; had EMT apply occlusive dressing to get freed up to help stabilize HP during intubation.

Summary: D prioritized CP based on HP’s poor prognosis, and so sent EMT to HP. D used EKG to see if HP can be declared non-viable. D decompressed CP. HP is packaged and given to the backup unit.

Prioritization: D looked to see if HP could be dropped, then had the EMT treat HP while D managed CP.
**Resources:** D had EMT assess HP, and manage airway with a King airway (because in D’s system EMTs can administer King airways), plus using a bag valve mask. Had EMT put HP in Trendelenberg position (raising legs) to raise blood pressure (because EMTs cannot do IVs in D’s system).

![Diagram of medical procedures]

**Figure 4.27:** Paramedic F sequence for Multi-Patient

**Summary:** F attended to HP and confirmed that EMT was managing CP. F worked on HP’s airway, and planed transport. F intubated HP. F administered O2 and IV to CP. Both CP and HP were packaged. As CP’s tension pneumothorax appeared, F treated it.

**Prioritization:** F administered a full treatment of HP, but (after a push from the EMT) was responsive to CP.

**Resources:** F had EMT assess CP, administer oxygen, and administer an IV (typically outside the scope of EMT-Bs, but within the scope of EMTs in F’s state of practice). Had EMT package CP, apply occlusive dressing, and monitor. Had EMT help with packaging HP. F did not use backup.
Summary: G went to HP as CP looked non-critical. Sent EMT to assess if CP needed emergency treatment. Worked on airway for HP. Asked for backup to help the EMT with CP, and in response to decline, directed use of O2 and occlusive dressing. Once G had resources breathing for HP, and CP declined, G attended to CP, decompressing the tension pneumothorax.

Prioritization: G focused on HP, but after addressing airway and breathing, was responsive to CP.

Resources: G delegated EMT to CP, but did not provide direction until after push from EMT (had assumed EMT would not need direction). Had EMT administer O2 and occlusive dressing. G recruited a police officer to operate ventilation bag for HP. As CP declined, G switched places and had EMT package HP. G initially viewed backup as providing support for EMT.
Summary: H approached HP to see if he could be declared non-viable. Instead decided HP was a load-and-go. H directed basic responses for CP. H worked on an airway for HP. CP was handed-off to the backup unit. When managing CP, H considered various means to obtain permission to perform decompression, before finding that protocol requirements were already met.

Prioritization: H looked to see if HP could be dropped, but instead started with basic treatment. H directed basic treatment of CP while giving HP an airway.

Resources: H had EMT assess CP, and apply occlusive dressing. H recruited a police officer to operate ventilation bag for HP.

Summary: I went to the more critically looking HP, and called for backup as CP's status was unknown. I decided that HP could be bag-ventilated for the duration of the wait for the backup. While bagging HP, I directed the EMT to apply O2 and the occlusive dressing to CP. HP was handed-off to the backup unit.
**Prioritization:** I ventilated HP and responded to CP’s decline with basic treatment, while waiting for backup.

**Resources:** I had EMT assess CP, and apply occlusive dressing and O2. I waited for backup instead of initiating new interventions or plans.

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**Figure 4.31:** Paramedic J sequence for Multi-Patient

**Summary:** J attended to CP, and had EMT evaluate HP for non-viability. Upon finding that HP cannot be pronounced, J calls for backup. J anticipated CP’s tension pneumothorax and treated it. Afterwards, J addressed HP. HP was handed off to the backup unit.

**Prioritization:** J focused on CP, looking to see if HP could be dropped. J managed CP, addressing HP only after CP was decompressed.

**Resources:** J had EMT evaluate HP for non-viability; operate ventilation bag for HP. Presented with only one EKG monitor, J decides to take if off of CP to use on HP (reluctantly, due to risk of this being seen as abandonment of CP).

Overall, most paramedics started with HP, then shifted to CP. The differences are what they did with HP, and how responsive they were to CP. Paramedics A, C, and D mostly took care of basics before doing advanced interventions. F and G
were focused on HP but were responsive to pushes about CP. The remainder were either thorough (J) or balanced in their focus (H, I) but not both.

The ME paramedics utilized the EMT in more ways than did the LE paramedics. The activities the EMT performed for the LE group are: administering O2, applying the occlusive dressing, and operating the ventilation bag. The activities performed for the ME group include those plus: evaluating tracheal deviation, stabilizing during intubation, inserting an airway adjunct (King airway), and managing blood pressure.

4.4.4 Preliminary Discussion

4.4.4.1 Utilizing resources and levels of control

Unlike other health care providers, it is not particularly exceptional for a paramedic to be responsible for more than one unstable patient at a time, with minimal resources at hand. These results show the cognitive challenges and strategies involved in effectively managing such a situation.

There are still limits to the authority of the paramedic. Given the poor prognosis of HP, the demands of CP, and the delay in getting backup, some paramedics looked to see if they could pronounce HP as non-viable, and therefore focus efforts where they would not be wasted. Their protocols for pronouncing did not allow them to pronounce HP as non-viable, so they had to allocate resources to managing him.
Paramedic J was confronted with a similar problem, but with CP. J needed to use the one EKG monitor he had, but it was already on CP. J was hesitant to remove it, expressing concern that such an act could be construed as abandonment.

However, there were instances of the paramedics showing how they can work around protocol limitations to achieve their goals. Upon recognizing the CP needed decompression, paramedic H was confronted the possibility of a protocol limitation. In H’s system, physician approval is required for a paramedic to decompress a chest, unless the vital signs are extreme enough. While checking on the vital signs, H was also planning what options (in terms of patient trajectory and in terms of exaggerating the vitals signs) would ensure that H could perform the necessary decompression without professional repercussions. (The vital signs were extreme enough to allow decompression without approval.)

Utilization of the EMT also presented some scope of practice problems. EMTs cannot intubate, and in most systems cannot administer IVs. Paramedic D was able to work around these limitations by having the EMT use a King airway instead of an endotrachial intubation, and placing HP in the Trendelenberg position (raising the legs to increase blood pressure in the rest of the body).

This use of the EMT illustrates adaptability in response to constraints. D was able to see other ways to manage the airway and blood pressure, beyond the standard ones. In general, the ME paramedics were able to see a greater variety of ways to utilize the EMT than were the LE paramedics.
For the most part, the ME paramedics demonstrated capacities for adaptation. Paramedics A and F decided to transport both patients. D adapted interventions to fit the EMT’s scope of practice. On the other hand, half of the LE did not go beyond basic interventions during the time they had two patients.

Some of the more experienced paramedics demonstrated the ability to change priorities. A, D, F and G started with HP but were able to switch focus upon interventions for CP. A and D were more proactive, not requiring pushes from the EMT.

These capabilities of shifting attention, adapting utilization of the EMT and means of transport, and updating prioritizations, all constitute ways of exerting higher levels of control. Instead of simply controlling each patient’s physiological status by responding to signs with particular interventions, the paramedic is modifying the methods of intervention, and the short-term goals.

4.4.4.2 Differences between Knowledge Elicitation and Staged-World studies

In expending significant effort on the Head Shot patient, the performance of the ME paramedics in the Staged-World study differs from the response recommended by the expert panelists in Phase 1. The expert panel discussion of the Multiple-Patient scenario generated a description of experienced paramedic performance in which the Head Shot patient was given minimal treatment, prioritizing limited resources for the more viable Chest Shot patient. However,
the staged world study generated a pattern of performance in which the more experienced paramedics garnered the resources to perform significant care on both patients (even though they recognized the poor prognosis of the Head Shot patient).

The Phase 1 panelists did not misjudge the case or come up with an improper plan of care. Nor did the experienced paramedics commit mistakes by attending to both patients.

Given the discussion of the case as a challenge scenario, involving trade-offs and resource constraints, the panelists appropriately concluded that the best response involved prioritization of the more viable (but nonetheless in risk) patient over the less viable one.

The paramedics in Phase 2 were presented with the scenario in a different context—a simulated call. Concrete, highly salient representations of the patients were present, as was an EMT partner. These paramedics were much more immersed in the situation than were the panelists. The simulated situation helped bring forth attitudes about patients, and skills at resource utilization and attention management. Conversely, the less immersed, more abstract relationship to the situation experienced by the panelists enabled more reflection on broader issues of risk management and prioritization.

The multiple patient scenario was based on an actual call experienced by one of the panelists. The importance of the trade-off decision made by that paramedic at the time was captured in the discussion. The specific goals and constraints that
defined that particular decision were fully available to that paramedic in that situation (leading to the appropriate trade-off decision), but they were not captured in the panelists’ consensus representation of the scenario, nor in the manifestation of the scenario in the simulation.
5.1 Limitations

The important dimension of scene management, especially the social aspect (Campeau, 2008b), was not fully incorporated into theses scenarios or the simulation.

It is realistic to have the paramedic paired with a junior EMT with whom the paramedic is unfamiliar. However, it does not involve the same patterns of coordination as the more typical situation of being part of a team of familiar colleagues, with whom the paramedic will continue to work.

Neither did these scenarios and the simulation attempt to incorporate the complex roles of patients and family members, and how their social and emotional states interact with those of the paramedic and each other. It is expected that expertise and the corresponding abilities to detect patterns, anticipate issues, and adjust goals and tactics, would be more visible in these sorts of situations.

Nor were relationships with ED staff or other non-EMS stakeholders incorporated. Disposition decisions were limited to a small number of hospitals, distinguished only by location, level, and any relevant labs or specialties. Missing was any informal information about the people and their skills, nor any
transactive memory of encounters, nor expectations concerning future interactions.

The analysis of the paramedics’ performances is limited in two particular respects. The clinical interventions were analyzed at a fairly high level, without exploring the specific differences between one paramedic’s flow rate of oxygen, or IV needle gauge, and another’s. Except for years of experience, little analysis has been done regarding possible relationships between performance and other participant attributes.

5.2 Expertise

In being exposed to calls in complex situations (via these scenarios and the simulator), the experienced paramedics in the study displayed the adaptations they have developed from working in complex situations. These enable the paramedics to utilize the resources available (including material and social resources). One way of looking at expertise which takes context into account is with respect to the expert’s relationships with these different levels of resources.

As expertise develops, changes occur in the paramedic’s relationship with his or her set of knowledge and skills. More connections develop, particularly with schemas or scripts concerning assessment and management possibilities. For the More Experienced paramedics, the swollen leg of the Chest Pain patient was related to the chest pain and shortness of breath.
For the ME paramedics, some material resources provided a wider range of functions. Nitroglycerin and albuterol were not only for treatment, but for diagnosis. The ME paramedics were able to get more from the other people on scene. In addition to having the EMT do a greater variety of tasks, they were able to get more information from the patients, using the patients as an information resource, and even evaluating the veracity of the Chest Pain patient as source of medical status information.

Relationships with other stakeholders are not just about immediate use as resources. In the distributed work of EMS, managing relationships involves maintaining credibility, common ground, and reciprocity. The Less Experienced paramedics, by doing less diagnosis and less treatment of the patients, pushed additional work downstream. The ME paramedics were able to deliver the patients to the ED staff in a more prepared state, and with more information about their conditions.

In accomplishing more, the ME paramedics are displaying a different relationship with their own capabilities as paramedics, and roles as agents in a distributed system. The fact that the ME paramedics did attempt to come to a more precise presumptive diagnosis for the Chest Pain case, and did attempt to perform more significant interventions on the Head Shot patient in the Multi-patient case, means that they believed they had the capabilities to achieve those aims, and that it was within their role to do so.
5.3 Control

5.3.1 Gathering and using information

For paramedics there is considerable latitude regarding the depth of the problem to be explained, how far back along the chain of causality to go. The focus is on primarily on the acute problem (as illustrated by one of the expert panelists, the diagnosis is of ‘hypoglycemia, not diabetes; drug overdose, not addiction’). On one hand, having just enough of a mental model of the patient’s condition to select the appropriate procedure is sufficient. To the extent that the procedures are broadly applicable, and/or there are algorithms to guide the selection of procedures, the model of the patient’s condition may be fairly non-specific. With minimal understanding of the underlying issues, the patient’s airway, breathing, circulation, and pain can be managed, and he or she can be delivered to an ED.

On the other hand, without some understanding of the underlying issues, anticipation of risks and prioritization of tasks are difficult. Factors related to an ongoing problem may be neglected, with consequences for the EMS (a misdiagnosis at the ED may lead to a return home, followed by another call to EMS; a patient developing a chronic condition and poor management practices can result in frequent need for EMS help). There will be insufficient information to make a good decision regarding the disposition of the patient. The paramedic will be unable to help the ED staff with preparations and prioritizations, which can delay the turn-around time of the EMS unit.
Failing to acquire and organize information according to likely conditions may reinforce an image of the paramedic as more of an “ambulance jockey” and less of a clinical peer, thereby missing an opportunity to gain credibility, and influence over decision in the ED.

In the Chest Pain scenario, the more experienced paramedics went further with their diagnoses, going beyond the “MI or not” assessment protocol. They explored a wider range of hypotheses, using various assessment methods. The switched from cardiac assessment to respiratory assessment, then to examining the body and legs, and/or asking about different aspects of the patient’s immediate or long-term history. They switched approaches from one to another as led by their knowledge and reasoning, the data available, and the resources available, in pursuit of a satisfactory explanation.

Paramedics want to have an impact on the well-being of their patients [a primary motivation in the selection of relatively low-paying, high-stress EMS careers (Metz, 1982)], and they want to avoid slow turn-around times. Given those interests, the effort by an experienced paramedic to come to a more complete diagnosis likely has benefits for the patient, and for the future credibility and influence of the paramedic him or herself.

The diagnostic process is influenced by the fact that paramedics have latitude regarding diagnoses, the requirements for saing interventions upon the patient, and the responsibility for and control of resources enabling assessment. Studies
of physicians performing diagnosis, and studies in which information is presented independent of interventions or resource allocations, neglect these factors.

5.3.2 Management of plans and other resources

Much of the time, the only resources available to the paramedic are the people and equipment on the ambulance, if not only that which is brought to the side of the patient on-scene. With these resources the paramedic must manage the scene, the patient (or patients), and coordinate for more resources. In this study the ME paramedics demonstrated more responsive resource management techniques in a variety of ways.

They were able to use the EMT partner in a greater variety of ways than were the LE paramedics. It is possible that this is due solely to the greater number of interventions done in general, or that better use of the EMT helped enable the greater number of interventions. Some of the ways the ME paramedics used the EMT indicate a deliberate, tactical use of a specific resource. Paramedic A used the EMT as an independent consultant in evaluating the Chest-shot patient for tracheal deviation. Paramedic D deviated from standard ways of managing the airway and circulation in order to accommodate the limited scope of practice of the EMT. This suggests that the ME paramedics had a better understanding of (or greater access to mental representations of) the courses of action made available through the EMT.
The more experienced paramedics also demonstrated a greater sensitivity to future demands, by anticipating the development of the tension pneumothorax in the Chest-shot patient. Many of the LE paramedics demonstrated knowledge of the general requirement of a one-way air flow bandage for chest perforation wounds, but the ME paramedics were more likely to see the trajectory of this patient as very likely leading to a tension pneumothorax. This understanding of trajectories may be used in planning the resource allocation and management of the patients.

The more experienced paramedics were able to shift attention between the two patients in the Multiple Patient scenario more frequently. Their distributions of assessments and interventions were more spread across the two patients over time.

This execution of multiple, interacting sequences (involving assessments and re-planning) was guided by knowledge of possible patient trajectories and possible courses of action. These possibilities may be more accessible for the ME paramedics than for LE paramedics. It may also be the case that, for the ME paramedics, the management of the sequences of action for each patient required less continuity than for the LE paramedics.
5.3.3 Levels of Control

The more experienced paramedics were able to:

- Generate more hypotheses, and perform a greater variety of assessments;
- See more of the possible trajectories of the patients; and
- See more ways to use the EMT, and more of the possible courses of action.

Through their knowledge structures and perception of the situation (guiding and priming, respectively), these paramedics had access to more of the problem space.

The key elements in this greater access are the multiple means and tactics of achieving particular aims. These paramedics were able to step back, and recognize variations in how to accomplish the tasks at hand, adapting the approach to suit the situation. They were able to select different ways to:

- approach assessment and diagnosis (going beyond the “MI or not” protocol);
- use the EMT (doing more tasks than ventilation);
- and manage patients (attending to, and even transporting, both at the same time).

The work of paramedics can be expressed with nested control loops (Jagacinski & Flach, 2002; Lee, 2010). At one level, the paramedic is controlling a physiological process by managing an intervention (for example, increasing oxygen flow to raise saturated O2 values). At another level of control, the paramedic is modifying the lower-level control loop by updating the target value (e.g., leveling off at a lower sat O2 value because the patient is a smoker). At another level up,
the paramedic is modifying the means by which the process is controlled (e.g.,
administering a nebulizer to clear the lungs to raise sat O2 values). At a still
higher level, broader changes in tactics are made (e.g., consider assessing and
treating for anemia or other blood-related causes of low sat O2).

Experienced paramedics are able to exercise control at tactical and strategic
levels to pursue their aims. Regarding the example of the use of the EMT,
modifying tactics for use of the EMT enabled the more experienced paramedics to
treat both shooting patients more thoroughly than the did other paramedics.

Consider the example of arriving at a more fundamental diagnosis than necessary
for immediate treatment. This enables the paramedic to select the best
disposition for the patient, and to effectively negotiate for allocation of resources
for that patient. This also facilitates short-term future options (by returning to
service more quickly) and long-term future options (by enhancing credibility with
the ED staff).

Another example is a change in tactics in the process of taking a history. In
going a history of the Chest-pain patient, some of the more experienced
paramedics asked questions designed to provide information on how attentively
the patient managed his own health (Was he on aspirin? When did he last see his
doctor?) in order to assess the credibility of his information about his current
medical status. Instead of simply taking the information at face value, these
paramedics modified their tactics, in order to pursue the goal of an accurate
understanding. This shift was triggered by recognition of the possibility of inaccurate information.

5.4 Implications

5.4.1 Cognitive Task Analysis methods

The differences in what the ME paramedics did in the Multi-Patient case (in the Staged World study) vs. what the expert panelists recommended (in the Knowledge Elicitation study) illustrate the impact of different cognitive task analysis methods. In the discussion about some abstract paramedic confronted with two abstract patients, much of the focus was on trade-off decisions and risk management. In the simulation, with a particular paramedic attempting to (virtually) manage two specific (albeit fictional) patients right there, with an EMT and other resources present, the focus was on how to accomplish the management of both patients. The differences between the two groups (one of senior trainers and managers, the other of currently practicing paramedics) likely contributed. However, the context of the two different activities likely plays an even stronger role, given the importance of the scene in paramedic work (Campeau, 2008b) and the situated nature of much of the types of cognitive work (planning, resource management, attention management) of the paramedics (Robbins & Aydede, 2009; Suchman, 1987). Also, some of the ME paramedics had supervisory and training experience.
In the Knowledge Elicitation study, the participants were sharing their knowledge in the form of stories. The expert giving an account of a phenomenon in the expert's domain is in a position of control; he or she defines the elements, scope, and context of the story. Knowledge is brought forth by it being activated by this account of the expert's own creation. In the Staged World study, the participants were demonstrating work in the context of specific cases. Knowledge is activated by artifacts and events in the simulation, all largely under the control of the Simulation Administrator.

Different cognitive task analysis methods have different strengths and weaknesses. For studying paramedic work, the Knowledge Elicitation method used in Phase 1 was not sensitive to the goal setting and resource utilization tactics that the Staged World study did detect. This suggests that Knowledge Elicitation studies of similarly situated work should explore the use of scenarios, representations of the task environment, and other external representations, to support the participants in incorporating the situational aspects of cognitive work.

5.4.2 Health Information Technology applications

5.4.2.1 Telemedicine
Currently, paramedics can initiate two-way audio communication with EDs or Medical Directors, and in most systems they can transmit 12-lead EKGs. Increasing the type of information transmitted, and providing more control (over
what information gets transmitted and when) to the receiving agents (i.e., the ED) will have impacts at multiple levels.

The remote observers will have a partial view of what is occurring; they will be only partially situated at best. Audio and video feeds have limited ranges. Even if systems can be carried outside of the ambulance, the full range of visual and audio information will not be available (not to mention smells, the feel of surfaces, weights and resistances, etc.). Supporting the information reception of the remote observer will be necessarily be a secondary priority for the ambulance crew.

How the remote observers account for the situatedness of the ambulance crew (in terms of the crew’s better information, and in terms of their immediate, hands-on, sharp-end responsibility) will affect the relationship between the on-scene paramedics and the remote experts. If control over the technical manifestation of the relationship (the telemedicine system) is mutually negotiated, and adaptive to demands of both parties, then expertise on how to utilize these new and valuable resources can develop—for both paramedics and their use of remote experts, and remote experts and their use of paramedics.

One possible problem that could arise is paramedics sharing data selectively as a way to influence perception of the case by the ED staff. Selective use of information in negotiations with down-stream providers is already commonplace; telemedicine could simply become one other channel. Another risk relates to how authority and responsibility are influenced. Will paramedics
under direct supervision of a physician experience a decrease in authority, and assume a role of simply following instructions? Opportunities not visible to a remote observer (non-paramedic at that) will no longer be utilized, and expertise at managing situations will erode.

5.4.2.2 **Electronic Medical Records**

Providing access to electronic medical and personal health records has potential for enabling paramedics to see more risks and constraints earlier in the process. However, these records constitute asynchronous communication between distributed agents, and as such can come with coordination problems. A primary issue is the attention demands and resources of the paramedic, who cannot review a detailed medical record prior to initiating priority assessment and safing actions. Furthermore, the sequence and representation of the information, and the timing of its presentation, will influence the diagnostic process of the paramedic.

Another aspect is the need for assessing the credibility of the information provided by patients or family. Tools to support analysis of information should include functions for evaluating sources and comparing, contrasting, and corroborating information (Elm et al., 2005).

5.4.3 **Training & Evaluation**

Training, as a means of supporting the development of not just competency but expertise, can attempt to enhance the paramedic’s relationships with knowledge
and with material and social resources. Similarly, evaluation can assess these relationships, and the degree to which the paramedic can perceive relevant functional aspects of various resources relative to particular situations.

Using scenarios and external representations to support situated cognition is an important technique for both training and evaluation. The technology used in this study is inexpensive, portable, and effective. Such systems could be used to generate meaningful, interactive, engaging simulations to expose students and paramedics to a wide range of cases. Experiencing different cases, including challenging cases, can prepare paramedics for rare cases, sensitize them to atypical presentations, and help them accumulate greater quantities of cases for reference.

As part of expertise concerns the paramedic’s understanding of him- or her-self as fulfilling the role of paramedic in a distributed system, it is important to support the development of that relationship between the person and the role. Evaluations, especially milestone evaluations such as certification testing, are opportunities to guide that development. Connections between becoming certified, and having greater responsibilities with patients, and a greater role in a distributed, multi-professional health and public safety system, can be emphasized.

5.5 Future Studies

Given the emphasis from the expert panel on interactions with ED staff, and the potential role of expertise and control in coordination with the ED staff, one
direction for future research is how paramedics make disposition decisions, and how they manage their relationships with the ED staff. Components of this research would include knowledge elicitation studies focused on recognition and navigation of dependencies involving ED resources; observations of interactions between EMT/paramedics and ED staff; and interviews with ED staff focused on their interactions with and assessment of EMS staff.

Complex scenarios could be explored with paramedics with the method of cognitive task analysis via critiquing (Miller, Patterson, & Woods, 2006; Zelik, Patterson, & Woods, 2007). Larger scale situations, and particular types of roles and relationships (and changes therein) could be explored, without requiring simulations or large scale, multi-person exercises.

These studies would help prepare for the development of scenarios and simulations focused on greater fidelity to longer-term patterns of interactions across agents. These simulations could involve multiple people, and compressed time frames. While not identical to the large scale exercises studied by Trent et al. (2007) and Voshell (2009), these studies of cognitive work in complex domains, involving longer time periods and multiple agents, could serve as starting points.


Appendix A: Expert Knowledge Elicitation
Materials
A.1 *Informed Consent Form*

CONSENT  IRB Protocol Number: 200980342
Behavioral/Social Science  IRB Approval date: 2009 12 10

The Ohio State University Consent to Participate in Research

**Study Title:** Elicitation of Cognitive Challenges from Expert Paramedics

**Researcher:** Dr. David Woods, OSU College of Engineering

**Sponsor:** National Registry of Emergency Medical Technicians

This is a consent form for research participation. It contains important information about this study and what to expect if you decide to participate.

Your participation is voluntary.

Please consider the information carefully. Feel free to ask questions before making your decision whether or not to participate. If you decide to participate, you will be asked to sign this form and will receive a copy of the form.

**Purpose:**
The scope of paramedic work is evolving due to greater breadth and complexity of cases, and increased interdependency with other components of the emergency medical service system. These factors influence the set of competencies required of paramedics in the future; how paramedics develop expertise and apply it in new and ambiguous situations; and the ways in which this expertise will be utilized by EMS systems as the systems evolve in response to new constraints and opportunities.

The goal of this research is to explore the future requirements for paramedic competency by investigating expertise in paramedics as it relates to handling of complex cases, and coordinating with other parts of the EMS system.

**Procedures/Tasks:**
If you choose to participate, you will take part in a series of focus group sessions, with five other expert paramedics, taking place in Columbus Ohio over two days. All the sessions will be audio-taped. Frequent breaks are planned (approximately every 90 minutes or so), plus lunch breaks on both days.
Day one will begin with introductions and an overview of the planned activities. Part of the day will involve sessions geared towards exploring concepts related to particular challenges in paramedic work. You will take part in discussions about concepts related to cases that are ambiguous and/or complex, and to challenges in coordination with other parts of the Emergency Medical Service system. You will work with the rest of the group and the
facilitator in developing a list of concepts, and laying them out to depict how they relate to one another.

Another part of the day will involve personal interviews in which an investigator and you discuss cases and situations you have dealt with, selecting one for further exploration. You will be asked questions about how the situation unfolded, and how you made decisions and addressed problems.

You will also participate in a focus group addressing the issues of challenges and expertise in paramedic work. You will be asked to help come up with a training and evaluation scenario that focuses on skills related to paramedic expertise.

Day two will bring with a brief review of the main points discussed on day one, during which you are encouraged to make any clarifications or corrections. Also on day two will be sessions in which the facilitators will present scenarios to the group involving a hypothetical case of a paramedic dealing with a challenging situation. You and the other participants will be asked to reflect and comment on the situation and how the paramedic in the scenario handled it. You will also be asked to critique the scenario, and to suggest changes to make the scenario a more valid and useful evaluation tool.

After lunch, the main points from the morning session will be reviewed, and you will be encouraged to make clarifications and corrections. Lastly, you will be asked to reflect on your experiences in the sessions, and if you have any suggestions for improvement.

**Duration:**
You will fly into Columbus Ohio on Dec 13th. Day one (Dec 14th) will last from approximately 9 am to 5 pm, with multiple short breaks and a lunch break. Day two (Dec 15th) should last approximately from 9 am to 2 pm (also with short breaks and a lunch break). You will fly out of Columbus that afternoon.

**Risks and Benefits:**
It is possible, but unlikely, that discussions of past incidents may bring up unpleasant memories. It is also possible that other participants may disagree with your opinions or evaluation concerning a case or issue, and you could find their judgments unpleasant. In the unlikely event that unpleasant emotional tensions or personal criticisms manifest themselves, the facilitators will respond appropriately, by re-focusing the discussion, introducing a break, or otherwise reducing the stress for the participants.

You will not benefit directly from participating in the study. The potential benefits to the EMT community, and society in general, are a better understanding of the challenges that will face paramedics, and guidance for the development of training systems, evaluation methods, and job support systems that will facilitate the provision of emergency medical care by paramedics.
Confidentiality:
Efforts will be made to keep your study-related information confidential. We are asking all participants to respect one another's confidentiality, by remembering to not disclose the identity or any personal details of fellow participants outside of this group. However, there may be circumstances where this information must be released. For example, personal information regarding your participation in this study may be disclosed if required by state law. Also, your records may be reviewed by the following groups (as applicable to the research):

- Office for Human Research Protections or other federal, state, or international regulatory agencies;
- The Ohio State University Institutional Review Board or Office of Responsible Research Practices;
- The sponsor, if any, or agency (including the Food and Drug Administration for FDA-regulated research) supporting the study.

Incentives:
As a token of appreciation, we are providing participants with a $100 gift card. Additionally, the NREMT is covering the costs of your airline ticket and hotel, and will provide meals and local transportation.

By law, payments to subjects are considered taxable income.

Participant Rights:
You may refuse to participate in this study without penalty or loss of benefits to which you are otherwise entitled. If you are a student or employee at Ohio State, your decision will not affect your grades or employment status. Your decision will not affect your paramedic certification status or employment status.

If you choose to participate in the study, you may discontinue participation at any time without penalty or loss of benefits. By signing this form, you do not give up any personal legal rights you may have as a participant in this study.

An Institutional Review Board responsible for human subjects research at The Ohio State University reviewed this research project and found it to be acceptable, according to applicable state and federal regulations and University policies designed to protect the rights and welfare of participants in research.

Contacts and Questions:
For questions, concerns, or complaints about the study, or if you feel you have been harmed by participation, you may contact Michael Smith; smith.5652@osu.edu; (614) 292-1296.

For questions about your rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact Ms. Sandra Meadows in the Office of Responsible Research Practices at 1-800-678-6251.
CONSENT
Behavioral/Social Science

IRB Protocol Number: 2009B0342
IRB Approval date: 2009 12 10
Version: 

Signing the consent form

I have read (or someone has read to me) this form and I am aware that I am being asked to participate in a research study. I have had the opportunity to ask questions and have had them answered to my satisfaction. I voluntarily agree to participate in this study.

I am not giving up any legal rights by signing this form. I will be given a copy of this form.

Printed name of subject

Signature of subject

Date and time

Printed name of person authorized to consent for subject (when applicable)

Signature of person authorized to consent for subject (when applicable)

Relationship to the subject

Date and time

Investigator/Research Staff

I have explained the research to the participant or his/her representative before requesting the signature(s) above. There are no blanks in this document. A copy of this form has been given to the participant or his/her representative.

Printed name of person obtaining consent

Signature of person obtaining consent

Date and time

Page 4 of 4 Form date: 12/15/05

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A.2 List of Topics

Topics: Handoffs & Documentation
(providing information)

Different roles for documentation for each of your organizations?
Trends relating to documentation?

What are major aspects of the job (on a call) that do not get captured on the form?

Stories of difficulties in dealing with ED?
A time when you wished you had gone to another ED because of the state of the ED, or how you were received?

Questions for each event in coordination w/ ED

- call to ED
- arrival
- handoff to ED
- documentation

How does a novice do ____ compared to an expert?
What difficulties with cognitive work (e.g. planning, coordination, etc) can happen during ______?

How does familiarity with ED staff help?
How does knowing about hospital status help?
How does other things that help?

Strategies for getting listened to?

Expectations or planning for...

Feelings about handoff?

Trends influencing handoff, coordination w/ ED?

"boucebacks to the ED",
GPS system use,
how they would characterize complexity of patients,
how they would characterize complexity of an ED,
how they hand off now and how they would like to hand off, what mistakes novices make.

**Topic: Coordination and Communication**

**Acquiring information**

On a call, what information do you need, and where do you get it from?

**Information**

(How detailed? Where from? What helps & what doesn’t?)

- Location
- # of patients
- Chief complaint
- Reference information (protocol, drug info, etc.)
- Scene factors
- Patient vitals
- Patient history
- Medicines
- Special needs
- Resource status (e.g., hospital diversion)
- Other

**Sources of Information**

(How do you get the info? When? What is helpful and what is not?)

- Dispatch/911 operator
- Partner
- Equipment/instruments
- Patient
- Family
- Bystander
- First responders
- Police
- Ems supervisor
- Ed staff
- Medical control/director
- Reference material (cards, pda)
- Other

What sorts of information do find to be reliable, and what sort of information do you find to be less reliable?
Can you tell me of any experiences with trying to find important information...
- and being unsuccessful?
- and being unsure of its accuracy?

Tell me about an incident where you needed to go outside your normal set of resources to answer a question.

Can you tell me about a case where a patient’s medical record was available?

**Coordination**
What tasks require coordination with other people?

By what basis do you form expectations of others’ actions?

Can you tell me about an instance where coordination with others went badly?
Where people had different understandings of the situation, or there was a misinterpretation?

**Coordination with partner**
How is coordination established?
Under what situations does coordination go smoothly, and under what situations is coordination difficult or bumpy?

**Requesting additional help or resources**
What are resources you might need, that you would have to request (because they are controlled by others)?

Who do you contact? What is the procedure?

Any experiences with resources you needed being unavailable?

Any experiences with requesting resources and later finding they were not needed?

How do you find out about the status of resources? (engine, hospital, air ambulance...)
Topic: Medical Cases

Non-Specific Complex Cases

When I mention complex medical cases -- where it was hard to figure out what was going on, or when things kept changing, or where multiple things were going on at once, does any past experience come to mind?

Chest Pain

We’ve heard that chest pain can result from lots of different causes, including some very serious ones, and that it can be hard to easily tell one problem from another. What do you think about that?

Are there any particularly difficult calls for chest pain that you have handled? Cases where you had to work hard to figure out what was needed?

Any cases where more than one thing was going on at the same time?

Respiratory Distress – Shortness of Breath

We’ve heard that calls for shortness of breath - difficulty breathing can be hard because of the range of things that can be going on – stuff that is not very serious, and stuff that is life threatening; with much different (and incompatible) ways of managing the patient. What are your thoughts about that?

Do any especially troublesome or confusing cases come to mind?

Pulmonary Embolism

Pulmonary Embolisms, so we’ve been told, can be tricky to recognize, but they are also potentially very serious. Thoughts?

Can you tell us about a case in which you recognized a pulmonary embolism? What causes were you evaluating?

What signs did you see that led you to consider pulmonary embolism?
A.3 *Work Structure*

[Diagram of call structure and topics]

**Figure A.1: Call Structure x Topics**

A.4 *Phrases to Help Exploration*

** Starting/Shifting  
Explore (Knowledge Audit) – triggering discussion**

**Eliciting Stories**

- What is challenging in this work?
- Tell me about a call you went where ______
- Have you had an experience involving ______?
- Reconstruct for me the call you went on...
• Take me through the call...
• Reconstruct for me...
• What happened...
• This is an example of X. Any other examples of X?
• What other kinds of cases/situations would be affected by X?

**Challenges in Expertise**

• How have you developed your skills?
• Which person would you prefer for this case – someone fresh out of a good training program, or someone how has been around a number of years?
• What type of experiences do you look for in a good paramedic?
• What is difference between nurse, physician, and paramedic?
• How do you get feedback?

**Know**

**Big Picture**
• “What is important about the big picture - understanding of whole situation - for this task?
• What are the major elements you need to keep track of?”

**Noticing**
• “Experience where part of a situation just “popped” out at you?
• Where you noticed things going on that other’s didn’t catch?”

**Job Smarts**
• “When you do this task, are there ways of working smart, or accomplishing more with less - that you have found useful?”

**Can Do**

**Past and Future**
• “Is there a time when you walked into the middle of a situation and knew how things got that way, and where they were headed?”

**Anomalies**
• “Can you describe an instance when you noticed a deviation, something different than typical?
• When you know something was amiss?”

**Opportunities/Improvising**
• “Example when you have improvised in this task?
• Noticed an opportunity to do something better?”

**Equipment Difficulties**
• “Have there been times when equipment pointed in one direction, but your own judgment told you to do something else?
• When you had to rely on experience to avoid being led astray by the equipment?”
Self-Monitoring
• “Can you think of a time when you realized that you would need to change the way you were performing to get the job done?”

• Let’s say you wanted to come up with a scenario to really challenge people. What would this “scenario from hell” involve?

Stepping Back - Reinvigorating

What is happening in your city/EMS, regarding...
• Distribution/type of calls
• Budget
• Training
• Interaction w/ other public safety, hospitals

Trends
• What do you see as changing?
• What is influencing the role of paramedics in your EMS?
• EMS as a front line of the healthcare system... What do you think about that?

Information Technology
• PHR - Personal Health Records – what might utility or impact be?
• RHIO- Regional Health Information Organizations - what might utility or impact be?

Deepening - digging into topic at hand

Boundaries of event
• What happened before this?
• How did it turn out eventually?
• What happened after that?

Cues
• What were you noticing?

Information
• What information did you use in making this decision?
• How did you get this information?

Analogs
• Were you reminded of any previous experience?
• What seemed relevant about that previous experience for this case?
Goals
• What were your specific goals and objectives at this time?

Options
• What other courses of action were available to you?
• How was this option chosen or others rejected?

Experience
• What specific training or experience was necessary in making this decision?

Assessment
• If you were asked to describe the situation to someone else at this point, how would you summarize the situation?

Mental models
• Did you imagine the events and how they would unfold?

Decision making
• What let you know that this was the right thing to do at this point in the event?
• What would help with management of _____?
• What or whose expertise would be valuable to have on scene?
• What or whose expertise would be valuable to have in the ambulance?

What-If
• How would a novice paramedic have handled the situation?
• What mistakes might he or she have made?
• Would he or she have noticed what you noticed?
• How would an EMT-B have handled the situation?
• How would a nurse have handled the situation?
• How would a physician have handled the situation?
• How would you have proceeded if the patient did/ did not have ____ chronic condition?
• If you had ______ (particular information) available at the time, would you have proceeded differently?

Envisioning
• What might the rules of the road be in 10 years?
• How do we expect things to work?
• Design a future so things go better.
• In future, how do you handle challenge X?
• How would you see technology X?
• When would it be helpful, and when would it not be helpful?
• What might help coordination?
• What information from ED or from patient record would help?
• What would support continuity of care?

Scenario/Simulation
“As you go through this scenario, imagine you are the practitioner in the incident.”
• What actions would you take at this point in time?
• What do you think is going on here? What is your assessment of the situation at this point in time?
• What pieces of information led you to this situation assessment and these actions?
• What errors would an inexperienced person be likely to make in this situation?

• How are things going wrong here?
• How could things change?

Redirect (dynamics of conversation)

Get Others Talking
• How does that work in your EMS?
• Does anyone else have experiences like this?
• What is happening in your city/EMS?
• From the perspective of ____, how do you see it?

Voice
• If I were a student paramedic on a ride-along, what would you tell me?
• Pretend I am the triage nurse. Tell me what I need to know about the call.
• How did that make you feel?

**Complexity Factors**
Data overload – important info buried in lots of potentially important info
Missing information
Lots of noise/false alarms
Masking symptoms
Ambiguous cues, symptoms, signs
Uncertain information
Complex or counter-intuitive dynamics
Multiple, simultaneous influences (vs. Apparent single one)
False initial explanations (garden path) vs. Slowly emerging alternate
Stereotype violations -
Implied relationships (red herring) – actually just coincidental
Hidden coupling, cascading effects
Distributed information – across people
Distributed information across time
Interdependencies among roles (coordination bottlenecks)
Inadequate guidance
Over-constrained task
Double-bind (damned if you do, damned if you don’t)
  • No authority but have responsibility
  • Early intervention vs agendas of junior and senior colleagues
  • Generalist failing to bring in specialist, or unnecessarily bring in specialist
  • One party pays price for the benefit of another party (Grudin’s law)
Goal conflicts
No predefined plan or procedure
Mismatch between plan/procedure and situation
Impasse (plan can no longer work)
Opportunity – unexpected resource or event
Unintended effects
Shifting objectives
Stress, fatigue (tunnel vision)
Workload
Attention demands
Interruptions
Weak leadership & in-fighting
Unreliable communications
Distributed teams
Appendix B: Expert Knowledge Elicitation
Findings Summary
B.1. Introduction to Summary

This summary was generated by the author, based on observation notes from multiple research team members, and the author's transcription of the audio recordings.

This summary presents main points raised in the discussion, focused on aspects of EMS work most relevant to expertise and coordination. Some comments are attributed to specific participants, primarily because of the association between the comment and type of EMS system of the participant. The abbreviations for each panelist are based on the type of system the panelist had been with most recently for an appreciable length of time.

- Huge city, fire-based service (HCFB)
- Multi-city region, private service (MCRP)
- Large city, fire-based service (LCFB)
- Medium city, third service (MC3S)
- National certification organization (NCO)

Unattributed comments represent the author’s interpretation of the consensus of the participants commenting on that issue.

B.2. Broad EMS Issues

Physicians, government administration, and others not experienced in EMS are leading decisions and planning. EMS personnel should have more involvement in policy development.

Structure and operation of EMS systems has a great deal to do with clinical outcomes.

Systems are experiencing high growth, increasing run numbers.

The variability of EMS systems means care must be taken in developing and applying best practices across systems.

B.3. Medical Control

Medical control varies greatly between systems. Some systems have medical directors which are specialists in emergency care (even sub-specialists within that), whereas others have no training specific to emergency medicine, and may be based far away from the region they are covering. There are efforts to increase the quality of medical direction.

For some systems, communication with a medical control physician (for online medical control) is routine, whereas in others it rare, only when the paramedics are encountering situations in which there are no standing orders or are outside the scope of the paramedics' competencies.
For escalation of legal or other non-medical issues (which most ED physicians would not be trained in), many services have supervisors or other experts the paramedics can call. Some systems have very limited scopes of practice for the paramedic, whereas others are quite broad. Rural services need to be able to perform a broader range of interventions than do urban services.

**B.3.1. Research/Treatment**

Decisions about treatments are being made with an “all or nothing” frame. The stance on intubations has been (and in some services still is) to intubate almost anyone who is unconscious. Some services are now considering never intubating. Part of the challenge is that there is a shortage of good studies demonstrating what is useful under what conditions. Protocols are being developed based on studies with very little data. Some medical directors are concerned, and would like more specificity in terms how a new technique is adopted, such as paralytics for intubation. They would like to pick which paramedics in their service can and cannot perform the new technique, instead of it being all or none.

**B.4. Interaction with Hospitals**

**B.4.1. Systems Issues**

Competition between hospitals for ED patients enables EMS to influence hospitals. For emergency problems for which there are beneficial new technologies or practices, the EMSs prefer to take the patients to those hospitals where those technologies or practices are used. Some of these are technologies and practices that are applied in pre-hospital care, and are pushed by the EMS (such as transmitting 12-leads to the hospital, and more recently using induced hypothermia). Cardiology is the main area this is happening in. After some hospitals adopt the new technology or practice, and more of the relevant cases are taken to those hospitals, other hospitals notice and respond by investing in the technology or practice. The initial adoption of the technology or practice by the EMS and the initial hospital(s) is a deliberate process. The use of thrombolytics in pre-hospital care in HCFB was initiated by the local university medical center. The use of 12-leads in MCRP was pushed by the EMS, and involved looking at the research base in collaboration with hospitals and a medical school, and emphasizing the benefit (including reimbursement rates for PTCAs) with cardiologists. Use of ventilation guided by CO2 concentration, and mechanical CPR, are examples of technology used by many EMS but not in EDs. Organizational factors make it easier for EMSs to adopt new technology more rapidly than EDs.
Thus, pre-hospital care options, and options to bypass the ED, influence selection of the receiving hospital.
Options to select between different hospitals (e.g., cardiac, stroke, trauma) and to decide upon alternatives to the ED (such as bypassing the ED and going straight to a cardiac lab) depend on:

- EMS or paramedics having a say (directly or via informal advising to the patient) as to the disposition of the patient. In systems where there are few if any choices (such as many rural areas), this breaks down.
- Paramedics being able to properly evaluate the patient to see if the special process and/or disposition is indicated, and hospitals having faith that paramedics’ assessments are accurate. Paramedics can and have developed this assessment skill, but it takes time.

Political and financial factors can influence the question of proper patient disposition – sometimes to the detriment of patient care.

**B.4.2. Urgency and Response**

There are different ways in which the medical needs of the patient and the type of EMS response misalign. In terms of responses greater than the needs of the patient, part of this is from providers erring on the side of caution. There are also often cases of patients requesting levels of response they may not need. Paramedics can try to dissuade patients from requesting emergency transport when it is not indicated, but there are limits and risks with initiating non-transport. The fact that transporting is often easier and faster than not (enabling units to stay in service more) is also a factor.

Patient can be under-served when the urgency is under-estimated (e.g., a BLS call that turns out to be a heart attack). Patient refusals are not uncommon (being able to change the mind of refusing patients is a very valued skill). Also, there are small but real increases in non-transport at the end of shifts, suggesting that the providers' desires to get off work soon influence their perceptions of patients' needs.

**B.4.3. Dynamics of ED Diversion**

When one hospital goes on diversion, the input to other EDs increases, especially those close to the first ED because they are also close to the patients. These hospitals then go on diversion, requiring that patients in that area be diverted to different areas, farther from their homes.

Often the hospitals the patients are diverted to are not part their insurance plans, so they stay in the EDs until they can be transferred to hospitals in their plans. This requires transportation.

The hospitals on or approaching diversion status are trying to clear beds in order to transfer patients out their EDs. Getting the patients out of the hospitals requires transportation. In cities where the ambulance services do both 911 and non-emergent transports, these resources may be in short supply, because the
diversion state is related to a high level of need for EMS care, and the additional travel required to further hospitals ties up the ambulances longer.

B.4.4. **ED Status and Other Factors Influencing Hospital Selection**

When there are multiple EDs to select from (which is not the case in many rural areas), patient preference usually determines which ED is selected. However, unstable patients may need a closer facility, and other medical needs (such as severe trauma, suspected MI or stroke) may require an ED with a particular capability. The diversion status of an ED obviously influences the decision (although paramedics may still attempt to get the diverting ED to accept a patient if circumstances warrant). The turn-around time at the ED, the number of ambulances delivering there within the past hour, also influence the decision. These indicators of ED status are shared via formal systems (such as dispatch). Motivated by concern for the patient, and/or sometimes a concern with turn-around time or other aspects of how the ED treats EMT/paramedic units, paramedics can try to persuade patients to accept transport to non-preferred EDs.

And as discussed in section B.4.1 above, the role of paramedics in choosing which EDs to deliver patients has a significant business impact.

B.4.5. **Dynamics With Patient**

There are some calls that may not require transport to an ED. Calls for hospice or other do-not-resuscitate patients are unfortunately common. Others such calls are diabetics with acute blood sugar problems, or people with recurring acute problems such as seizures or rapid heartbeats that have not been helped at the ED in the past. Some EMSs are expanding the role of paramedics to treat and not transport such cases, though medical control approval may be required. Other systems are constrained by lack of reimbursement if the patient is not transported.

Except for palliative care for the hospice patients, some long-term medical management is indicated for most of these patients. Furthermore, there are patients with severe problems who will refuse transport even though it is necessary. The cost and hassle of medical treatment in general and EDs specifically are seen as reasons for utilization of EMS and lack of utilization of EDs.

B.4.6. **Frequent Flyers**

People with serious chronic health problems and lack of support for managing those problems can become very frequent users of EMS and the ED. Programs helping these people through the use of social services have had some success, but many of these people are still unable to shift out of the dependence on
emergency care. In addition to the expense on the system, there is the risk that EMTs/paramedics will become accustomed to responding to the frequent patient in a particular way, and fail to recognize a new and serious problem.

B.5. **Paramedics and Hospital Staff**

Emergency Department staff, nurses in particular, are said to disregard findings and observations from EMTs/paramedics. However, paramedics known to the ED staff as competent will be received differently than new, inexperienced EMTs/paramedics.

ED nurses are seen as having a focus on gathering standard data. They are presented as sometimes being barriers to rapid treatment of patients, instances of delays with cardiac patients being mentioned in particular. Paramedics deal with arresting patients quite frequently, and question the need for redundant assessment (by someone with arguably less MI experience) and the resulting delay in the patient being seen and treated by a physician.

B.5.1. **Field Vs. ED**

The focus of diagnoses in the field is on the immediate problem ('hypoglycemia, not diabetes; overdose, not addiction'). The interventions are necessarily focused on high priority threats to life and limb.

Many procedures can be performed more quickly in the ambulance than in the ED. One reason is the adherence to important procedural constraints that constitute good practice in the ED (which are not generally followed in the more constrained ambulance/field). Another reason is the greater coordination challenges in the ED, resulting from multiple patients, multiple resources, and multiple on-site stakeholders.

B.5.2. **Anticipating Wait in ED**

The delays in delivery of care in the ED have led paramedics to treat mere arrival at the hospital as insufficient for handoff. Paramedics will assume responsibility for critical patient events that they can manage more promptly than the crowded ED. Two examples: A patient having a cardiac arrest in the ambulance in the ED parking lot should have been treated in the ambulance as opposed to being rushed into the ED, where response was delayed for several minutes [MC3S]. A person seizing in the parking lot was treated by the paramedic in the ambulance as opposed to being brought into the ED; the ED physician agreed, saying it would have taken 20 minutes in the ED to address the problem [MCRP]. Pain management is also done proactively, with pain medication being given in order to help the patient during his or her wait in the ED before he or she is helped by the ED staff.
B.5.3. **Turn Around Time**

Turn around time ranges from 10-15 minutes [HCFB] to 30 minutes [MC3S]. Extenuating circumstances (such as having to clean up the ambulance after a messy patient) lengthen this. The systems have ways to encourage rapid turnarounds, via warnings from dispatch or automated systems that will put units back in service unless they ask for more time.

B.5.4. **Entrapment**

While there are times paramedics will stay with patients for some time in the ED to ensure appropriate care, abuse of the availability of paramedics (via ED staff temporarily keeping paramedics on their patients instead of assuming responsibility) was cited as a common problem [HCFB, MCRP]. This entrapment of paramedics is a way for EDs to cope with a shortage of staff relative to patient load.

However, the priority of new patients in the field, and the responsibility of the ED staff to care for patients in the ED (regardless of handoff) have resulted in a tactic to escape entrapment. The rational is that patients who are stable enough to wait with paramedics are stable enough to wait in the ED waiting room; patients who need to be watched are left by the nursing station; and patients who are unstable are brought back to the treatment area, because they are sick enough to be seen immediately. Threats of regulatory fines for unacceptable delays have improved the issue.

B.6. **Resource Management within Run**

Challenges specific to rural services are largely due to longer response and transport times. More interventions may be required; protocols not useful in urban (such as MAST trousers) may be useful in rural. Resources may need to be rationed; in frontier/wilderness response, oxygen flow may be controlled to ensure that the tank lasts long enough. [MC3S, HCFB]

An example of useful variation from protocol, and utilization of other resources: The patient had severe shotgun wound to lower face. He was far from a trauma center, so the local ambulance had rendezvoused with air ambulance to fly him to a trauma center. Because of the wound, use of an oxygen mask and normal ventilation was not possible, and rolling him over would cause bleeding/draining at too fast a rate to control. The patient needed an emergency cricothyrotomy. The air ambulance paramedics knew how to crik somebody (part of their protocol) but had never actually done one on a live person before. They knew that it would be very risky. They also knew that there was a community hospital nearby and that because it was 9 am the surgery would have just opened. The patient was driven to the hospital, where the more experienced surgical team crik’ed him and got the bleeding controlled. The helicopter picked him up at the hospital, and flew him to the trauma center. The medical director was initially
angry, but realized they did the safer, better way, by deciding to not follow their protocol in this case. [MC3S]

B.7. Documentation and Handoff

B.7.1. Documentation Systems

HCFB Electronic – but they have to print it, or hospital has to download, because systems don’t talk.
LCFB Electronic, which automatically gets faxed to hospital.
MC3S Paper. They are supposed to leave the form at the ED after finishing patient care, but can postpone until end of shift if things are busy.
MCRP Electronic system (manual took 35 minutes to fill out). They turn in the run report 24 hours later.

B.7.2. Use by Hospitals

The narrative, and the timeline (chronological documentation of events/interventions), is most useful for physicians. The checkboxes are only for data collection/QI purposes.
Occasional calls from doctors looking for run reports indicate they are being used. Cardiologists use 12-lead reports (there are no other indications of use).
The interest in reports from EMS varies from hospital to hospital; one children’s hospital focused on the parents to the exclusion of the EMS staff [LCFB].

B.7.3. Training On Documentation

Paramedics/EMTs generally receive a few hours on documentation in their education. The focus is on the importance of documentation, how it is used, and the importance of completeness. Some trainers focus on the importance of how professional the documentation looks, and what that means in a legal trial.
Local systems provide some instruction to employees on their particular systems.

B.7.4. Use Of Electronic Documentation Tools By EMT/Paramedics

Electronic documentation can be faster, but not initially. In the back of a moving ambulance, electronic is easier than writing.
Electronic can be used to ensure that required fields are filled out for each page in sequence. (However, from a cognitive systems/usability perspective, there are concerns about imposing an inflexible sequence and prioritization of data entry.)
However, for the system where paramedics do verbal reports to ED staff who enter it into EPIC, there was a difficult learning curve, with a harsh turn around time during first few weeks. But after 6 months, it is faster than written.
One risk of the emphasis on documentation, and in particular using new technology such as digital tablets, is altering the focus of paramedics such that they are paying too much attention to the form and not enough on the patient. But this something that should be addressed in training. [LCFB]

B.7.5. Information
Determining a standard set of information to document/handoff is challenging. The essentials are: medicines; allergies; the interventions that have been done to patient, and the reaction of the patient to those interventions (is patient better or worse?). The remainder is more administrative.

LCFB is involved in development of a documentation system with the goal of capturing data en route to facilitate verbal reporting to the ED, including trying to provide the information to the ED in the sequence most useful to them.

B.8. Oversupply of Paramedics
Many systems have too many paramedics relative to the volume of ALS calls. There are political pressures with local governments to provide “top tier” providers on all calls, regardless of need. The paramedics are not getting to practice their paramedic-level skills with sufficient frequency. This results in poor skill development and calibration. [MC3S, HCFB]

In the Seattle EMS (considered a top system) they only have 60 paramedics, as there is insufficient clinical material to support more [MC3S]. In MC3S, the original trend of more paramedics (such as requiring a paramedic on a very low risk BLS call) has been reversed, resulting in the paramedics performing ALS techniques more frequently, and improvements in quality.

Having several paramedics on a scene can result in coordination problems, particularly with the paramedic in charge trying to delegate tasks and assume responsibility [HCFB, MC3S].

B.9. Performance

B.9.1. Competency and Expertise
Quality of job performance is not just specific technical skills, but includes engagement and rapport with patients, and an ability to assess situations quickly, with some automaticity.

An expert will fluidly and automatically evaluate the scene, accumulate information, make rapid decisions, and begin planning. Once they are doing the initial formal assessment, they are modifying the initial care plan. [HCFB]

Newer paramedics, or those who have not been able to develop expertise because of lack of feedback, are prone to operating as “protocol paramedics”, being able to follow guidelines, but having problems when patients do not fit cleanly into specific categories, and fall outside of the guidelines. Too much black and white
thinking, and failing to respond to subtleties, is a problem for these paramedics. Poorer performing paramedics can have problems determining when a protocol is appropriate or not. Experts can see when a protocol is not working, and change gears [LCFB].

**B.9.2. Calibration**

Expert paramedics know what they do not know, and when they need to ask for help. They know when they are tired and at risk for poor performance. Poorer performing paramedics don’t know what they don’t know.

**B.9.3. Common Problems**

Factors related to adverse outcomes include: failure to do basic EMT stuff (vitals, assessment, simple initial interventions); problems with 'common ground' between providers (disregarding direction from collaborators); and failure to control operations and manage the scene.

**B.10. Assessment**

Paramedics in principle are diagnosing only problems they can deal with as emergency responders (e.g., hypoglycemia, not diabetes; drug overdose, not addiction).

Paramedics do differential diagnoses, but may not figure it out. Not coming to a diagnosis, and treating only symptoms, or not doing treatment, is fine. Distinguishing between ‘sorta’ sick and really sick is critical. Many very serious, complex cases present as just ‘sorta’ sick. Expert should know they cannot assess everything, and take patient to where they can.

In complicated cases, patient have more than one thing going on. Example: a chronic alcoholic is at risk for lots of acute medical problems (e.g, GI bleed).

An example of assessment problems is the case that paramedics were treating as hyperventilation, failing to notice recent knee surgery – a major risk factor for pulmonary embolism. Hyperventilation is a diagnosis of exclusion. Many things can cause rapid breathing. Much of medicine is ruling things out, testing hypotheses. But paramedics can get stuck on the initial conclusion that rapid breathing is hyperventilation, or that chest pain is heart attack.

Novices can miss things because 1) they do not have much experience these sorts of cases, or 2) they have repeated experience with a type of case and fail to consider exceptions.

Bringing up challenging cases (like sickle cell crisis) is useful to help paramedics realize what they do not know.

Noticing absence of cues is a challenge, but is important. For example, lungs in which there are no rales or crackles may be still (no breathing).
B.10.1. Barriers to Assessment

There can be challenges to getting a history. If there are language difficulties, the hospitals have resources that EMS may lack. BLS or private ambulance are less skilled than the paramedic, and may not be appropriate given the uncertainty. Full assessment, as doing on unconscious patient, is appropriate if they are unstable.

B.10.2. Twelve-Lead Information

Twelve-lead EKG is important tool for assessing status of heart; in some systems it is required in chest pain calls; in others it might be avoided due to the requirement to transport if a 12-lead used. It is useful in defending the decision to pursue a non-cardiac course of action. Nonetheless, MI assessment can be difficult; even ED physicians sometimes misdiagnose MIs as pleuretic chest pain. Assessment problems arise because 12-lead training is narrow, focusing mainly on ST elevation. Some medics may believe that no ST elevation means no heart attack. Other sources of information – a series of 12-lead readings; serial enzyme; signs and symptoms and story – are neglected. TIPi score has been used to decide between ALS and BLS transport, and used to convince reluctant patients to come to ED.

B.10.3. Information from Family/Other

Family or bystanders can be important sources of information, but are sometimes undervalued. Two examples were shared of paramedics arguing with family members who turned about to be right (a mother with cirrhosis acting psychotic because of ammonia level, not intoxication; a daughter was really going into seizure even though at the beginning she was still talking). The family is good at describing what the patient is like normally, providing a baseline for comparison.

B.10.4. Information from Dispatch

Information from dispatch can facilitate fixation; it is hard to remove the diagnostic label once it has been applied. MCRP had a system that gave elaborate reports with some history, but it was changed after 10 years because it was predisposing paramedics, and leading them to plan based on inaccurate information. Dispatch information has quality problems. Some systems have call takers who are minimally trained and follow narrow protocols, so any mention of diabetes or stroke means the chief complaint is listed as diabetes or stroke. Getting useful information from the caller can be difficult. Asking assessment questions is tricky; agonal or gasping breaths can lead to a “yes, they are breathing” answer. Most lay people, even trained in CPR, will not recognize the beginning of a cardiac arrest. Furthermore, many calls for “heart attack” are just people wanting a ride to the hospital.
A comparison of presumptive and after-the-fact diagnoses was .57 correlation at best [MRCP].
There are a few essential pieces of information, such as: Is patient a child? Is there an entrapment? Call location, callback number. The 4 commandment questions are: 1) chief complaint or incident type; 2) approximate age; 3) status of consciousness; 4) status of breathing.

B.10.5. **Algorithms**

One call taking system forced a series of yes/no questions, which added over 3 minutes to each call. Other EMS systems were asking 4 commandment questions first, then putting the call out (priority 1), then asking the rest of the questions – modifying priority level as necessary.
Emergency medical dispatch algorithms can be of value when it is used for a system’s own prioritization, but there are no validation studies yet showing a medical outcome differences due to the use of medical priority dispatch algorithms/systems.

B.10.6. **Records**

There is some doubt about how useful a long medical record is to a newer paramedic. Paramedics would try and make use of any information, such as Personal Health Records, but the actually utility depends on the situation. Such records could be useful for patients with alternated mental status or other communication issues.
The EMS system of LCFB has a database of people they have treated. New patients get entered in. Old patients’ records get pulled up once medics get their drivers license or social security number (which is not before the paramedics arrive on scene). It saves time, because most of the report is already done.

B.10.7. **Challenge Cases**

*Complex cases:* Unknown problem, poor history, vague complaint (“I just don’t feel right”); a 50 year old who is dizzy; a patient with fainting; a patient with chest pain; a patient with altered mental status; a patient who has just had seizures.

*Hiring exercise:* A low speed car crash in which patient is on his way to the ED for pulmonary edema. Failing to question adequately, and just following basic approach of putting patient on backboard and c-collar, will result in the patient drowning.

*Other case:* An unconscious guy lying be ladder with broken leg – but did something happen before he fell?
Specific types of challenges include being able to re-direct after getting unexpected/negative results to an intervention; and being able to question what happened earlier, prior to signs and symptoms returning to normal.
B.11. **Feedback and Development of Expertise**

It takes a long time to go beyond the formal training and learn when and when not to use the protocols. Developing expertise requires feedback, and having a senior person to help explain things the paramedic does not recognize. A program involving medical residents riding in ambulances in MC3S was very valuable for the paramedics, who were able to get feedback and explanations regarding clinical issues.

A paramedic serving in a fire engine crew (as opposed to an EMS unit crew), and most rural paramedics, do not have another paramedic to discuss things with (in addition to encountering cases less frequently). This makes development of expertise harder.

While paramedics may feel competent, able to handle most situations with ease, after one year in a busy system, there are periodic re-calibrations, in which they realize what they do not know. This might be a call where things go badly, or a problem that did not fit into the paramedic’s categories. Constructive feedback can be used to turn such events into teaching moments.

B.11.1. **Performance Criteria**

There is no complete system for assessing and quantifying performance of paramedics. In MCRP, the metric used in contracts was updated from response time to non-degradation of physiology. Complaints from the ED and from patients are included in evaluation of a paramedic’s overall performance, as is performance of specific skills.

Use of particular techniques in cases is essential for maintaining skills. This is measured in terms of number of patient contacts and specific procedures (e.g., IVs, intubations) done by each paramedic annually. Presenting paramedics with challenge cases is a way to assess their levels, and prompt recalibration if necessary. Examples include: sickle cell crisis, renal failure, and 35 year old female with diffuse abdominal complaint.

B.11.2. **Training**

Training of EMTs/paramedics is challenged by several elements:
- The quantity of material (“arcane knowledge”) that was part of earlier curriculums, but the necessity of which is under debate;
- New technologies and techniques that were not part of training earlier (for example, 12-leads used to differentiate between types of MIs, paralytics for intubation, thrombolytics)
- A smaller knowledge base out of high-school;
- An expectation for graduates to possess the knowledge that took practicing paramedics years to develop.
Continuing education is seen as largely re-hashing the basics, instead of evolving in response to changes in the nature of paramedic work. In most systems it fails to be utilized strategically.

B.11.3. Simulation

Simulators can be useful, especially high-fidelity simulators, but access is a problem. Even with mobile simulators, there are still scheduling challenges and financial barriers.

B.12. Escalation Pattern

B.12.1. Challenges of Tiered Systems

Tiered systems (such as those of LCFB and HCFB) enable paramedics to get more ALS experience. Depending on the decision made by dispatch, a BLS unit of EMT-Bs can arrive first, and then decided whether or not an ALS unit of paramedics is necessary. Difficulties arise with cases that are not clearly BLS or ALS. The EMTs in the BLS unit can fail to recognize when ALS care is required. Part of this is poor calibration, exacerbated by the EMTs repeatedly seeing paramedics perform assessment protocols to determine criticality, and wrongly assuming they can successfully follow the assessment processes they observed. Part of it is hesitation at calling for paramedic support when the case is ambiguous, because paramedics in tiered systems tend to dislike being called for cases that are not truly ALS, feeling that such cases are ‘beneath them’.

B.12.2. Interaction with EMT

Failure of paramedics to double-check the assessments or decisions of EMTs can lead to problems. Protocols may even indicate that the paramedic should take specific vital signs. However, it is common for paramedics to develop trust in the assessments of some of the EMTs they work with. In instances where the results do not make sense, the measures should be re-checked.

B.13. Operations at Scene

Who is in charge on scene? Generally, the crew leader of the first arriving unit is in charge. This unit is last to leave. Some systems have a shift commander who (if available) would take command, or if the first unit is overwhelmed and does not declare that they are the EMS supervisor, the second unit to arrive becomes in charge. The dynamics depend on the demands of the situation, and the resources. A competent family member could collect medications. The paramedic and the partner may be occupied with managing the patient (e.g., patient is struggling to
breath), or the partner can be finding where to put the cot, or scouting for the egress route, while the paramedic gets vitals.

A problem with several paramedics on scene is that there is insufficient delegation – it can be hard to keep them from doing their own thing. Good management includes assessing the situation, and assigning tasks to people, while also getting input from them. Ideally, the person should be standing back, making assessments, getting information, and directing people.

In multiple trauma situation, novice paramedics are going to go to the thing that looks worst and get stuck there, whereas an expert is going to look around and do triage. [HCFB].

Compared to fire-fighting, especially wildland fire fighting, EMS has poor training for incident command. The entire thing that the commander is trying to manage is complex and difficult to understand. It requires multi-tasking and communication.

B.13.1. Focus and Goal Management

If a crew member or law enforcement officer is injured, it causes disruption. People will need to be re-directed back to following standard triage priorities. However, it might make sense to treat the team member and get them off scene in order to quickly re-establish the focus of the team.

Air ambulance helicopters have the effect of causing everyone to stop the work they are doing – as a distraction, and from the labor needed to establish safe landing. It is very hard to use a helicopter for one patient, and simultaneously manage and transport multiple other patients.

B.13.2. Assessment and History Taking

Assessment and history taking is made more difficult when multiple people are doing it (“history by committee”). There is no coherent, integrated account. This is different than having a second person provide another perspective on interpretation, which can be useful, especially if the first person is getting stuck.

B.13.3. Training

Some training for scene management may done via exercises (table top, and higher fidelity with other responders) [MCRP], but a lot is done on the job [MC3S].

B.13.4. Scene Safety and Assessment

Situations with “unknown medical problem” and potential of scene safety issues require more caution, investigation, and planning. For example, many carbon monoxide poisoning cases presented as multiple people in the house complaining of the flu.
B.13.5. **Family**

Family members can present challenges. Children cannot be left unattended. Family members can suffer misperceptions regarding delays in transport, or otherwise be unruly. It is useful for scene management if the paramedic can get the most outspoken person on side of the EMS unit.

**B.14. Transportation**

B.14.1. **Air Ambulances**

Helicopters for transport can be useful, but there are costs, and the tradeoff makes sense only under certain circumstances. The time required for arrival of and preparation for the helicopter means that for shorter distances, ground transportation will get the patient to the trauma center faster. MCRP mentioned research (of DD Trunkey) indicating that mortality was minimized when ground transport was used for distances less than 30 miles (straight line to trauma center), and air transport for over 30 miles. This, plus the requirements for landing zones, means that helicopters have limited use on calls in urban areas. Other costs include the safety risks, and the resources used to set up the landing zone and prepare for the helicopter. Because of the attention focused on the helicopter, other tasks suffer. It is difficult to progress on the transport preparation of other patients at the same time as a helicopter transport.

B.14.2. **Travel Mode**

Running “hot” - with lights and sirens – increases the risk of accidents. Some services (such as MCRP) are getting rid of that response mode altogether; in their response area, transport times are around seven minutes, so running hot is not necessary. Other decisions (such as designation of priority) are more important than response travel mode. There is even a push to get rid of sirens on the trucks [NCO].

Distance and the medical needs of the patient are not the only factors that influence the paramedic's decision; he or she may decide that bad traffic warrants running hot.

**B.15. Establishing and Controlling EMS Operations**

B.15.1. **Control of BLS**

In some areas, fire units do BLS calls. Other regions may have private ambulances do transport for BLS calls. HCFB reports that they explored shifting to private transport for BLS, but that reservations about giving up control of BLS patients present a barrier.
B.15.2. Small EMS Systems

Small towns and rural areas may not have the demand or the resources for establishing and maintaining a sizable professional staff for their EMS. They may require waivers allowing them to operate below required minimum staff sizes. Many rely on volunteers instead of full-time professionals. In many areas, there is much overlap between the volunteer fire and the volunteer EMS personnel and other resources. An active fire means the EMS capability is diminished or non-existent. Declines in volunteerism impact both functions. There is a trend among small cities in which they make up for being unable to maintain a fire department by using mutual aid agreements with their metropolitan centers or counties. They maintain a small ambulance service that presumes to help cover the needs of the metropolitan area or county, and in turn get coverage from the metro/county fire department.

B.16. Roles – Interactions with Fire/Rescue

At fires, EMTs/paramedics are usually present to provide treatment in case of any injuries or other medical problems. However, in many services the EMTs/paramedics have fire training, and are drawn (or even encouraged by fire-based incident commanders) to become involved in the fire-fighting activities. At incidents involving medical as well as fire and/or rescue operations (such as vehicle extrications), conflicts can arise. In principle, the paramedic is in charge of medical issues, and the fire officer is in charge of scene management safety issues. However, problems can arise. Interactions between medical assessment and treatment plans, extrication methods, and scene safety management, require coordination between paramedics and fire/rescue. There can be power differentials between a newer paramedic and a senior fire commander. Furthermore, fire personnel or other stakeholders often have some EMT training, and may try to assume some authority over medical issues.
Appendix C: Staged-World Study
Materials
C.1 Informed Consent Form

The Ohio State University Consent to Participate in Research

Study Title: Expertise of Paramedics in Emergency Medical Services
Researcher: Dr. David Woods, OSU College of Engineering
Sponsor: National Registry of Emergency Medical Technicians

This is a consent form for research participation. It contains important information about this study and what to expect if you decide to participate.

Your participation is voluntary.

Please consider the information carefully. Feel free to ask questions before making your decision whether or not to participate. If you decide to participate, you will be asked to sign this form and will receive a copy of the form.

Purpose:
The ability of paramedics to provide pre-hospital care and support the functions of the Emergency Medical Service system depends on not only knowledge and skill regarding protocols, but on applying knowledge and skill in complex and novel situations. In the course of serving as a paramedic and providing care for numerous patients, a paramedic develops ways of interpreting situations, strategies or techniques for addressing problems and mitigating risks, and other ways of handling the complexities of EMS work.

The goal of this research is to explore how paramedics manage complex situations, and the nature of the methods that paramedics have developed over time. This will help in the design and development of training, evaluation, and other support tools, ensuring that the ways paramedics have developed to manage situations and adapt to new opportunities and constraints are accounted for.

Procedures/Tasks:
If you choose to participate, you will travel to Columbus Ohio to meet with researchers at the headquarters of the National Registry of Emergency Medical Technicians. You will fill out a questionnaire concerning your background and experiences as a paramedic. Afterwards, you will participate in a session with one or two researchers, in which you will go through a set of case scenarios. This session will be video-recorded. For each case scenario, you will be presented with a description of an emergency medical situation, and asked about what you would do in that situation. New developments in the case will be introduced, and you will be asked how you would respond. In some scenarios, you will be asked to comment on the actions of a hypothetical paramedic. The descriptions provided by the researchers will at
times be supplemented with photos, sounds, or video clips. After each scenario, and after the full set of scenarios, the researchers will ask you questions about how you responded, and your impressions of the cases.

After the session with the scenarios, you will participate in a debriefing, in which the purpose of the study will be reviewed, and you will have the opportunity to ask any questions about the scenarios or other aspects of the study.

**Duration:**
You will fly into Columbus Ohio on either the morning of the day you are meeting with the researchers, or the day before. You will fly out early the next day after the meeting, or the evening after the meeting. Thus, your expected time commitment is approximately a day and a half, depending on the specifics of the travel schedule. The background questionnaire should take no more than 10 minutes to complete, and the duration of the session with the researchers will be approximately two hours.

**Risks and Benefits:**
In being asked to respond to the scenarios, it is possible that you may find some of the problems frustrating, or be unsure of what type of response might be best. If this occurs, it is possible but unlikely that you may interpret this in a negative or self-critical way. Throughout the session, and especially if the researchers sense frustration or doubt, they will stress how this study is using complex and ambiguous scenarios to look at how paramedics handle challenging situations; it is not designed to assess anyone’s ability as a paramedic. Breaks will also be introduced if necessary. The debriefing will also allow an opportunity for you to discuss any of these concerns.

You will not benefit directly from participating in the study. The potential benefits to the EMT community, and society in general, are a better understanding of the challenges that will face paramedics, and guidance for the development of training systems, evaluation methods, and job support systems that will facilitate the provision of emergency medical care by paramedics.

**Confidentiality:**
Efforts will be made to keep your study-related information confidential. However, there may be circumstances where this information must be released. For example, personal information regarding your participation in this study may be disclosed if required by state law. Also, your records may be reviewed by the following groups (as applicable to the research):

- Office for Human Research Protections or other federal, state, or international regulatory agencies;
- The Ohio State University Institutional Review Board or Office of Responsible Research Practices;
- The sponsor, if any, or agency (including the Food and Drug Administration for FDA-regulated research) supporting the study.
Incentives:
As a token of appreciation, we are mailing participants a $200 gift card. Additionally, the NREMT is covering the costs of your airline ticket and hotel, and will provide meals and local transportation.
By law, payments to subjects are considered taxable income.

Participant Rights:
You may refuse to participate in this study without penalty or loss of benefits to which you are otherwise entitled. If you are a student or employee at Ohio State, your decision will not affect your grades or employment status. Your decision will not affect your paramedic certification status or employment status.

If you choose to participate in the study, you may discontinue participation at any time without penalty or loss of benefits. By signing this form, you do not give up any personal legal rights you may have as a participant in this study.

An Institutional Review Board responsible for human subjects research at The Ohio State University reviewed this research project and found it to be acceptable, according to applicable state and federal regulations and University policies designed to protect the rights and welfare of participants in research.

Contacts and Questions:
For questions, concerns, or complaints about the study, or if you feel you have been harmed by participation, you may contact Michael Smith; smith.5652@osu.edu; (614) 292-1296.

For questions about your rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact Ms. Sandra Meadows in the Office of Responsible Research Practices at 1-800-678-6251.
CONSENT
Behavioral/Social Science

IRB Protocol Number: 2010B0014
Version:

Signing the consent form

I have read (or someone has read to me) this form and I am aware that I am being asked to participate in a research study. I have had the opportunity to ask questions and have had them answered to my satisfaction. I voluntarily agree to participate in this study.

I am not giving up any legal rights by signing this form. I will be given a copy of this form.

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**Investigator/Research Staff**

I have explained the research to the participant or his/her representative before requesting the signature(s) above. There are no blanks in this document. A copy of this form has been given to the participant or his/her representative.

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Form date: 12/15/05

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C.2 *Simulation Room*

Figure C.1: Conference Room Set Up for Simulation
C.3 Representations of Equipment and Supplies

![Diagram of various equipment]

Figure C.2: General Equipment
<table>
<thead>
<tr>
<th>Safety Goggles</th>
<th>Surgical Masks</th>
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<tr>
<td>Respiratory Protection Mask</td>
<td>Gloves</td>
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<tr>
<td>Shoe Covers</td>
<td>Hand Cleaner</td>
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<td>Helmet</td>
<td>Jacket</td>
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<td>Boots</td>
<td>Reflective Vest</td>
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Figure C.3: Personal Protective Equipment
King Airway Kit
Tube size 3, 4 and 5

Oxygen Mask
(Non-Rebreather, high-flow)

Oxygen Mask
(Simple/low-flow)

Oxygen Tank
(with Regulator)
(portable)

Pleural
Decompression/Needle
Thoracostomy Kit
Angiocatheter – 10-13 ga,
Syringe – 30cc;
Betadine swabs

Needle Cricothyrotomy Kit
Angiocatheter – 10-13 ga;
Syringe – 30cc;
Betadine swabs

Figure C.4: Airway and Breathing 1
Figure C.5: Airway and Breathing 2
Figure C.6: Intubation Blades

Laryngoscope blades:
- #2, 3, 4
- Macintosh (curved)

Endotracheal tubes:
- 2.5, 3.0, 3.5, 4.0 uncuffed

Endotracheal tubes:
- 6.0, 7.0, 8.0, cuffed

Laryngoscope blades:
- #0, 1, 2, 3, 4
- Miller (straight)

Laryngoscope handle

Endotracheal tubes:
- 4.5, 5.0, 5.5, uncuffed
Figure C.7: Intubation Equipment
Monitor/Defibrillator
(with Pulse Ox Finger Sensor)

Obstetrical Kit
umbilical cord tape/clamps;
scissors/scalpel;
aspirating bulb syringe;
gloves;
drapes;
dressings & towels;
clean plastic bag

Figure C.8: EKG Monitor and OB Kit
Figure C.9: Immobilization Equipment
Figure C.10: Bandages

- Band-Aids
- Dressings (Sterile)
- Gauze Pads
- Gauze Rolls
- Triangular Bandages
- Universal Dressing – Large
- Occlusive Dressing
- Burn Sheets
- Sheers
- Safety Pins
- Irrigation Tubing
- Sterile Saline
- Cold Packs
Figure C.11: IV Needles and Fluids

Crystalloid Solution
(Ringer’s Lactate)

Syringes:
1cc, 3cc, 5cc, 10cc, 30cc

IV Catheters:
16ga, 18ga, 20ga, 22ga, 24ga

IV Tubing:
Mini drip (60gtt),
Macro drip (10/15gtt)

Needles:
18ga 1”, 20ga 1”, 22ga 1”, 25ga”

Saline Solution
Saline Lock with extension tubing

Armboard

Alcohol Swabs

Intraosseous Needle

Venous Tourniquet

Razor

Figure C.12: IV Equipment
<table>
<thead>
<tr>
<th>Medication</th>
<th>Brand Name</th>
<th>Quantity/Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adenosine</td>
<td>Adenocard</td>
<td>(3mg/3mL syringe)</td>
</tr>
<tr>
<td>Amiodarone HCL</td>
<td>Cordarone</td>
<td>(150mg/5mL ampule)</td>
</tr>
<tr>
<td>Calcium Chloride</td>
<td></td>
<td>(100mg/1mL)</td>
</tr>
<tr>
<td>Diphenhydramine</td>
<td>Benadryl</td>
<td>(50 mg/1mL vial)</td>
</tr>
<tr>
<td>Epinephrine 1:1,000</td>
<td>Adrenalin</td>
<td>(1mg/1mL ampule)</td>
</tr>
<tr>
<td>Furosemide</td>
<td>Lasix</td>
<td>(20mg/1mL mg vial)</td>
</tr>
<tr>
<td>Lidocaine</td>
<td>Xylocaine</td>
<td>(100mg/5mL syringe)</td>
</tr>
<tr>
<td>Midazolam</td>
<td>Versed</td>
<td>(5mg/1mL vial)</td>
</tr>
<tr>
<td>Naloxone</td>
<td>Narcan</td>
<td>(1mg/ml vial)</td>
</tr>
<tr>
<td>Nitroglycerin spray</td>
<td>Nitrolingual</td>
<td>(0.4 mg)</td>
</tr>
<tr>
<td>Albuterol</td>
<td>Ventolin</td>
<td>2.5mg/3ml unit dose ampule</td>
</tr>
<tr>
<td>Aspirin</td>
<td>Bufferin</td>
<td>(325 mg tabs)</td>
</tr>
<tr>
<td>Dextrose, 50%</td>
<td></td>
<td>(25g/50mL syringe)</td>
</tr>
<tr>
<td>Dopamine</td>
<td>Intropin</td>
<td>(800 mg pre-mix)</td>
</tr>
<tr>
<td>Epinephrine 1:10,000</td>
<td>Adrenalin</td>
<td>(1mg/10mL syringe)</td>
</tr>
<tr>
<td>Glucagon</td>
<td>Glucagen</td>
<td>(1 mg (1 unit) vial)</td>
</tr>
<tr>
<td>Magnesium Sulfate</td>
<td></td>
<td>(500mg/1mL vial)</td>
</tr>
<tr>
<td>Morphine Sulfate</td>
<td></td>
<td>(10mg/10mL syringe)</td>
</tr>
<tr>
<td>Nitroglycerin paste</td>
<td>Nitro-Dur</td>
<td>(1 tube)</td>
</tr>
<tr>
<td>Sodium Bicarbonate</td>
<td></td>
<td>(50 mEq)</td>
</tr>
</tbody>
</table>

Figure C.13: Medications
Appendix D: Chest Pain Case Materials
D.1 Chest Pain Scenario

This scenario will be done as a mixed fidelity simulation. When possible, images and sounds will be presented directly to the Participant Paramedic, instead of described by the Administrator. Likewise, we will ask the Participant Paramedic to physically interact with the props and other representations in the room when relevant.

The patient will be represented by a series of photos displayed life size (waist up) on a large flat screen monitor (36” x 21”) positioned flat on the table as if the patient is lying on a stretcher. Visual information, such as paleness, cyan lips, anxiety & pain, is conveyed through the images. The fact that these are life-sized photos of real people should help keep people engaged, and provide some verisimilitude.

Other visual information (e.g., output from monitor) will also be presented visually. In some cases, lung sounds will be played on the computer speakers. Information that would be told to the Paramedic in real life (e.g., responses to questions) will be presented by the Administrator.

Describing situations or findings will only be done when it is not practical to show a representation of the situation or physical phenomenon for the Paramedic to interpret. Information will be presented to the Paramedic only when actions have been taken that would (in real life) make that information available to the paramedic.

Some equipment (e.g., gloves, stethoscope) will be real; other material will be represented by printed images on cards or similar. Using a piece of equipment – such as starting an IV, means taking that piece of “equipment” from the “bag” and placing it on the “patient” in the appropriate location.

Set Up & Arrival
Table D.1: Information at Beginning of Scenario

<table>
<thead>
<tr>
<th>Ambulance</th>
<th>Said</th>
<th>Shown or Done</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administrator</td>
<td>5 am Monday morning</td>
<td></td>
</tr>
<tr>
<td>Administrator</td>
<td>Call from dispatch: Chest pain, 55 yo male. Address</td>
<td></td>
</tr>
<tr>
<td>Working class neighborhood.</td>
<td>Paper with “Chest pain, 55 year old male.”</td>
<td></td>
</tr>
<tr>
<td>Show location on map.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paramedic</td>
<td>We proceed to scene -- Mode?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>On-Scene</th>
<th>Said</th>
<th>Shown or Done</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administrator</td>
<td>Small 1 story house.</td>
<td></td>
</tr>
<tr>
<td>Middle aged woman in housecoat opens door.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paramedic</td>
<td>EMT and I grab: stretcher, med bag, drug bag, monitor, oxygen...</td>
<td>Grabs “equipment”</td>
</tr>
<tr>
<td>Administrator</td>
<td>She says “I’m so glad you’re here. My husband is having a heart attack.&quot;</td>
<td></td>
</tr>
<tr>
<td>Administrator</td>
<td>House is well kept. You see ashtrays and cigarette packs around.</td>
<td></td>
</tr>
<tr>
<td>Administrator</td>
<td>See a middle aged man lying face up on the couch in the living room.</td>
<td>Show image on big monitor.</td>
</tr>
</tbody>
</table>

**Initial Assessment**

**History**

*In response to questions from paramedic:*

**Onset & Chief Complaint**

“I woke up ok....at 4 and went... to make coffee.... and my chest started hurting... and I became... all out of breath... all the sudden”

“can you help me?”

“Oh Lord... I think this... is going to kill me”

**Pain**

Sharp

Hurts more when I breath in
Taking a deep breath makes it hurt worse.

More on my left side.

Severity – it hurts a lot when I inhale. Not as bad as kidney stones – but 9 or 10 out of 10.

“It’s serious... isn’t it?”

**Medications**
cholesterol med (Lipitor)  
prevacid

**Allergies**
none

**Past History**
Age – 55

Dad & older brother died of heart attacks.  
“Am I going ... to be next?”

No heart problems, but taking cholesterol meds

**GERD**

Kidney stones 15+ years ago.

Professional history: Carpenter. Before that was in Army.

**Food/Etc.**

Last smoke was last night after dinner.  
Last food was last night.

**Smoking**

pack a day for past 5 years.  
Had quit for several years, but before that smoked ½ - 1 pack/day for over 10 years.
**Initial Findings**

in response to assessment actions by paramedic:

Mental status – alert, oriented, anxious (implied)
Airway – open & clear (implied)

He is a little pale, sweaty

Skin is cool.

**Vitals**
Breathing – R 28 and shallow.
Circulatory – radial pulse 110
BP 110/70
Blood glucose normal (140 mg/dl)

**Monitor**
SaO2 = 89%

---

**Figure D.1: EKG Tracing of Man with PE**

**Lung sounds**
– lung sounds (more quiet at base).
Breath sounds in general are more distant & quiet.
Further Assessment

No nausea
Feeling tired, weak
No fainting
No headache

Head
   lips and inside of mouth look cyanic
   no blood in mouth

Neck – veins distension

Chest Percussion
   Percussion – no hyperresonance, no dullness

Abdomen
   no tenderness;
   no enlarged organs
   no pulsating masses

   muscle use in breathing – minimal/negative

Extremities
   circulation ok
   no pitting edema?

   legs a little swollen – with one leg (left) more swollen than the other. No pain.

   He has a DVT. One leg is more swollen, is more red (errhythemic) and warmer

Presumptive Diagnosis

MI
PE
aortic dissection/aneurysm
CHF/pulmonary edema
COPD
Table D.2: Interventions and Updated Findings

<table>
<thead>
<tr>
<th>Interventions</th>
<th>Findings on re-assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen via mask (non rebreather)</td>
<td>Increase in O2, decrease in RR</td>
</tr>
<tr>
<td>Oxygen via CPAP or positive pressure</td>
<td>Increase in O2, decrease in RR</td>
</tr>
<tr>
<td>Nitroglycerine</td>
<td>Drop in BP</td>
</tr>
<tr>
<td>Morphine (would be just for pain most likely)</td>
<td>Decrease in BP</td>
</tr>
<tr>
<td>Dopamine – low dose</td>
<td>Decrease in BP, increase in O2</td>
</tr>
<tr>
<td>Dopamine – high dose</td>
<td>Increase BP, increase pulse</td>
</tr>
<tr>
<td>Fluid (lactated Ringer’s, saline)</td>
<td>Crackles; increase in BP</td>
</tr>
<tr>
<td>aspirin</td>
<td>none</td>
</tr>
<tr>
<td>Diuretic – furosemide (Lasix)</td>
<td>Drop in BP after 20 minutes</td>
</tr>
<tr>
<td>Bronchodilator - Albuterol</td>
<td>Slight increase in pulse</td>
</tr>
</tbody>
</table>

Oxygen – not everyone has CPAP. Non-rebreather, nasal cannula more common.

IV access

**Communication and Transport**
Which hospital? Normal ED somewhat close, or cath lab further away, or Level I trauma center even further away?

Lights and sirens or not?

What does paramedic report to hospital while en route?

Is 12-lead transmitted?
D.2 Flow Chart

Set up & Arrival

Initial Assessment

monitor

Full Assessment

Putative Dx

Re-Assessment

history

medications

past history

mouth

neck veins

chest & neck

muscle use in

breathing

lung assessment

heart sounds

abdomen - muscle

use in breathing

abdomen - tenderness

blood flow -

compare pulses

extremities

look for pitting edema

nitrates

Thrombolytics

Aspirin

morphine

oxygen

MI

PE

aortic dissection/

aneurysm

CHF/pulmonary

edema

COPD

anti-dysrhythmics (lidocaine, amiodarone, adenosine)
dopamine - anti-hypertensive

CPAP/PPV

fluid (lactated Ringer's, saline)
diuretic - Furosemide (Lasix) - anti-hypertensive
bronnchodiilator - Albuterol

transport decision

med direction

destination

telemetry

Figure D.2: Chest Pain Protocol and Problem Space
D.3 Hospital Locations

Figure D.3: Location of Chest Pain Case and Hospitals
### D.4 Vital Sign Values

#### Initial Values
- **Pulse**: 110
- **BP**: 110/70
- **RR**: 28, shallow
- **O2**: 90%

Table D.3: Vital Signs for Interventions over Time

<table>
<thead>
<tr>
<th></th>
<th>Oxygen</th>
<th>Oxygen &amp; Nitro</th>
<th>Oxygen+IV</th>
<th>Oxygen+IV &amp; Nitro</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pulse</strong></td>
<td>Move</td>
<td>Middle</td>
<td>Limit</td>
<td>Move</td>
</tr>
<tr>
<td><strong>BP</strong></td>
<td>110</td>
<td>110</td>
<td>110</td>
<td>110</td>
</tr>
<tr>
<td><strong>RR</strong></td>
<td>22</td>
<td>20</td>
<td>18</td>
<td>22</td>
</tr>
<tr>
<td><strong>O2</strong></td>
<td>93%</td>
<td>95%</td>
<td>97%</td>
<td>93%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pulse</strong></td>
<td>One</td>
<td>Two</td>
<td>Three</td>
<td>One</td>
</tr>
<tr>
<td><strong>BP</strong></td>
<td>95/60</td>
<td>90/50</td>
<td>85/45</td>
<td>95/65</td>
</tr>
<tr>
<td><strong>RR</strong></td>
<td>22</td>
<td>20</td>
<td>18</td>
<td>22</td>
</tr>
<tr>
<td><strong>O2</strong></td>
<td>93%</td>
<td>95%</td>
<td>97%</td>
<td>93%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pulse</strong></td>
<td>110</td>
<td>110</td>
<td>110</td>
<td>110</td>
</tr>
<tr>
<td><strong>BP</strong></td>
<td>115/75</td>
<td>118/78</td>
<td>120/80</td>
<td>105/65</td>
</tr>
<tr>
<td><strong>RR</strong></td>
<td>22</td>
<td>20</td>
<td>18</td>
<td>22</td>
</tr>
<tr>
<td><strong>O2</strong></td>
<td>93%</td>
<td>95%</td>
<td>97%</td>
<td>93%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pulse</strong></td>
<td>110</td>
<td>110</td>
<td>110</td>
<td>110</td>
</tr>
<tr>
<td><strong>BP</strong></td>
<td>105/65</td>
<td>100/62</td>
<td>95/58</td>
<td></td>
</tr>
<tr>
<td><strong>RR</strong></td>
<td>22</td>
<td>20</td>
<td>18</td>
<td>22</td>
</tr>
<tr>
<td><strong>O2</strong></td>
<td>93%</td>
<td>95%</td>
<td>97%</td>
<td>93%</td>
</tr>
</tbody>
</table>
D.5 *Image of Patient*

Figure D.4: Chest Pain Patient (Front View)
Appendix E: Chest Pain Case Findings
The left columns are the narrative descriptions of the paramedics’ performance, and the right columns are the brief summaries of the performance. Wavy lines in the table indicate a point of revision.

**Table E.1: Paramedic A (Chest Pain Case)**

<table>
<thead>
<tr>
<th>A takes in scene, and begins taking history, then getting a description of pain, and it’s location and severity. Applies O2, and asks about last doctor visit. Assess skin temperature, takes pulse, BP, respiration rate, and listens to lungs. Asks about other medicines, smoking history. A asks if anything helps or increases pain.</th>
<th>Assessing health factors and egress issues General history, pain relative to MI Assessing respiratory health and management</th>
</tr>
</thead>
<tbody>
<tr>
<td>A starts an IV, gets consent for transport, and gives him one dose of nitroglycerin.</td>
<td>Standard chest pain treatment</td>
</tr>
<tr>
<td>A re-assesses pain and sat O2.</td>
<td>Atypical response for MI</td>
</tr>
<tr>
<td>A asks about any recent surgeries, and occupation (sedentary or not). A is told of patients recent vacation. A asks about location and timing, and proposes PE.</td>
<td>Assessing for PE risk factors</td>
</tr>
<tr>
<td>A prepares for transport to ED with Cath Lab, and applies a second nitroglycerin. Reassess for pain, and calls ED.</td>
<td>Manage and transport</td>
</tr>
</tbody>
</table>
Table E.2: Paramedic B (Chest Pain Case)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>B notices scar, plans on asking about history, and applies oxygen. Gets radial pulse, listens to lung sounds, and asks about fever. Hooks up EKG and O2 sensor, and checks sat O2.</td>
<td>Assessment</td>
</tr>
<tr>
<td>Starts IV. B suggests that it is more likely respiratory than cardiac, but gives him aspirin and nitroglycerin.</td>
<td>Basic treatment</td>
</tr>
<tr>
<td>Then asks about history with COPD, CHF, respiratory, and looks for pedal edema in the legs. B sees swelling and asks if this is normal. Gives patient a nebulizer. B exposes the legs, and proposes a possible DVT and PE. B gets the history of the leg, and asks if there was an injury (no).</td>
<td>Narrowing-in</td>
</tr>
<tr>
<td>B decides to take the patient to the ED with Cath Lab (as a PE could precipitate cardiac problems), and continues to monitor with 12-lead EKG, and provide oxygen and IV.</td>
<td>Manage and transport</td>
</tr>
</tbody>
</table>
**Table E.3: Paramedic C (Chest Pain Case)**

<table>
<thead>
<tr>
<th><strong>C asks about police presence and scene safety,</strong> Scene safety</th>
<th><strong>then greets the patient while assessing pulse, skin, general impressions. Directs EMT to apply non-rebreather, and get BP while C hooks up EKG.</strong> General assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sees unremarkable EKG, and asks about pain level, description, and movement.</strong> Focused assessment for MI</td>
<td></td>
</tr>
<tr>
<td><strong>Listens to lungs, and in response to “diminished”, asks if it is just the patient not breathing deeply, then requests patient to breath deeply. C hears full, clear bilateral (which, to C, excludes PE).</strong> Respiratory assessment</td>
<td></td>
</tr>
<tr>
<td><strong>C palpates chest, trying to elicit pain, asks for other triggers or relievers of pain (assessing for muscular-skeletal causes). Asks for recent coughing or illnesses (none)</strong> Broadening search</td>
<td></td>
</tr>
<tr>
<td>and medical history (heart valve surgery, Lipitor, family history of MI). Calms in response to anxiety. C decides to follow chest pain protocol, and administers aspirin, checks for Viagra use, and gives one dose of nitroglycerin. Reassess pain. Defaults to chest-pain protocol</td>
<td></td>
</tr>
<tr>
<td>Then C palpates abdomen, looking for pulsating mass such as with an abdominal rupture causing referred pain. Asks if there is any additional medical history, and is told about the recent leg development. Broadening, searching again for alternate causes</td>
<td></td>
</tr>
<tr>
<td><strong>C examines the leg, checking for pus, weeping, and scaling, and pedal pulses.</strong> Focused assessment on legs</td>
<td></td>
</tr>
<tr>
<td><strong>C starts IV access, and calls the ED, describing the legs as having pedal edema and cellulitis infection (right leg). C gets a blood sugar reading. Chooses to take patient to the ED with Cath Lab, and continues reassessing lung sounds, pain levels, and vital signs.</strong> Manage and transport</td>
<td></td>
</tr>
<tr>
<td><strong>Asked for a presumptive diagnosis, C is unsure, states that it can’t be PE because of the clear lung sounds, and suggests he might just be septic.</strong> Prompt: Too many constraints</td>
<td></td>
</tr>
<tr>
<td><strong>Told of the recent air flight, C says it is a PE.</strong> Cues: Revises framing</td>
<td></td>
</tr>
</tbody>
</table>
Table E.4: Paramedic D (Chest Pain Case)

<table>
<thead>
<tr>
<th><strong>D</strong> directs the EMT to get vital signs and apply oxygen while <strong>D</strong> gets a history of what happened from the patient’s wife. The EMT attaches the EKG while <strong>D</strong> gets a history of the recent event and heart history from the patient. <strong>D</strong> examines the skin, and listens to the lungs.</th>
<th><strong>Assessment and history taking</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>D</strong> sees some potential issues in the EKG, and decides to approach it as a cardiac event (no risk in doing so).</td>
<td><strong>Deciding to approach as cardiac</strong></td>
</tr>
<tr>
<td><strong>D</strong> has EMT give aspirin while <strong>D</strong> requests a BLS company. <strong>D</strong> checks for Viagra use, and administers the nitroglycerin.</td>
<td><strong>Standard chest pain treatment</strong></td>
</tr>
<tr>
<td><strong>D</strong> asks about the patient’s last visit to a physician, and checks blood sugar.</td>
<td><strong>Gauging general health</strong></td>
</tr>
<tr>
<td><strong>D</strong> reassess pain, gets a description of the pain, and re-assess the skin. <strong>D</strong> establishes an IV, and gives another nitroglycerin.</td>
<td><strong>Continuing with chest pain treatment</strong></td>
</tr>
<tr>
<td><strong>Arrival of BLS unit.</strong></td>
<td><strong>Additional resources to manage patient</strong></td>
</tr>
<tr>
<td>While <strong>D</strong> has BLS carry the patient out, <strong>D</strong> asks the patient’s wife about what was happening when it started.</td>
<td><strong>Refocusing on other information source</strong></td>
</tr>
<tr>
<td>She tells <strong>D</strong> about her husband returning from a long trip. <strong>D</strong> says that cardiac is still a concern, in addition to the risk of DVT and PE, and transports to the ED with Cath Lab.</td>
<td><strong>Integrating new information while maintaining concern for MI</strong></td>
</tr>
</tbody>
</table>
Table E.5: Paramedic E (Chest Pain Case)

<table>
<thead>
<tr>
<th>Action</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>$E$ talks with the patient and checks breathing, asking about health problems and medication,</td>
<td>General assessment</td>
</tr>
<tr>
<td>while $E$ puts on the EKG and the EMT puts on the oxygen. $E$ asks about pain movement and level. $E$ checks on the Sat O2, and asks about regular oxygen use, and heart history.</td>
<td>Cardiac assessment</td>
</tr>
<tr>
<td>Palpates the chest, asking about pain, and tenderness, enlarged organs or pulsating masses.</td>
<td>Assessing respiratory and other possible causes</td>
</tr>
<tr>
<td>$E$ considers COPD issues, and listens to the lungs.</td>
<td>Focus on COPD</td>
</tr>
<tr>
<td>$E$ re-assess EKG, and plans on transporting, and getting a good history for the ED.</td>
<td>Plans on transport and history-taking</td>
</tr>
<tr>
<td>$E$ reviews the findings, and asks about last physician visit and if there are any respiratory issues. $E$ reassesses anxiety and breath sounds.</td>
<td>General (re)assessment and history</td>
</tr>
<tr>
<td>$E$ asks about peripheral edema, and examines the feet. $E$ notices the swelling, and starts an IV. $E$ suggests CHF, and considers (but does not give) a diuretic.</td>
<td>Looks at CHF</td>
</tr>
<tr>
<td>$E$ is told that the leg swelling is new. $E$ suggests peripheral edema from CHF (and the lungs are quiet because they are too full to produce rales), or a DVT. $E$ palpates leg to check for edema, then administers a nebulizer, and mentions transporting.</td>
<td>Cued to recentness of leg swelling, considers DVT but does not exclude CHF.</td>
</tr>
<tr>
<td>$E$ is told that the leg swelling was preceded by an air flight. $E$ concludes that it is a DVT. $E$ proceeds to Level 1 with Cath Lab (because of 24 hour surgery).</td>
<td>Cued to recent air travel, concludes DVT.</td>
</tr>
<tr>
<td>Event</td>
<td>Analysis</td>
</tr>
<tr>
<td>---------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>F has the EMT get BP while F listens to the lungs and applies Sat O2 sensor. F gets a respiratory history, looking through medications.</td>
<td>Assessment, focused somewhat on respiratory</td>
</tr>
<tr>
<td>F administers a nebulizer of Albuterol, and asks about the pain. Has EMT apply oxygen, while F attaches the EKG. F reassess breathing and lungs, and looks at tracing.</td>
<td>Treating and assessing response</td>
</tr>
<tr>
<td>F notices chest scar and asks about past heart problems.</td>
<td>Modifies focus towards cardiac</td>
</tr>
<tr>
<td>F administers aspirin, starts an IV, assesses pain level, and administers a nitroglycerin. F plans on loading the patient and transporting to the ED with Cath Lab.</td>
<td>Standard cardiac treatment</td>
</tr>
<tr>
<td>F asks about movements associated with pain (including sitting up, an indicator of pleurisy), and re-assesses pain level and lung sounds. F reports to the ED. States that it does not seem like an MI and asks about fever or flu and eating.</td>
<td>Exploring alternatives to cardiac</td>
</tr>
<tr>
<td>F is told that his last meal was on the airplane. F looks at legs, mentions pitting edema but then says it is a possible DVT and PE.</td>
<td>Cues to recent air travel, assesses legs and concludes DVT &amp; PE.</td>
</tr>
</tbody>
</table>
Table E.7: Paramedic G (Chest Pain Case)

<table>
<thead>
<tr>
<th>Action</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>G begins with a focus on conditions for travel and scene safety.</td>
<td>Scene safety</td>
</tr>
<tr>
<td>Talks with patient, and has EMT establish O2 via non-rebreather and get</td>
<td>Assessment</td>
</tr>
<tr>
<td>vitals while G hooks up EKG &amp; O2 sensor. Asks if he's had a history</td>
<td></td>
</tr>
<tr>
<td>of “this” before.</td>
<td></td>
</tr>
<tr>
<td>After looking at EKG, decides to follow standard cardiac care –</td>
<td>Standard chest-pain</td>
</tr>
<tr>
<td>loading pt, establishing IV (TKO rate), transporting to ED with</td>
<td>protocol; manage and</td>
</tr>
<tr>
<td>Cath Lab.</td>
<td>transport</td>
</tr>
<tr>
<td>When prompted to go further, G assesses pain, and gives nitroglycerin,</td>
<td>Prompt: Treat with</td>
</tr>
<tr>
<td>re-assesses pain &amp; BP, gives 2nd dose, re-assess pain &amp; BP, and</td>
<td>nitroglycerin</td>
</tr>
<tr>
<td>gives 3rd dose.</td>
<td></td>
</tr>
<tr>
<td>When asked about sat O2 levels, G explains that it isn't an issue</td>
<td>Cues: Focuses on</td>
</tr>
<tr>
<td>because it isn't below 90%, and high-flow O2 is standard treatment</td>
<td>treatment &amp; procedures</td>
</tr>
<tr>
<td>for cardiac patients. When shown the legs, G reflects on G’s focus</td>
<td></td>
</tr>
<tr>
<td>on chest pain only.</td>
<td></td>
</tr>
<tr>
<td>When presented with history of leg being noticed after trip, G asks</td>
<td>Cue: Revises framing</td>
</tr>
<tr>
<td>if it was a long distance flight, asks about sputum, and concludes</td>
<td></td>
</tr>
<tr>
<td>the PE is primary possibility.</td>
<td></td>
</tr>
<tr>
<td>Action</td>
<td>Outcome</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>H talks with patient and has EMT give oxygen, then asks patient to</td>
<td>Assessing, treating anxiety</td>
</tr>
<tr>
<td>calm his breathing down.</td>
<td></td>
</tr>
<tr>
<td>H asks about pain quality and movement, and listens to lungs. H</td>
<td>MI assessment; generic treatment</td>
</tr>
<tr>
<td>puts on EKG and Sat O2 sensor, and starts moving the patient to the</td>
<td></td>
</tr>
<tr>
<td>truck. H sets up an IV and checks blood sugar. H asks pain level,</td>
<td></td>
</tr>
<tr>
<td>and looks at the EKG tracing.</td>
<td></td>
</tr>
<tr>
<td>H calls ED and asks if patient with chest pain should be treated</td>
<td>Unsure if MI or not</td>
</tr>
<tr>
<td>with chest pain protocol even if nothing is showing on the EKG.</td>
<td></td>
</tr>
<tr>
<td>ED instructs H to follow H's chest pain protocol. H checks BP,</td>
<td>As per instructions, following chest pain protocol</td>
</tr>
<tr>
<td>administers aspirin, and one dose nitroglycerin. H reports to ED,</td>
<td></td>
</tr>
<tr>
<td>checks BP, and notices chest scar. Learns about past surgery, and</td>
<td>Finds evidence supporting MI</td>
</tr>
<tr>
<td>calls ED to report that.</td>
<td></td>
</tr>
<tr>
<td>Asks about relief of pain (none), checks on BP, and gives another</td>
<td>Maintains MI hypothesis in light of evidence to contrary</td>
</tr>
<tr>
<td>dose of nitroglycerin. H states they would be at ED now. When</td>
<td></td>
</tr>
<tr>
<td>prompted with a lack of improvement to the pain from the nitroglycerin,</td>
<td>Revision of ED assessment triggers no explicit re-framing</td>
</tr>
<tr>
<td>H suggests that it might be a very large MI.</td>
<td></td>
</tr>
<tr>
<td>When presented with an alternate, negative response to H's question</td>
<td></td>
</tr>
<tr>
<td>of the ED (do not follow chest pain protocol because it is not a</td>
<td></td>
</tr>
<tr>
<td>cardiac event), H responds with transport and management.</td>
<td></td>
</tr>
<tr>
<td>When given the cue of the patient's leg becoming sore yesterday,</td>
<td>Cued to leg history, concludes DVT/PE</td>
</tr>
<tr>
<td>H concludes DVT and PE.</td>
<td></td>
</tr>
</tbody>
</table>
Table E.9: Paramedic I (Chest Pain Case)

<table>
<thead>
<tr>
<th>I talks with the patient while EMT provides oxygen. I hooks up EKG and Sat O2 sensor, and asks for a description of the pain, the location, and if it is moving. I asks if he has had this before (no), and plans on transportation. I gives him some aspirin, asks about allergies, established an IV, and asks for a pain level.</th>
<th>Standard assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>I considers but decides not to give nitroglycerin because of the unremarkable EKG. I considers morphine as an option, and states that it does not seem like an MI.</td>
<td>Not likely MI – holding off on cardiac interventions</td>
</tr>
<tr>
<td>I assesses BP (‘good’), pulse (‘so-so’) and Sat O2 (‘not good, but probably normal as his is a long term smoker’). I selects the ED with Cath Lab, and proposes transmitting the 12-lead EKG to the ED to see if they recommend nitroglycerin.</td>
<td>Evaluating ambiguous status; planning delivery to and possible instructions from ED</td>
</tr>
<tr>
<td>When prompted with a failure of pain relief in response to a nitroglycerin dose, I proposes morphine as pain relief. I proposes vagal stimulation to calm him down. When prompted with a negative reaction to that (still anxious), I proposes a second nitroglycerin.</td>
<td>Focus on immediate treatments rather than provisional diagnoses</td>
</tr>
<tr>
<td>When cued with history of swollen leg, I considers insect bites, injury, or infection as cause of inflammation. When cued with recent air flight, I considers bites or injury sources from other locales.</td>
<td>Approaches leg issue independent from chest pain</td>
</tr>
</tbody>
</table>
Table E.10: Paramedic J (Chest Pain Case)

<table>
<thead>
<tr>
<th>Step</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>J sees if patient is responsive, and asks about the chest scar. J administers oxygen, hooks up EKG, and asks if this feels similar to past heart issue (no). J gets pain description, relation to breathing, and pain level, and looks at EKG tracing.</td>
<td>Assessment and history</td>
</tr>
<tr>
<td>J checks on response to oxygen, starts an IV, sits patient up to see if breathing is assisted.</td>
<td>Basic treatment</td>
</tr>
<tr>
<td>J asks about what was going on when it started, and listens to lungs. J states that it does not seem like an MI. J asks about medical history, learns about Lipitor, asks if there is anything else, and learns about the recent leg soreness.</td>
<td>Further assessment and focus away from cardiac</td>
</tr>
<tr>
<td>J checks for pulses and equal sensation and movement in the legs.</td>
<td>Leg assessment</td>
</tr>
<tr>
<td>J double-checks on if sitting up helps or not (no, negative for CHF).</td>
<td>Assessing for CHF</td>
</tr>
<tr>
<td>J plans on transporting him to ED with Cath Lab (because it is only 3 minutes further than closer ED).</td>
<td>Focus on transport</td>
</tr>
<tr>
<td>Asked for a presumptive diagnosis, J in unsure but suggests that it is respiratory, possibly CHF (right-sided, affecting lungs), because there is pedal edema.</td>
<td>Considering respiratory, CHF</td>
</tr>
<tr>
<td>Prompted to ask about history, J asks if the leg is normally like that.</td>
<td>Prompt, leading to re-focus on leg</td>
</tr>
<tr>
<td>With no response, J is cued with the air flight. J proposes a blood clot leading to a PE.</td>
<td>Cued to air flight, concludes DVT/PE</td>
</tr>
</tbody>
</table>
Appendix F: Multiple Patients Case Materials
F.1 Multiple Patient Case Flowchart

Two Patient Trauma - Flowchart

- Set Up and Arrival
  - Initial Assessment of Chest Shot
    - Report of EMT Initial Assessment and Treatment of Head Shot
    - Initial Treatment of Chest Shot - with EMT
- Initial Assessment of Head Shot
  - Report of EMT Initial Assessment of Chest Shot

- Initial Treatment of Chest Shot - Solo (EMT occupied with Head Shot)
  - Transportation Planning - Possibility 1
  - Transportation Planning - Possibility 2
  - Transportation Planning - Possibility 3

- Decision About Hospital
  - Loading Chest Patient
    - Assessing Patient En Route
      - Treating Tension Pneumothorax - Possibility 1
      - Treating Tension Pneumothorax - Possibility 2
    - Possible Misdiagnosis and Treatment of Tension Pneumothorax

- Calling Hospital
  - Documentation
    - Arrival at ED
      - Handoff

Figure F.1: Multiple Patients Case Flowchart
F.2 *Multiple Patients Scenario*

**Two Patient Trauma Case**

**Summary of Case**

The paramedic is presented with two patients – a head shot victim and a chest shot victim. The paramedic must make a prioritization decision. A novice may become fixated on one patient, and neglect to manage the larger situation. The paramedic must recognize that the head shot patient is dying and should not consume all the resources (thereby threatening the life of the chest shot patient). He or she must not fixate on implementing interventions.

Once in route, the paramedic must be aware that patient status is not static, and requires reassessment. He or she must recognize the unintended side-effect of an earlier intervention (the occlusive dressing on the bullet wound traps air in the chest, preventing lung expansion during breathing), and respond.

**Layout of the Walk-throughs/Simulations**

The space, equipment, and patients will be represented in the scenario via artifacts which capture some of the functional aspects of the real world counter-parts.

The room is divided into 3 areas: the site with the patients, the ambulance, and the receiving hospital ED.

Each patient is represented by a flat screen computer monitor or (remotely accessed) laptop (which will display illustrations of patient, some vital signs as paramedic assesses them). Equipment is represented by cards or post-its that can be stuck to the frame of the computer display. Clipboard with run-sheet is in “ambulance.”

At the start of the scenario, the Scenario Administrator (A), *the EMT confederate* (E), and the *participant Paramedic* (P), are in the ambulance area – E sitting to the left of P, as if E is driving.

A second researcher will operate the video camera.
Table F.1: Multiple Patient Set-up and Arrival

<table>
<thead>
<tr>
<th>Ambulance</th>
<th>Said</th>
<th>Shown or Done</th>
</tr>
</thead>
</table>
| A         | It is early afternoon. Weather is mild.                              | Paper with: “two adult males, gunshot wounds. Corner of Vincent St. and Pitt St. Police on scene.” Map showing location and hospitals*.
|           | Dispatch says there are two adult males with gunshot wounds at corner of Vincent St. and Pitt St. Police have secured the scene. |                                                                                       |
| P         | We proceed to the scene, lights and sirens.                         |                                                                                   |
| Arrival   |                                                                      |                                                                                   |
| A         | You see some police cars at the intersection. The police look busy but not on guard. A police offer waves at you and points over to the drug store parking lot at one corner of the intersection. In the parking lot, another police offer waves at you and points to the two patients you see over there. | Turns on the two displays in “site” area. One shows an illustration of a man sitting on a truck bumper, blood on his chest, moderately distressed expression. The other shows an illustration of a man lying on the ground, decerebrate posturing, blood by his head. |
| P         | I radio dispatch for another ambulance unit                         |                                                                                   |
| A         | Dispatch replies that one is en route, will be there in 4 or 5 minutes |                                                                                   |
| P & E     | Put on gloves                                                       |                                                                                   |
| P         | To E: I'll get ____, you get the other                              |                                                                                   |
| P         | Grabs bag, heads over to patient.                                   |                                                                                   |
| E         | Grabs bag, heads over to patient.                                   |                                                                                   |
Table F.2: Initial Assessment of Head Shot

<table>
<thead>
<tr>
<th>Site</th>
<th>Said</th>
<th>Shown or Done</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>Goes to head shot pt</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>He is white male, looks to be in mid-30’s. His breathing is infrequent.</td>
<td>Illustration shows wound a little above and behind ear. Pool of blood under head. Pupils dilated.</td>
</tr>
<tr>
<td>P</td>
<td>I’m addressing him – “I’m a paramedic – can you hear me?”</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>No response</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>I’m causing pain</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>No response</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>I’m checking the breathing and pulse</td>
<td>Holds stethoscope to display.</td>
</tr>
<tr>
<td>A</td>
<td>Rate is 8, and shallow. Here is what it sounds like.</td>
<td>Play agonal breathing sound clip.</td>
</tr>
<tr>
<td>A</td>
<td>The pulse is erratic and slow – around 50.</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>I’m checking his pupils.</td>
<td>Uses penlight</td>
</tr>
</tbody>
</table>

Table F.3: Report of EMT Initial Assessment of Head Shot

<table>
<thead>
<tr>
<th>Site</th>
<th>Said</th>
<th>Shown or Done</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>To P: He’s non-responsive. Pulse is about 50 and not regular. He’s breathing is really slow – rate of 8 maybe, and shallow. He’s just gasping infrequently. Pupils are dilated and unresponsive.</td>
<td>Standing by display for Head Shot</td>
</tr>
<tr>
<td>E</td>
<td>To P: “What do you want me to do? Should I give him oxygen and bag him?”</td>
<td></td>
</tr>
</tbody>
</table>
### Table F.4: Initial Assessment of Chest Shot

<table>
<thead>
<tr>
<th>Site</th>
<th>Said</th>
<th>Shown or Done</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>Goes to chest shot pt</td>
<td></td>
</tr>
<tr>
<td>A/D</td>
<td>He is white male, looks to be in mid-20’s. Shot in upper right chest.</td>
<td>Illustration shows wound in right side of chest; sweaty, anxious expression</td>
</tr>
<tr>
<td>P</td>
<td>I introduce myself and assess orientation. ‘Hi, I’m ___ a paramedic. What’s your name?’ What happened?’</td>
<td></td>
</tr>
<tr>
<td>A(as C)</td>
<td>[He says:] “I got shot....My name is...Walter. “ His breathing is fast &amp; labored.</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>Do you know where you are?</td>
<td></td>
</tr>
<tr>
<td>A(C)</td>
<td>“I’m in the ... parking lot of ...the drug store.”</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>When did this happen?</td>
<td></td>
</tr>
<tr>
<td>A(C)</td>
<td>“A few... minutes.... ago. “</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>I listen to his lungs, check his pulse</td>
<td>Uses stethoscope</td>
</tr>
<tr>
<td>A</td>
<td>His respiratory rate is 28. His right lung is fairly quiet – you don’t hear much.</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>His pulse is 120; weak radial pulse.</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>The wound at his chest is foaming slightly.</td>
<td></td>
</tr>
</tbody>
</table>

### Table F.5: Report of EMT Initial Assessment & Treatment of Chest Shot

<table>
<thead>
<tr>
<th>Site</th>
<th>Said</th>
<th>Shown or Done</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>To P: Shot in right chest. Right lung is silent. Respiratory rate is 28, pulse is 120. The bullet wound is foaming a little.</td>
<td>Standing by display for Chest Shot</td>
</tr>
<tr>
<td>E</td>
<td>I’m giving him oxygen at 15 L/m by non-rebreather, and covering the wound.</td>
<td>Connects “oxygen” to “mask”, and puts “mask” on “patient”. Holds hand on “patient”</td>
</tr>
</tbody>
</table>
### Table F.6: Initial Treatment of Chest Shot (without EMT)

<table>
<thead>
<tr>
<th>Site</th>
<th>Said</th>
<th>Shown or Done</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>I give him oxygen at 15 L/m by non-rebreather mask.</td>
<td>Connects “oxygen” to “mask”, and puts “mask” on “patient”</td>
</tr>
<tr>
<td>P</td>
<td>I tape an occlusive bandage over the wound</td>
<td>Puts “dressing” on “patient”</td>
</tr>
<tr>
<td>P</td>
<td>I get the stretcher</td>
<td>Goes back to “ambulance” and carries “stretcher” back to “site”. Puts “patient” on “stretcher”</td>
</tr>
</tbody>
</table>

### Table F.7: Initial Treatment of Chest Shot (with EMT)

<table>
<thead>
<tr>
<th>Site</th>
<th>Said</th>
<th>Shown or Done</th>
</tr>
</thead>
<tbody>
<tr>
<td>P or E</td>
<td>I give him oxygen at 15 L/m by non-rebreather mask.</td>
<td>Connects “oxygen” to “mask”, and puts “mask” on “patient”</td>
</tr>
<tr>
<td>P or E</td>
<td>I get the stretcher</td>
<td>Goes back to “ambulance” and carries “stretcher” back to “site”. Puts “patient” on “stretcher”</td>
</tr>
<tr>
<td>E</td>
<td>I cover the wound</td>
<td>Puts hand on “patient”</td>
</tr>
<tr>
<td>P &amp; E</td>
<td></td>
<td>Put the “patient” on the “stretcher”</td>
</tr>
</tbody>
</table>
### Table F.8: Transportation Planning - Possibility 1

<table>
<thead>
<tr>
<th>Site</th>
<th>Said</th>
<th>Shown or Done</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>The other unit has arrived. The paramedic and EMT come out with their stretcher, and they look at you. What do you tell them to do?</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>I tell them to package and transport the head shot, and that we are taking the chest patient – he gets priority</td>
<td></td>
</tr>
</tbody>
</table>

### Table F.9: Transportation Planning - Possibility 2

<table>
<thead>
<tr>
<th>Site</th>
<th>Said</th>
<th>Shown or Done</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>The other unit has arrived. The paramedic and EMT come out with their stretcher, and they look at you. What do you tell them to do?</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>I tell them to help with the chest patient – he takes priority</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>I go with chest patient. EMT and either other EMT or paramedic take care of head patient.</td>
<td></td>
</tr>
</tbody>
</table>

### Table F.10: Transportation Planning - Possibility 3

<table>
<thead>
<tr>
<th>Site</th>
<th>Said</th>
<th>Shown or Done</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>The other unit has arrived. The paramedic and EMT come out with their stretcher, and they look at you. What do you tell them to do?</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>I tell them that we need to load the head shot patient first – he takes priority</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>The other paramedic says that the head shot patient is dying, and that the other patient – the chest wound – needs to go first.</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>Let’s pretend now that you are the arriving paramedic, and the paramedic already on-scene is loading up the head-shot case, and directs you to take care of the chest shot case.</td>
<td>Turn off Head Shot display</td>
</tr>
</tbody>
</table>
Table F.11: Loading Chest Shot

<table>
<thead>
<tr>
<th>Site/Ambulance</th>
<th>Said</th>
<th>Shown or Done</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>To E: We will now move the patient into the ambulance</td>
<td></td>
</tr>
<tr>
<td>E &amp; P</td>
<td>E &amp; P put “patient” on “stretcher” and carry “stretcher” to “ambulance”. <em>E maintains pressure on chest wound.</em></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td><em>E retrieves “bags/equipment”</em></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td><em>P connects O2 monitor to “patient”</em></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>Display shows O2 of 94% (+/- 2% based on time); pulse of 125 (+/- 5 based on time)</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td><em>P puts “IV” into “patient”</em></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>Starts siren and road noise sound clip on computer.</td>
<td></td>
</tr>
</tbody>
</table>

Table F.12: Assessing Patient en Route

<table>
<thead>
<tr>
<th>Ambulance</th>
<th>Said</th>
<th>Shown or Done</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Without cueing P, changes display to illustration of semi-conscious, more distressed, more sweaty, slightly cyanic patient. Jugular distention.</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>Without cuing P, Changes O2 to 92%, pulse to 130</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td><em>I reassess the patient – look at his breathing, ask how he is doing</em> Look at display</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>He responds groggily and seems a little out of it, but he also looks and sounds anxious. His breathing seems more labored – almost hyperventilating.</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>His right chest is bulging a little.</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td><em>He’s hypoxemic. It could be a tension pneumothorax.</em></td>
<td></td>
</tr>
</tbody>
</table>

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### Table F.13: Treating Tension Pneumothorax - Possibility 1

<table>
<thead>
<tr>
<th>Ambulance</th>
<th>Said</th>
<th>Shown or Done</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>I burp the dressing on the wound</td>
<td>Partially removes “dressing” from “patient”</td>
</tr>
<tr>
<td>A</td>
<td>You feel some air come out.</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>His breathing gets a little slower and deeper.</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>He seems more alert now.</td>
<td>On display, change O2 to 96%, decrease pulse to 110</td>
</tr>
<tr>
<td>A</td>
<td></td>
<td>Change display to illustration of more awake, red-lipped, less sweaty, less anxious patient</td>
</tr>
</tbody>
</table>

### Table F.14: Treating Tension Pneumothorax - Possibility 2

<table>
<thead>
<tr>
<th>Ambulance</th>
<th>Said</th>
<th>Shown or Done</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>I insert a catheter or large gauge needle into his upper right chest</td>
<td>Takes “needle” and applies it to “patient”</td>
</tr>
<tr>
<td>A</td>
<td>His breathing gets a little slower and deeper.</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>He seems more alert now.</td>
<td>On display, change O2 to 96%, decrease pulse to 110</td>
</tr>
<tr>
<td>A</td>
<td></td>
<td>Change display to illustration of more awake, red-lipped, less sweaty, less anxious patient</td>
</tr>
</tbody>
</table>
Table F.15: Possible Misdiagnosis and Treatment of Tension Pneumothorax

<table>
<thead>
<tr>
<th>Ambulance</th>
<th>Said</th>
<th>Shown or Done</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Without cueing P, changes display to illustration of semi-conscious,</td>
<td>Without cuing P, Changes O2 to 92%, pulse to 130</td>
</tr>
<tr>
<td></td>
<td>more distressed, more sweaty, slightly cyanic patient. Jugular</td>
<td></td>
</tr>
<tr>
<td></td>
<td>distention.</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>I reassess the patient – look at his breathing, ask how he is doing</td>
<td>Look at display</td>
</tr>
<tr>
<td>A</td>
<td>He responds groggily and seems a little out of it, but he also looks and sounds anxious. His breathing seems more labored – almost hyperventilating.</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>His right chest is bulging a little.</td>
<td></td>
</tr>
</tbody>
</table>
F.3 Hospital Locations

Figure F.2: Location of Multiple Patient Case and Hospitals
### Figure F.3: Functional Diagram of Head Shot

#### Two patient Trauma -- Shot in Head

**En Route**
- Arrive
- Prepare

**Assess scene safety & respond**
- Determine Location and number of patients
- Body fluid
- Social hazard
- Environmental hazard
- Request additional ALS unit

**Ensure sufficient resources**
- Initial impressions
- Delegation of EMT
  - Adult male (mid 30's)
  - Medium build, decerebrate posturing
  - Shot in head (right side, above & behind ear)
  - Not responsive, infrequent breaths
  - Both pupils dilated
  - Stethoscope
  - Penlight
  - Pupils non-responsive
  - Breathing is agonal
  - Pulse erratic & slow - 55
  - Respiratory rate 8, shallow
  - Blood pressure?

**Ensure scene safety**
- Police milling about
- See two patients in parking lot - one on ground, one sitting on police van bumper

**Arrival at Scene**
- Drive
- “Address, code: 2 pts, shooting, police secured”
- Push - text

**At Patient**
- General impression & initial assessment
  - Appearance
  - LOC
  - Distress
  - Airway
  - Breathing
  - Circulation
  - Vital signs

**Enable rapid medical care**
- Needs rapid transport, minimal intervention
- Load onto stretcher
- C-spine immobilization
- Oxygen, ventilation (BVM?)
- Move into ambulance

**In Ambulance**
- Call Hospital
- Transport
- Re-assessment
  - Circulation
  - Breathing
  - Vitals

**At Hospital**
- Handoff
- Documentation

**Provide info to ED**
- Pulse ox
- Pulse monitor
- Any medications?

- Lower, erratic pulse
- Respiration very infrequent
- Lower blood pressure?

- No respiration, no pulse; dies

**Figure F.3: Functional Diagram of Head Shot**

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Figure F.4: Functional Diagram of Chest Shot
### F.4 Vital Sign Values

Time/progression is measured by the activities of the paramedic.

Assuming that:
- intubation takes "5 units"
- doing rapid trauma assessment takes "1 unit"
- oxygen, starting ventilation takes "1 unit"
- starting IV takes "2 units"
- starting monitor takes "3 units"

#### Status of Head Shot

**Table F.16: Status of Head Shot**

<table>
<thead>
<tr>
<th></th>
<th>Initial</th>
<th>After &quot;4 units&quot;</th>
<th>After &quot;8 units&quot;</th>
<th>After &quot;12 units&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nothing</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulse</td>
<td>50, irregular</td>
<td>No radial, 45</td>
<td>No femoral, 40</td>
<td>No femoral, faint carotid</td>
</tr>
<tr>
<td>BP</td>
<td>85/64</td>
<td>&gt;80, &gt;70</td>
<td>&gt;70, &lt;60</td>
<td>&gt;70</td>
</tr>
<tr>
<td>RR</td>
<td>8, infrequent, shallow.</td>
<td>Agonal &lt;8, no resistance</td>
<td>Agonal &lt;8, no resistance</td>
<td>Agonal &lt;8, no resistance to</td>
</tr>
<tr>
<td></td>
<td>agonal</td>
<td>to ventilation</td>
<td>to ventilation</td>
<td>ventilation</td>
</tr>
<tr>
<td>O2</td>
<td>88%</td>
<td>84%</td>
<td>Error</td>
<td>Error</td>
</tr>
<tr>
<td>Non responsive</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Oxygen**

|                |                          |                           |                           |                               |
| Pulse          | 50, irregular            | No radial, 45             | No femoral, 40            | No femoral, faint carotid     |
| BP             | 85/64                    | >80, >70                  | >70, <60                  | >70                           |
| RR             | 8, infrequent, shallow.  | Agonal <8 after intubation, no resistance to ventilation | Agonal <8 OR no resistance to ventilation | Agonal <8 OR no resistance to ventilation |
|                |  agonal                  |                           |                           |                               |
| O2             | 88%                      | 89%                       | 90%                       | 91%                           |
| Non responsive |                          |                           |                           |                               |

**Oxygen + IV**

|                |                          |                           |                           |                               |
| Pulse          | 50, irregular            | 48, irregular             | 46, irregular             | 44, irregular                 |
| BP             | 85/64                    | 86/67                     | 87/70                     | 88/73                         |
| RR             | 8, infrequent, shallow.  | Agonal <8 after intubation, no resistance to ventilation | Agonal <8 OR no resistance to ventilation | Agonal <8 OR no resistance to ventilation |
|                |  agonal                  |                           |                           |                               |
| O2             | 88%                      | 90%                       | 92%                       | 94%                           |
| Non responsive |                          |                           |                           |                               |
Corresponding status of the Chest Shot

Table F.17: Status of Chest Shot

<table>
<thead>
<tr>
<th></th>
<th>Stage 1 (Initial)</th>
<th>Stage 2</th>
<th>Stage 3</th>
<th>Stage 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Image 1</td>
<td>Image 2</td>
<td>Image 3</td>
<td>Unit arrives</td>
</tr>
<tr>
<td>Report from “EMT”</td>
<td>&quot;Shot in left chest. Left lung is silent. Respiratory rate is 27, pulse is 120 (weak radial). Bullet wound is foaming a little. Don’t see any other injuries. I’m holding my hand over wound.&quot;</td>
<td>&quot;Looking pale &amp; anxious. Breathing more rapid&quot;</td>
<td>&quot;Getting lethargic, does not look good.&quot;</td>
<td></td>
</tr>
<tr>
<td>Patient behavior</td>
<td>Fully oriented</td>
<td>Responsive, says “I’m not feeling good”</td>
<td>“can’t breath – hurts”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nothing</td>
<td>Oxygen</td>
<td>Oxygen + IV</td>
<td></td>
</tr>
<tr>
<td>Pulse</td>
<td>120 (weak radial)</td>
<td>125 (no radial)</td>
<td>130 (no radial)</td>
<td>140 (weak femoral)</td>
</tr>
<tr>
<td>BP</td>
<td>84/60</td>
<td>81/56</td>
<td>77/52</td>
<td>74/48</td>
</tr>
<tr>
<td>RR</td>
<td>27</td>
<td>30</td>
<td>33</td>
<td>35</td>
</tr>
<tr>
<td>O2</td>
<td>96%</td>
<td>93%</td>
<td>90%</td>
<td>87%</td>
</tr>
<tr>
<td>Oxygen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulse</td>
<td>120 (weak radial)</td>
<td>125 (no radial)</td>
<td>130 (no radial)</td>
<td>140 (weak femoral)</td>
</tr>
<tr>
<td>BP</td>
<td>84/60</td>
<td>81/56</td>
<td>77/52</td>
<td>74/48</td>
</tr>
<tr>
<td>RR</td>
<td>27</td>
<td>25</td>
<td>26</td>
<td>27</td>
</tr>
<tr>
<td>O2</td>
<td>96%</td>
<td>95%</td>
<td>94%</td>
<td>93%</td>
</tr>
<tr>
<td>Oxygen + IV</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulse</td>
<td>120 (weak radial)</td>
<td>123 (weak radial)</td>
<td>125 (weak radial)</td>
<td>130 (weak radial)</td>
</tr>
<tr>
<td>BP</td>
<td>84/60</td>
<td>83/57</td>
<td>82/55</td>
<td>81/52</td>
</tr>
<tr>
<td>RR</td>
<td>27</td>
<td>25</td>
<td>26</td>
<td>27</td>
</tr>
<tr>
<td>O2</td>
<td>96%</td>
<td>95%</td>
<td>94%</td>
<td>93%</td>
</tr>
</tbody>
</table>
F.5 *Images of Patients*

Figure F.5: Initial View of Head Shot
Figure F.6: Initial View of Chest Shot
Figure F.7: Head Shot patient
Figure F.8: Chest Shot Patient - pre-bandage
Figure F.9: Chest Shot Patient - bandaged
Figure F.10: Chest Pain Patient - Tension Pneumothorax
Appendix G: Multiple Patients Case
Findings
Tables G-1 through G-8 describe the actions of each paramedic (in terms of the EMS domain) in the left column, and the respective generic cognitive categories in the right column.
<table>
<thead>
<tr>
<th>Event Description</th>
<th>Decision (prioritization)</th>
<th>Uncertainty management, planning</th>
<th>Planning (intervention med-cost HP-Airway)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP is awake, so HP priority both go to HP assess HP planning OP airway</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>established severity of HP</td>
<td></td>
<td>Uncertainty management, planning</td>
<td></td>
</tr>
<tr>
<td>EMT managing HP airway preparing for transportation</td>
<td></td>
<td>Coordination (direction), resource allocation Planning</td>
<td></td>
</tr>
<tr>
<td>requesting backup for CP</td>
<td></td>
<td>Attention management. Anticipation – need for more resources; coordination – sending request for more resources</td>
<td></td>
</tr>
<tr>
<td>Paramedic assessing CP anticipating tension pneumo use EMT to evaluate ambiguous sign apply aclusing dressing</td>
<td></td>
<td>Uncertainty management. Anticipation. Uncertainty management, coordination (consult) Intervention (CP-Breathing)</td>
<td></td>
</tr>
<tr>
<td>asking about backup timing evaluates waiting, decides to transport both planning interventions, resource use</td>
<td></td>
<td>Anticipation – need for more resources; Decision, planning. Evaluating coordination COA.</td>
<td></td>
</tr>
<tr>
<td>recruits cop to drive</td>
<td></td>
<td>Resource management (recruits resource)</td>
<td></td>
</tr>
<tr>
<td>EMT manages HP</td>
<td></td>
<td>Attention management. Coordination (direct); resources allocation</td>
<td></td>
</tr>
<tr>
<td>confirming EMT on HP airway</td>
<td></td>
<td>Coordination, uncertainty management</td>
<td></td>
</tr>
<tr>
<td>Paramedic getting IVs for both</td>
<td></td>
<td>Interventions (HP-Circulation; CP-Circulation)</td>
<td></td>
</tr>
<tr>
<td>reassessing CP confirming improvement</td>
<td></td>
<td>Uncertainty management</td>
<td></td>
</tr>
<tr>
<td>assessing HP identifying worsening trend considering CPR limited options for HP considering atropine</td>
<td></td>
<td>Uncertainty management Pattern/problem recognition Decision, evaluating COA Planning intervention high cost HP-Circulation</td>
<td></td>
</tr>
<tr>
<td>monitors on both resource questions – if only 1 ekg would use it on HP considering intubation for HP</td>
<td></td>
<td>Uncertainty management Decision, evaluating COA – planning intervention (HP-Breathing)</td>
<td></td>
</tr>
<tr>
<td>reviewing status of CP prioritizing HP</td>
<td></td>
<td>Attention management Uncertainty management</td>
<td></td>
</tr>
<tr>
<td>interventions on HP (intubation + hyperventilation)</td>
<td></td>
<td>Intervention high-cost HP-Breathing</td>
<td></td>
</tr>
<tr>
<td>reassessing CP</td>
<td></td>
<td>Attention management Uncertainty management</td>
<td></td>
</tr>
<tr>
<td>re-confirming HP is priority reassessing – concerned about circulation administers atropine to raise pulse</td>
<td></td>
<td>Attention management Intervention high-cost HP-Circulation</td>
<td></td>
</tr>
<tr>
<td>asking how far from hospital</td>
<td></td>
<td>Planning</td>
<td></td>
</tr>
<tr>
<td>unloading HP first</td>
<td></td>
<td>prioritization</td>
<td></td>
</tr>
</tbody>
</table>
### Table G.2: Paramedic C (Multi-Patient Case)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Management/Planning/Coordination/Resource Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>confirma just 2 pt</td>
<td>Uncertainty management</td>
</tr>
<tr>
<td>decides to assess HP</td>
<td>Decision/prioritization (HP looks more critical)</td>
</tr>
<tr>
<td>sends EMT to CP</td>
<td>Attention management. Resource allocation</td>
</tr>
<tr>
<td>gets report from EMT – stage 1</td>
<td>Coordination (gets info); Coordination (direction).</td>
</tr>
<tr>
<td>instruct EMT to put O2 on CP</td>
<td>Manage CP-Breathing</td>
</tr>
<tr>
<td>calls for backup</td>
<td>Anticipation – need for more resources; coordination – sending request for more resources</td>
</tr>
<tr>
<td>evaluates backup arrival time relative to time to trauma center</td>
<td></td>
</tr>
<tr>
<td>assesses HP</td>
<td>Planning intervention (high-cost HP-Airway). Manage CP-Breathing (protocol, anticipation/risk management). Free resource (EMT)</td>
</tr>
<tr>
<td>decides to intubate</td>
<td></td>
</tr>
<tr>
<td>frees up EMT by instructing use of occlusive (3side)</td>
<td></td>
</tr>
<tr>
<td>asking about backup</td>
<td>Planning/coordination/resource management (backup)</td>
</tr>
<tr>
<td>plans on giving CP to backup</td>
<td>Decision/Planning (coordination – unload responsibilities)</td>
</tr>
<tr>
<td>packaging HP</td>
<td>Intervention (low-cost HP-ssX)</td>
</tr>
<tr>
<td>assessing HP – looking for wounds</td>
<td>Uncertainty management.</td>
</tr>
<tr>
<td>handoff CP to backup</td>
<td>Coordination – unloads responsibility to new actors.</td>
</tr>
<tr>
<td>plans on transport of HP to trauma center</td>
<td>Planning. Intervention (low-cost HP-Circulation)</td>
</tr>
<tr>
<td>reassess</td>
<td></td>
</tr>
<tr>
<td>IV trendelenberg</td>
<td></td>
</tr>
<tr>
<td>report to hospital</td>
<td>Coordination re ED, &amp; ED-backup.</td>
</tr>
<tr>
<td>also includes alert to incoming CP pt</td>
<td></td>
</tr>
<tr>
<td><em>Admin switches to Chest Patient</em></td>
<td></td>
</tr>
<tr>
<td>assessment</td>
<td></td>
</tr>
<tr>
<td>sees JVD</td>
<td></td>
</tr>
<tr>
<td>needle decompression</td>
<td></td>
</tr>
<tr>
<td>reassess</td>
<td></td>
</tr>
<tr>
<td>packaging monitor</td>
<td></td>
</tr>
<tr>
<td>IV trendelenberg</td>
<td></td>
</tr>
<tr>
<td>assessing (sees reason to look at abdomen)</td>
<td></td>
</tr>
</tbody>
</table>
### Table G.3: Paramedic D (Multi-Patient Case)

| Action | Management
|--------|-------------
| trying to get info on what happened | Uncertainty management
| check HP for responsiveness, via EMT | Coordination (direct); assess HP
| goes to CP assessing, asking what happened put hand over wound | Attention management. Uncertainty management Intervention (CP-Breathing)
| call for backup | Anticipation – need for more resources; coordination – sending request for more resources
| get assessment from EMT confirming EMT’s scope of practice EMT to intubate HP w/ King airway | Coordination (get info); Coordination, uncertainty management Coordination (direct; intervention med-cost HP-Airway)
| occlusive dressing on CP assess O2 | Attention management. Intervention CP-Breathing Intervention CP-Breathing
| get assessment from EMT instruct trendelenberg (lack of resources) | Coordination (get info) Resource management; intervention (HP-Circulation)
| reviewing CP & HP conditions lack of resources put HP on monitor to see if he can be pronounced | Attention management. Planning; demand management. Investigating constraints/obligations prior to planning (demand management)
| EMT is bagging, managing wound | Resource management; intervention (HP-Breathing, HP-Other)
| asks for assessment of HP | Attention management. Coordination (gets info)
| reassess CP verifying that he CP is stable enough that Paramedic can go to HP | Attention management. Manage uncertainty. Decision/resource allocation.
| assess HP review asks for assessment of HP | Manage uncertainty. Coordination (gets info)
| reviewing status of care management | 
| assess CP | Manage uncertainty
| backup arrives hands off HP to backup (easier handoff than CP – less to explain) | Coordination – unloads responsibility to new actors. Decision – allocation of cases to actors (more interventions – simpler handoff)
| plans for both to Level 1 | Planning (high level goal)
| assess CP IV ready for transport reviewing care of CP | Uncertainty management Intervention (CP-Circulation)
**Table G.4: Paramedic F (Multi-Patient Case)**

<table>
<thead>
<tr>
<th>Action</th>
<th>Resource Allocation/Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>sends EMT to CP</td>
<td>Attention management</td>
</tr>
<tr>
<td>goes to HP</td>
<td></td>
</tr>
<tr>
<td>assesses</td>
<td></td>
</tr>
<tr>
<td>looks over at CP</td>
<td>Attention management</td>
</tr>
<tr>
<td>asks for assessment from EMT</td>
<td>Coordination (get info)</td>
</tr>
<tr>
<td>managing HP’s airway (OP, bagging)</td>
<td>Intervention (HP-Airway, -Breathing). Intervention is also an assessment (does he gag w/ OP tube).</td>
</tr>
<tr>
<td>assessing BP</td>
<td>Evaluating HP-Circulation</td>
</tr>
<tr>
<td>confirming EMT is holding wound of CP</td>
<td>Attention management</td>
</tr>
<tr>
<td>considering options – backup or transport both</td>
<td>Decision, planning. Evaluating coordination COA.</td>
</tr>
<tr>
<td>does not want to wait – decides to transport both</td>
<td></td>
</tr>
<tr>
<td>assess airway of HP</td>
<td>Intervention (HP-Airway)</td>
</tr>
<tr>
<td>intubates</td>
<td></td>
</tr>
<tr>
<td>EMT pushes CP stage 2</td>
<td>Coordination (listen to update)</td>
</tr>
<tr>
<td>instruct O2</td>
<td>Coordination (direct CP-Breathing, -Circulation)</td>
</tr>
<tr>
<td>asks for assess (RR, LOC, BP)</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td></td>
</tr>
<tr>
<td>do CP-spine &amp; boarding for HP</td>
<td>Attention management</td>
</tr>
<tr>
<td>load in truck</td>
<td>Intervention (HP-Other)</td>
</tr>
<tr>
<td>review HP state</td>
<td></td>
</tr>
<tr>
<td>review CP (planning)</td>
<td>Attention management</td>
</tr>
<tr>
<td>board and load in truck</td>
<td>Planning (high level goal)</td>
</tr>
<tr>
<td>assess (exit wound)</td>
<td></td>
</tr>
<tr>
<td>occlusive on CP</td>
<td>Resource management.</td>
</tr>
<tr>
<td>(to free up EMT hand, but two-person tasks were already being done)</td>
<td>Intervention (CP-Other)</td>
</tr>
<tr>
<td>assessing lung</td>
<td></td>
</tr>
<tr>
<td>board &amp; load in truck</td>
<td></td>
</tr>
<tr>
<td>(plan) to head to hospital</td>
<td>Planning (high-level goal)</td>
</tr>
<tr>
<td>both on monitors</td>
<td></td>
</tr>
<tr>
<td>see JVD</td>
<td>Does intervention for CP-Breathing.</td>
</tr>
<tr>
<td>fluid to raise BP</td>
<td></td>
</tr>
<tr>
<td>burp wound</td>
<td></td>
</tr>
<tr>
<td>EMT monitors CP (not driving?)</td>
<td></td>
</tr>
<tr>
<td>Paramedic goes to HP</td>
<td>Attention management.</td>
</tr>
<tr>
<td>report to ED</td>
<td>Coordination re ED</td>
</tr>
<tr>
<td>assess HP</td>
<td>Intervention (HP-Circulation)</td>
</tr>
<tr>
<td>IVs</td>
<td></td>
</tr>
<tr>
<td>unload CP first</td>
<td>Decision – prioritization.</td>
</tr>
</tbody>
</table>
Table G.5: Paramedic G (Multi-Patient Case)

<table>
<thead>
<tr>
<th>Event Description</th>
<th>Management/Coordination</th>
</tr>
</thead>
<tbody>
<tr>
<td>goes to HP, send EMT to see if CP serious (req resources) or not</td>
<td>Manage uncertainty.</td>
</tr>
<tr>
<td>calls for backup</td>
<td>Coordination (direction). Planning; demand management.</td>
</tr>
<tr>
<td>pulls assessment of CP - instructs EMT to treat (was expecting greater initiative from EMT)</td>
<td>Investigating constraints/obligations prior to planning (demand management)</td>
</tr>
<tr>
<td>assesses HP, plans to establish airway, notices decerebrate – thus chest more salvageable</td>
<td></td>
</tr>
<tr>
<td>asking about backup for EMT</td>
<td>Attention management Coordination (get info)</td>
</tr>
<tr>
<td>push from EMT – CP state 2, instruction O2 &amp; occlusive confirming that EMT cannot start IV (protocol, resource)</td>
<td>Coordination (direction)</td>
</tr>
<tr>
<td>asking about backup</td>
<td>Planning intervention (HP-Airway)</td>
</tr>
<tr>
<td>O2 for HP, needs resource for BVM, recruits more help, Rapid Trauma Assessment for HP.</td>
<td>Pattern recognition, prioritization</td>
</tr>
<tr>
<td>asking about backup</td>
<td>Planning/coordination/resource management (backup)</td>
</tr>
<tr>
<td>pull assessment of CP, switches places w/ EMT, starting IV on CP, EMT is packaging and loading HP, asking about backup</td>
<td>Innovation (HP-Breathing)</td>
</tr>
<tr>
<td>EMT is packaging and loading HP</td>
<td>Planning</td>
</tr>
<tr>
<td>notices JVD, assess lung, wants to recruit another person, needle decompression, verification – lung movement starts IV, recruits another person for bag valve</td>
<td>Resource management (recruits resource)</td>
</tr>
<tr>
<td>Backup arrives</td>
<td>Coordination – unloads responsibility to new actors. Decision – allocation of cases to actors (CP continuity, more serious)</td>
</tr>
<tr>
<td>gives HP to backup, EMT &amp; Paramedic packaging CP, Rapid Trauma Assessment</td>
<td>Manage uncertainty.</td>
</tr>
<tr>
<td>planning – both go to Level 1</td>
<td>Planning (high level goal)</td>
</tr>
</tbody>
</table>

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### Table G.6: Paramedic H (Multi-Patient Case)

<table>
<thead>
<tr>
<th>Event</th>
<th>Thought Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>calls for backup just after seeing 2 pts.</td>
<td>Anticipation – need for more resources; coordination – sending request for more resources</td>
</tr>
<tr>
<td>goes to headshot – checking to see if dead (so can not allocate resources).</td>
<td>Investigating constraints/obligations prior to planning (demand management)</td>
</tr>
<tr>
<td>While checking, sends EMT to chest</td>
<td>Spreads resources</td>
</tr>
<tr>
<td>Uses monitor to check of HP is dead after assessment, decides HP is load &amp; go</td>
<td>Planning; demand management. Investigating constraints/obligations prior to planning (demand management).</td>
</tr>
<tr>
<td>Chooses to ventilate w/ BVM</td>
<td>Selects general response type for case (re: high level goal); Does low cost intervention for HP-Breathing.</td>
</tr>
<tr>
<td>Push from EMT – initial state of CP. Responds w/ instruction to use occlusive (3 side); more assessment.</td>
<td>Coordination (listen to update). Coordination (direct). Manage CP-Breathing (protocol, anticipation/risk management). Free resource (EMT)</td>
</tr>
<tr>
<td>asks about backup (resources) recruited a cop to do bag-valve</td>
<td></td>
</tr>
<tr>
<td>asks about chest – gets 2nd state plans to load chest and head in ambulance then asks about backup (resources)</td>
<td>Attention management. Coordination (get info). Planning (high-level goal of transport) Planning/coordination/resource management (backup)</td>
</tr>
<tr>
<td>Backup on scene gives CP to backup</td>
<td>Coordination – unloads responsibility to new actors. Decision – allocation of cases to actors (continuity, more interventions – simpler handoff)</td>
</tr>
<tr>
<td>reassess HP categorize/plan as load-and-go calling ED re: CP</td>
<td>Attention management. Planning (high-level goal of transport) Coordination (w/ remote, future party)</td>
</tr>
<tr>
<td>assess chest IV (safing) sees JVD</td>
<td></td>
</tr>
<tr>
<td>planning – decompression but limited by protocol assessing relative to protocol criteria IV – adding fluid decides to do decompression – lets hospital know decompression reassess</td>
<td></td>
</tr>
</tbody>
</table>
Table G.7: Paramedic I (Multi-Patient Case)

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>confirming just 2 pts goes to HP</td>
<td>Uncertainty management.</td>
</tr>
<tr>
<td>sends EMT to CP</td>
<td>Decision/Prioritization</td>
</tr>
<tr>
<td>assessing HP bagging, O2</td>
<td>Coordination (direct). Resource allocation.</td>
</tr>
<tr>
<td>calls for backup</td>
<td>Intervention (HP-Breathing)</td>
</tr>
<tr>
<td>asks for assessment of CP</td>
<td>Anticipation – need for more resources; coordination – sending request for more resources</td>
</tr>
<tr>
<td>planning interventions (O2)</td>
<td>Coordination (get info)</td>
</tr>
<tr>
<td>telling EMT to put occlusive</td>
<td>Coordination (direct; intervention CP-Breathing);</td>
</tr>
<tr>
<td>planning transport to level 1 (both)</td>
<td>Planning (high level goal)</td>
</tr>
<tr>
<td>planning on maintaining pts until backup arrives</td>
<td>Planning</td>
</tr>
<tr>
<td>EMT pushes CP-stage 2 responds with intervention – non-rebreather mask</td>
<td>Coordination (listen to update)</td>
</tr>
<tr>
<td>planning – waiting for backup</td>
<td>Coordination (direct; low-cost intervention CP-Breathing)</td>
</tr>
<tr>
<td>Backup arrives decides CP is more serious</td>
<td>Decision/prioritization.</td>
</tr>
<tr>
<td>HP is given to backup</td>
<td>Coordination – unloads responsibility to new actors. Decision – allocation of cases to actors</td>
</tr>
<tr>
<td>plans CP as load-and-go assesses CP (exit wound, resistances to ventilation)</td>
<td>Planning</td>
</tr>
<tr>
<td>planning load and go IV assess</td>
<td>Intervention (CP-Circulation)</td>
</tr>
<tr>
<td>would intubate with more personnel, can’t by himself</td>
<td></td>
</tr>
</tbody>
</table>
### Table G.8: Paramedic J (Multi-Patient Case)

<table>
<thead>
<tr>
<th>Action</th>
<th>System Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>sees HP shot in head needs more info about CP goes to CP</td>
<td>Uncertainty management</td>
</tr>
<tr>
<td>oclusive dressing</td>
<td>Intervention (CP-Breathing), Resource management.</td>
</tr>
<tr>
<td>send EMT to HP to see if HP is dead</td>
<td>Attention management. Coordination (direction); resource management. Uncertainty management. Planning; demand management. Investigating constraints/obligations prior to planning (demand management)</td>
</tr>
<tr>
<td>intervention (O2, IV) and assess (monitor, lung) CP anticipating tension pneumo</td>
<td>Intervention (CP-Breathing, Circulation). Anticipation (CP-Breathing risk)</td>
</tr>
<tr>
<td>pulls assessment of HP requests backup</td>
<td>Attention management. Coordination (get info). Anticipation – need for more resources; coordination – sending request for more resources</td>
</tr>
<tr>
<td>wants to put monitor on HP, but it is still on CP. Legal implications of removal from CP Decides HP is priority, moves monitor gets vitals on HP</td>
<td>Decision re: resource allocation &amp; prioritization, protocol.</td>
</tr>
<tr>
<td>plan for EMT to bag valve HP</td>
<td>Planning intervention (HP-Breathing). Resource allocation.</td>
</tr>
<tr>
<td>starts IV on HP EMT bags HP</td>
<td>Attention management. Intervention (HP-Circulation) Coordination (direction) – invention (HP-Breathing)</td>
</tr>
<tr>
<td>checking on backup</td>
<td>Planning/coordination/resource management (backup)</td>
</tr>
<tr>
<td>assessing HP gives fluid notices posturing</td>
<td>Intervention (HP-Circulation)</td>
</tr>
<tr>
<td>Backup arrives gives HP to backup less done to HP, more continuity of care for CP</td>
<td>Coordination – unloads responsibility to new actors. Decision – allocation of cases to actors (continuity, more interventions – simpler handoff)</td>
</tr>
<tr>
<td>planning care &amp; transport of CP chooses level 1</td>
<td>Planning (high level goal)</td>
</tr>
</tbody>
</table>