# USING THE HEALTH BELIEF MODEL TO PREDICT USE OF HEMOGLOBINOPATHIES PREVENTATIVE BEHAVIORS, AMONG PREMARITAL SAUDIS AT RISK FOR DELIVERING A CHILD WITH HEMOGLOBINOPATHIES

by

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**Abstract**

**by**

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Hemoglobinopathies, specifically sickle cell disease (SCD) and beta thalassemia, are autosomal recessive genetic conditions that are common in Saudi Arabia; they are lifelong and preventable anemia diseases. Hemoglobinopathy preventative measure such as prenatal diagnosis (PND) and preimplantation genetic diagnosis (PGD) help high-risk couples produce children free of hemoglobinopathies or better prepare them to manage their affected children. However, evaluation using health belief model (HBM) of health beliefs regarding hemoglobinopathies and their preventive measures, can provide insights into the likelihood of premarital Saudis using preventive measures to reduce the risk of having hemoglobinopathy-affected children. The role of HBM in genetic decision-making can enhance educational intervention by incorporating health beliefs in genetic counseling. **The primary purpose** of this descriptive study is to examine how the components of the HBM (i.e., perceived susceptibility, perceived seriousness, perceived barriers, perceived benefits, cues to action, self-efficacy and fatalism) are associated with future intentions to utilize PND or PGD, among premarital Saudis at risk for having a future child with hemoglobinopathies. **Methods:** A convenience sampling of 101 premarital Saudis with hemoglobinopathies, either with a carrier status or affected status, were enrolled from five premarital screening clinics in Saudi Arabia. **Results:** The result

of the study revealed a moderately low perception of susceptibility and seriousness toward hemoglobinopathy. It also identified self-efficacy as a health belief that is highly associated with the intention to adopt PND or PGD as a hemoglobinopathy preventive measure. Further, consanguinity did not act as a moderator variable between health beliefs and intention to adopt hemoglobinopathy preventive measures despite the previous literature's confirmation of the high rate of consanguineous marriages in Saudi Arabia. **Conclusions:** The result of the study highlight the importance of enhancing self-efficacy in a population of premarital Saudis at risk for having a child with hemoglobinopathy. Self-efficacy can increase the uptake of PND or PGD to prevent hemoglobinopathies or alleviate its burden on health. The results of the study also confirmed the need to explore health beliefs prior to tailoring educational interventions because health beliefs are related to personal beliefs, which can differ based on many cultural, or religious factors.

**Using the Health Belief Model to Predict Use of Hemoglobinopathies Preventative Behaviors, Among Premarital Saudis at Risk for Delivering a Child with Hemoglobinopathies**

## Chapter I

In Saudi Arabia, hemoglobinopathies are common, particularly sickle cell disease (SCD) and thalassemia, which are debilitating and have devastating effects on patients and their families (Amr, Amin, & Al-Omair, 2011; Ayoub et al., 2013). These hemoglobinopathies are hereditary, and the likelihood for allelic expression increases when two related individuals carrying the gene reproduce. Therefore, in 2004, the government of Saudi Arabia enforced mandatory premarital screening to promote the health of the public, increase knowledge, and reduce high-risk marriages. Even though the law aimed to enhance decision-making for couples, it did not interfere with the final decision to pursue marriage (Alswaidi & O'Brien, 2010). After implementation of the law, researchers assessed the premarital screening law, and the results indicated that 90% of high-risk couples knew about their high-risk status and yet continued with their marriage plans anyway (Alhamdan, Almazrou, Alswaidi, & Choudhry, 2007; Al Sulaiman et al., 2010; Alswaidi et al., 2012).

In Saudi Arabia, 2% to 27% of people are carriers of the sickle-cell trait, and 1.4% of the population have SCD (Jastaniah, 2011). However, 3.2% of the population are carriers of the thalassemia trait, and 0.07% have thalassemia disease (Alhamdan et al., 2007). Analysis of the premarital screening law indicated the new mandatory screening was successful in identifying high-risk couples but did not decrease high-risk marriages. There are multiple factors that limit the success of premarital screening in reducing high-

risk marriages (Alswaidi et al., 2012). The biggest obstacle is that high-risk couples who intend to get married will still get married despite the risk (Al Sulaiman et al., 2010). Additionally, the culture in Saudi Arabia places great value on family and a sense of belonging to one's designated tribe, leading to a high rate of consanguineous marriages (up to 50% of all marriages in Saudi Arabia). Consequently, hemoglobinopathies persist across generations (Rashed, Osman, & Roudi-Fahimi, 2005).

The use of preimplantation genetic diagnosis (PGD) and prenatal diagnosis (PND) can help high-risk couples to have healthy children, or minimize their diseases burden (Arnett, Greenspoon, & Roman, 2013). PGD is a procedure in which in vitro fertilization (IVF) is performed to avoid genetic diseases—instead of for infertility. IVF is used to diagnose genetic defects in the oocyte, and only the unaffected embryos will be implanted in the uterus (Cunningham et al., 2018). PND refers to multiple procedures, including amniocentesis, chorionic villus sampling, and, in rare cases, fetal blood sampling to identify genetic abnormalities prior to birth (Cunningham et al., 2018). The termination of a hemoglobinopathy-affected fetus is unavailable in Saudi Arabia, but its application is done under specific circumstances, PND is a crucial medical service that needs to be implemented to help future parents create an appropriate plan of care for their child and utilize PND in the family planning process (Alkuraya & Kilani, 2001).

With the appropriate utilization of genetic counseling and family planning, high-risk couples can produce healthy children via PGD and receive reassurance or create a plan of care via PND (Traeger-Synodinos, Vrettou, & Kanavakis, 2011). These technologies enhance the decision-making for couples trying to create a healthy family, and alleviate debilitating diseases in the community, therefore the widespread use of

these medical technologies, can lead to the eradication of hemoglobinopathies in Saudi Arabia (Traeger-Synodinos et al., 2011). Before the application of these interventions, we need to understand the health beliefs of these high-risk population and their intentions behind utilizing PND and PGD, in an attempt to examine willingness, intentions and personal beliefs towards adopting these medical technologies. As a result, obtain an insight about barriers and facilitators a person face in the family planning process.

The Health Belief Model (HBM) proposes that once individuals perceive themselves at risk for having a serious condition that could yield devastating health consequences, they will adopt an action to eliminate or minimize their chances of getting the disease or suffer its terrible consequences (Hochbaum, 1958; Rosenstock, 1960, 1988). Cognitive theorists advocate for the use of health beliefs and expectations as a means to explore the perspective of patients and modify their behavior accordingly instead of attempting to change the behavior of patients directly, which has proven to be an unsuccessful method (Skinner, Tiro, & Champion, 2015). A study on applying the HBM on the population of people with the hemoglobinopathy trait or the disease, to explore their intention to utilize PND or PGD, has not been conducted. But, based on existing literature in other populations, we hypothesize that the health beliefs of high risk population regarding their future children and their perceptions of hemoglobinopathies will influence future utilization of PND and PGD as a crucial part of the family planning process.

## Background

### Hemoglobinopathies in Saudi Arabia

Hemoglobinopathies, specifically SCD and β-thalassemia, are autosomal recessive genetic conditions common in Saudi Arabia; they are also lifelong and preventable anemia diseases (Al-Saleh & Hussain, 1992). The Ministry of Health (MOH) declared the following status for couples at high risk for SCD and β-thalassemia disease based on the pattern of autosomal recessive inheritance: if both are carriers, future children have a 50% chance of getting the disease; if one is a carrier and the other is clinically affected with the disease, future children have a 50% chance of getting the disease; and if both are clinically affected, future children have a 100% chance of getting the disease (Schaefer & Thompson, 2014). The reported cost of treatment for a patient diagnosed with SCD or thalassemia is 100,000 riyals (approximately 30,000 USD) per year.

In SCD, a mutation in the β-globin gene occurs, leading to abnormal structures in the β-globin chain of the hemoglobin. The mutation causes a placement of valine at the sixth position instead of the normal glutamic acid. As a result, the abnormal β-globin chain couples with a healthy chain to create a sickle hemoglobin (Alsultan & Steinberg, 2014). SCD causes vascular occlusion and hemolysis, which yields many complications, such as episodes of periodic pain, osteonecrosis, pulmonary diseases, and stroke (Alsultan & Steinberg, 2014).

In Thalassemia, abnormal synthesis and production of the α- or β-globin causes a decrease or absence of globin, and, based on the location of the abnormal gene, patients are classified as either alpha or beta thalassemia (Benz, 2018). In the Middle East, including Saudi Arabia, β-thalassemia is the most common type of thalassemia and is present in different frequencies (3.2–7.2%) across the country (Alenazi et al., 2015; El

Hazmi, 1992). In β-thalassemia, hemoglobin A is absent or severely diminished, and hemoglobin A2 can be present at different frequencies, whereas hemoglobin F is more prevalent. A blood film of a β-thalassemia patient will present with poikilocytosis, hypochromia, target cells, and nucleated red blood cells (RBCs) (Damon & Andreadis, 2018). Complications from β-thalassemia include poor growth, bone deformities, hepatosplenomegaly, and thrombophilia; these patients are dependent on blood transfusions for survival and are at risk of an iron overload (Damon & Andreadis, 2018).

Patients diagnosed with SCD and thalassemia have a worse quality of life than the general population. The disease influences multiple aspects of patients' lives, including a continuous need for blood transfusions, physical deformities, cardiovascular (e.g., congestive heart failure), and bone (e.g., osteonecrosis) complications (McClish et al., 2005; Telfer et al., 2005).

**Premarital Screening**

The premarital screening law was established as a means to prevent thalassemia and SCD (Alhamdan et al., 2007). In 2003, the Saudi Arabian government introduced a mandatory premarital screening policy. Couples wishing to apply for a marriage certificate cannot advance their application without a premarital screening document for infectious diseases and hemoglobinopathies, but the decision to marry remains voluntary (Alhamdan et al., 2007). When the country's Ministry of Health (MOH) introduced the program to the public, it ensured feasible accessibility to the premarital testing by creating screening centers in 127 facilities across Saudi Arabia, free of charge, to screen almost 300,000 marriage applicants yearly. Fifteen of these centers are located in the

Western region, and nine centers in the Eastern region of the country (Ministry of Health, 2018).

However, the objective of the premarital policy, to reduce high-risk marriages, was not met. Even though the premarital screening is mandatory, the decision to marry remains up to the couple. An assessment of premarital screening showed that approximately 90% of high-risk couples were aware of their risk but obtained marriage certificates anyway (Alhamdan et al., 2007; Al Sulaiman et al., 2010; Alswaidi et al., 2012).

In Saudi Arabia, SCD and β-thalassemia are prevalent. Of the adult Saudi population of marriageable age (≥18 years), 4.2% are estimated to have the sickle-cell trait, and 0.26% have an SCD diagnosis (Alhamdan et al., 2007). A recent report from the Saudi MOH revealed that, for the past 10 years, the number of SCD patients increased by 9,417, causing the number of SCD patients around the country to increase to a total of 14,750 MOH-registered patients (Albakheet, 2015). According to Jastaniah (2011), the true prevalence of SCD and its traits remain unclear and underestimated because these statistics were obtained from the MOH premarital screening program database, which only included adults who apply for marriage certificates. Consequently, these statistics did not include children, those who passed away and adults who did not marry (Jastaniah, 2011).

Upon examining the prevalence of hemoglobinopathies, statistics have shown that β-thalassemia is less prevalent in Saudi Arabia than SCD. Memish, Owaidah, and Saeedi (2011) attempted to estimate the prevalence of thalassemia in Saudi Arabia based on premarital screening data over 6 years, and the results showed that 18.5 cases were

detected per 1,000 marriage applicants. Recently, during an awareness campaign of thalassemia disease, the MOH released statistics on thalassemia patients and carriers in Saudi Arabia over a 10-year period obtained from the premarital screening database (Ministry of Health, 2015). The statistics showed that 1,033 people were clinically affected with thalassemia diseases (0.03%), and 45,892 adults were carriers. These statistics were obtained from the premarital screening program database, which may underestimate the true prevalence of β-thalassemia in Saudi Arabia (Healthy days: International Thalassemia Day, 2015).

An assessment of the premarital screening program shows that 90% of high-risk couples know they are high risk and continue with their marriage plans anyway (Alhamdan et al., 2007; Al Sulaiman et al., 2010; Alswaidi et al., 2012). There are many hypotheses behind the high rate of risky marriages, and Alhamdan et al. (2007) highlighted the cultural aspect of this phenomenon by shedding light on the social structure of the Saudi community. The Saudi population values its titled tribes and wants to ensure the survival of the family name. As a result, consanguineous marriages are a popular practice in communities, with about 50% of marriages being between first and second cousins (Rashed et al., 2005). Consequently, the autosomal recessive gene continues to survive across generations. Al Sulaiman et al. (2010) explored the reasons for the marriage of high-risk couples, and 48% stated that family agreement and pressure were the leading cause behind the pursuit of marriage. Additionally, 34% were based on emotional love, 17% were based on other reasons, and 5% were not convinced of the veracity of the premarital screening results. Combined, this evidence suggests that the main objective of the premarital screening laws, reducing high-risk marriages, was not

successful (Alhamdan et al., 2007). This indicates that medical options and counseling are needed to promote family planning and enhance the lives of future children. Therefore, it is crucial to educate high-risk couples about the alternatives forms of prevention of genetic hemoglobinopathies, which include PND and PGD medical technologies.

**Family planning:**

Family planning services aim to enhance family's health through careful planning of pregnancies, and prevention of unintended pregnancies, and is one of the ten public health achievements in 20$^{th}$ century (CDC, 1990). For populations at risk for hemoglobinopathies, family planning is an important service to decrease the rate of SCD and β-thalassemia, because it facilitates availability of information regarding the implication of these genetic condition on the child and the family, along with the available medical services that assists in having an unaffected child (Standardization, 1979: Smith, Ashford, Gribble, & Clifton, 2009).

**PND and PGD**

For the past 20 years, the PND and PGD medical technologies have been utilized in health care to ensure the delivery of healthy children. In hemoglobinopathies, PND is performed after normal forms of conception, utilizing diagnostic procedures such as amniocentesis and chorionic villus sampling (CVS) to identify any genetic abnormalities prior to birth (Cunningham et al., 2018). During the first trimester, with the use of PND, fetal DNA testing for SCD and thalassemia can be identified during a specific time frame. For amniocentesis, the procedure is done after 15 weeks of gestation by withdrawing fetal amniotic fluid transabdominally, and, for CVS, the withdrawal of villi

with a syringe can be done intracervically or transabdominally, which occurs at 10–12 weeks after gestation (Yates, 2018). Once the sample is obtained, a chromosomal microarray analysis will be performed to detect any chromosomal abnormalities (Cunningham et al., 2018). PND will provide the couple with two possible options: First, if the fetus is affected with hemoglobinopathies, the parents can choose to terminate the pregnancy or continue with the pregnancy and create an appropriate plan of care by incorporating family support and preparing for the child's treatment after delivery. Second, if the fetus is healthy, then the parents will be reassured of the healthy pregnancy (Benn & Chapman, 2010).

A preimplantation genetic diagnosis (PGD) identifies and selects healthy offspring to be transferred by in-vitro fertilization for implantation. PGD has been applied to the clinical setting, and it has been recommended as an option for couples at risk for having a child with hemoglobinopathies or other genetic disorders, as well as treatment for infertility and unsuccessful pregnancies (Kanavakis & Traeger-Synodinos, 2002). PGD procedures occur through in-vitro fertilization clinics, after fertilization of embryos on day three, any genetic defects are developed. The diagnosis of hemoglobinopathies is established through the genetic analysis of DNA extracted from polar bodies or blastomeres of the fertilized embryo. Then the unaffected embryos are transferred to the uterus for implantation (Patrinos, Kollia, & Papadakis, 2005).

PND and PGD are effective at ensuring the delivery of healthy children among couples at risk for delivering a child with hemoglobinopathies (Traeger-Synodinos et al., 2011). In Saudi Arabia, PND and PGD is not fully understood, nor utilized by the public, and limited studies have examined the Saudi attitude toward PND or PGD. Alsulaiman

and Hewison (2006) examined Saudi parents ($n$ = 30) of children with a single gene or chromosomal condition, and only 27% accepted PGD, 13% preferred PND, and 10% accepted either procedure. Parents of children with thalassemia showed the highest preference for PGD, at 86%. Therefore, the acceptability of reproductive choices in the family planning process is based on the preferences of the couples and the available options (Alsulaiman & Hewison, 2006).

In Saudi Arabia, PND is not currently available for hemoglobinopathies in high-risk pregnant women because health care providers and medical organizations take the Islamic religion into consideration, which does not generally support abortion (Alkuraya & Kilani, 2001). However, the Islamic religion permits abortion under specific circumstances, such as if it occurs before 120 days postconception (Albar, 1991). This specific time frame makes CVS (performed after 10 weeks of gestation) more preferable and congruent with Islamic abortion law when compared to amniocentesis (performed after 15 weeks of gestation), permitting more time for decision-making and safer options for pregnancy termination (Cunningham et al., 2018). Other conditions that allow abortion in Islam include if the fetus was confirmed to be incompatible with life or if the pregnancy poses a threat to the mother's life (Albar, 1991). Therefore, the availability of PND among high-risk Saudi couples is recommended, if requested by the parents, even if abortion is not an option, as a means to prepare for the future treatment plan of the child (Alkuraya & Kilani, 2001).

Because Saudi Arabia is primarily a Muslim country, the majority of Muslim scholars support the use of PGD to eliminate genetic diseases but do not approve of its application for sex selection and nonmedical traits (Fadel, 2007). Muslims follow the

teachings of the Prophet Muhammad, when he said that god created both diseases and treatments, and for each disease there is a treatment, so seek treatment as long as it is not forbidden by god (Sunan Abī Dāwūd, n.d.).

This study positions both PND and PGD as hemoglobinopathy preventative measures. Even though each procedure has distinct moral and ethical implications in the medical community, the rationale behind clustering these technologies together in the study is that both can, to some degree, alleviate the suffering caused by hemoglobinopathies, and both can be offered before and after conception. PGD is usually offered prior to conception, as part of an appropriate family planning process, but PND can be offered if pregnancy happens unexpectedly. Therefore, even though each technology has different positive and negative attributes, both can be offered to affected patients. Another rational behind labeling PND and PGD as hemoglobinopathy preventative measures is because there is lack of Saudi literature examining knowledge about these medical technologies. As a result, this study will assist in identifying knowledge and health perception of Saudi towards PND and PGD.

**Health Belief Model and Health Behavior**

The elevated marriage rate among high-risk couples is because of the complexity of decision-making in the pursuit of marriage and the intersection of multiple religious and social factors (Al Sulaiman et al., 2010). Therefore, an exploration of the health beliefs of hemoglobinopathy high risk individuals needs to be addressed. Cognitive theorists emphasize the use of health beliefs and expectations as a means to explore the perspectives of patients. This information is then used to modify their behaviors accordingly, instead of attempting to change the behavior of patients directly, which can

be unsuccessful (Skinner et al., 2015). The health belief model (HBM) will be used in the study to capture the perceptions of high-risk population toward having a child with hemoglobinopathies and their intention to utilize preventative measures for hemoglobinopathies in the future. The model hypothesized that the likelihood of an individual adopting a health behavior is based on six dimensions: perceived susceptibility, perceived seriousness, perceived benefits, perceived barriers, self-efficacy, and cues to action (Hochbaum, 1958; Rosenstock, 1960, 1974a; Strecher & Rosenstock, 1996).

The HBM has been used extensively in nursing research to capture the perceptions of patients and relate them to patient behaviors in disease prevention and health promotion studies (Roden, 2004). Prior research utilizing the HBM in the field of genetic decision-making yielded a positive and negative correlation between the constructs of the HBM and healthy genetic decision-making, which highlights the crucial role of targeting patients' health beliefs as a means to advance their health behaviors. Gustafson, Gettig, Watt-Morse, and Krishnamurti (2007) examined the relationship among the health beliefs of African American women toward SCD to try to understand their low acceptance of genetic testing. They reported that participants had a high perception of disease severity but decreased levels of perceived susceptibility, which predicted the lack of genetic testing and screening among African American women (Gustafson et al., 2007). Rowley, Loader, Sutera, Walden, and Kozyra (1991) utilized the constructs of the HBM to predict prenatal testing in hemoglobinopathies, intention to refer a partner for testing, and prediction of partner testing. They found that the perception of barriers to prenatal testing were the strongest predictor of intent to refer a

partner for testing, whereas the perception of susceptibility to SCD was the weakest predictor of intent to refer a partner for testing. However, the perceived barriers to testing and perceived seriousness of the disease significantly predicted partner testing (Rowley et al., 1991). O'Connor and Cappelli (1999) utilized the HBM to understand one's intention to undergo cystic fibrosis carrier testing. They found that the low perceived barriers of testing (e.g., test availability), the high perceived benefits of testing (e.g., knowledge about self-carrier status), and the perceived severity of having a future child diagnosed with cystic fibrosis predicted intent to seek cystic fibrosis carrier testing. The perceived seriousness of cystic fibrosis was negatively associated with carrier testing (O'Connor & Cappelli, 1999).

Karimzaei et al. (2015) examined the health beliefs of couples who were carriers of the thalassemia major gene and its relationship to thalassemia preventative behaviors (e.g., genetic counseling and premarital screening). They concluded that the perception of barriers to engage in these behaviors was the strongest predictor of adopting thalassemia preventative behavior, and perceived susceptibility was negatively correlated with healthy behaviors. The authors correlated this fact to the participants' low score in knowledge (20% of the sample had adequate knowledge of thalassemia), highlighting the need to enhance awareness about the disease (Karimzaei et al., 2015). The results of the above studies were in congruence with Janz and Becker (1984), who conducted a review of HBM studies in the adult population. The result of the review identified the perceived barriers as having the highest significant ratios when compared to other health beliefs in the model. However, perceived susceptibility ranked the lowest in the significance ratio, and the authors explained the common occurrence of this phenomenon in relation to the

sick role behavior because of the inability to operationalize the concept of susceptibility when the diagnosis was already established (Janz & Becker, 1984). Additionally, the review recommended the use of the HBM in health promotion interventions because the dimensions of the HBM explained and predicted the practice of health behaviors under study. As seen in previous research, health beliefs vary based on the disease process and population. Nonetheless, the HBM is capable of exploring patient cognition and the intention to seek a health behavior; thus, highlighting the need to explore health beliefs in Saudis at risk for having a child with hemoglobinopathies and their intention to seek PGD and PND in the family planning process.

## Conceptual Framework

### Health Belief Model

To understand the health beliefs of high-risk population in the premarital stage, we will use the HBM as the guiding framework. The HBM hypothesizes that once individuals perceive themselves at risk for having a serious health condition that yields devastating consequences, they will adopt an action to eliminate or minimize their chances of getting the disease or from suffering its terrible consequences (see Figure 1; Hochbaum, 1958; Rosenstock, 1960, 1988). The HBM was developed in 1952 by Irwin Rosenstock and examines certain health beliefs and their relationships toward adopting healthy behaviors.

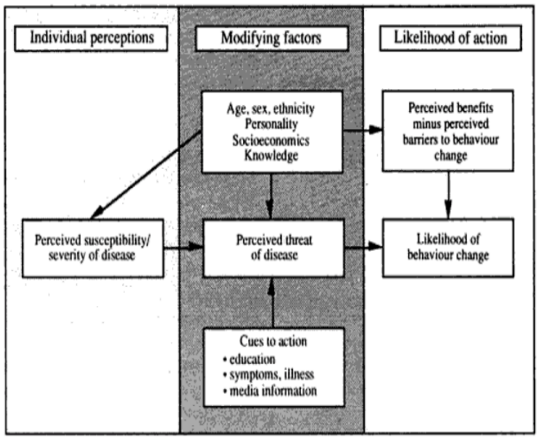



*Figure 1.* Health belief model.

The model hypothesizes that the likelihood of an individual adopting a health behavior is based on five dimensions: perceived susceptibility, perceived seriousness, perceived benefits, perceived barriers, and cues to action (Hochbaum, 1958; Rosenstock, 1960, 1974a; Strecher & Rosenstock, 1997). Later, self-efficacy was added as a sixth dimension to the model (Bandura, 1997). Self-efficacy addresses the individual ability and confidence to practice a health behavior to produce the desired outcome. The HBM is a useful tool in the study of individuals with high-risk to have hemoglobinopathy affected children, because the model assists in extracting personal, subjective expectations about the threat of the disease and its outcomes. Cognitive theorists recommend the use of health beliefs and expectations as a means to explore the perspective of patients and modify their behavior accordingly—attempting to change patient behavior directly, which has proved to be an unsuccessful method (Skinner et al., 2015). Champion and Skinner (2008) defined the HBM constructs more clearly as follows:

A. The perceived susceptibility is defined as the patient's perceptions regarding contracting diseases or conditions. For example, hemoglobinopathy high-risk person will score high in perceived susceptibility if he or she believe and understand the risk of having a child with hemoglobinopathies in each pregnancy attempt.
B. The perceived seriousness is defined as the patient's perceptions regarding the seriousness of the illness and its consequences if it is left unaddressed or treated. Perception about the seriousness of a condition can involve social or medical consequences. For example, hemoglobinopathy high-risk person will score high in perceived seriousness if he or she belief in the presence of the medical (e.g., pain, the need for a blood transfusion, hospitalization) and social (e.g., stigmatization, future

employment, health care costs) consequences of the future of children with hemoglobinopathies. If hemoglobinopathy high-risk person scored high in perceived seriousness and perceived susceptibility, he or she have an elevated level of threat perception.

C. Perceived benefits are defined as patients' perceptions regarding the benefits of a medical intervention aimed at reducing a health threat. For example, hemoglobinopathy high-risk individual will score high on perceived benefits if he or she believe that medical interventions such as PND and PGD will assist in having a healthy child.

D. Perceived barriers are defined as patients' perceptions regarding the barriers of a medical intervention. For example, hemoglobinopathy high-risk person will score high on perceived barriers if he or she express barriers to PND (worry about abortion) or PGD (cost and an unnatural form of conception).

E. Cues to action are defined as cues or signs that trigger the need to seek medical intervention. For example, cues to action in this population of hemoglobinopathy high-risk persons might be the result of the premarital screening or witnessing the devastating effects of hemoglobinopathies.

F. Self-efficacy is defined as "the conviction that one can successfully execute the behavior required to produce the outcomes" (Bandura, 1997). For example, self-efficacious hemoglobinopathy high-risk individual will display a confidence in seeking either PND or PGD in an attempt to have healthy children.

G. Fatalism is a concept that is not originally belong to the HBM, but due to the cultural background of the population understudy, who came from an Islamic background.

Fatalism is a religious belief that impact health beliefs. Fatalism is derived from the word “fate” which is the believe that our life events is already been set by fate.

**Research Based Modified Model**

The original HBM was modified to guide the proposed research study and answer the research questions. Modification were as follows: (see Figure 2).

- Exclusion of the modifying variable (e.g., demographic and cues to action), and adding a specific focus on consanguinity as a potential moderating variable on the relationship between health perceptions and intentions to utilize hemoglobinopathies preventative behavior.
- The original HBM model had a temporal order of health beliefs starting from perceived susceptibility to a condition and perceived severity of that condition, followed by cues to action as a modifying variable, and perceived benefits and perceived barriers as the last health belief prior to enhanced likelihood of behavioral change. However, given the cross-sectional nature of the proposed study, the modified model for the study does not propose examining the temporal order of health beliefs but rather explore all health perception simultaneously.
- The modified HBM proposed in this study will use the extended version of the original HBM, which added self-efficacy as a health belief. In Addition, the belief of fatalism as a health belief is also added to the model.
- Arrows in the modified HBM and research component is color coded. Since the first research question examine and describe health beliefs in the population, it does not test relationship, therefore, no arrow was designated to

the first research question. On the other hand, the blue arrow resembles the second research question, which examine the predictive ability of the HBM on intentions to utilize PND or PGD to deliver unaffected children. The green arrow resembles the third research questions, which will examine consanguinity as a moderator variable between health beliefs and intentions to utilize PND or PGD as a hemoglobinopathy preventative measure.

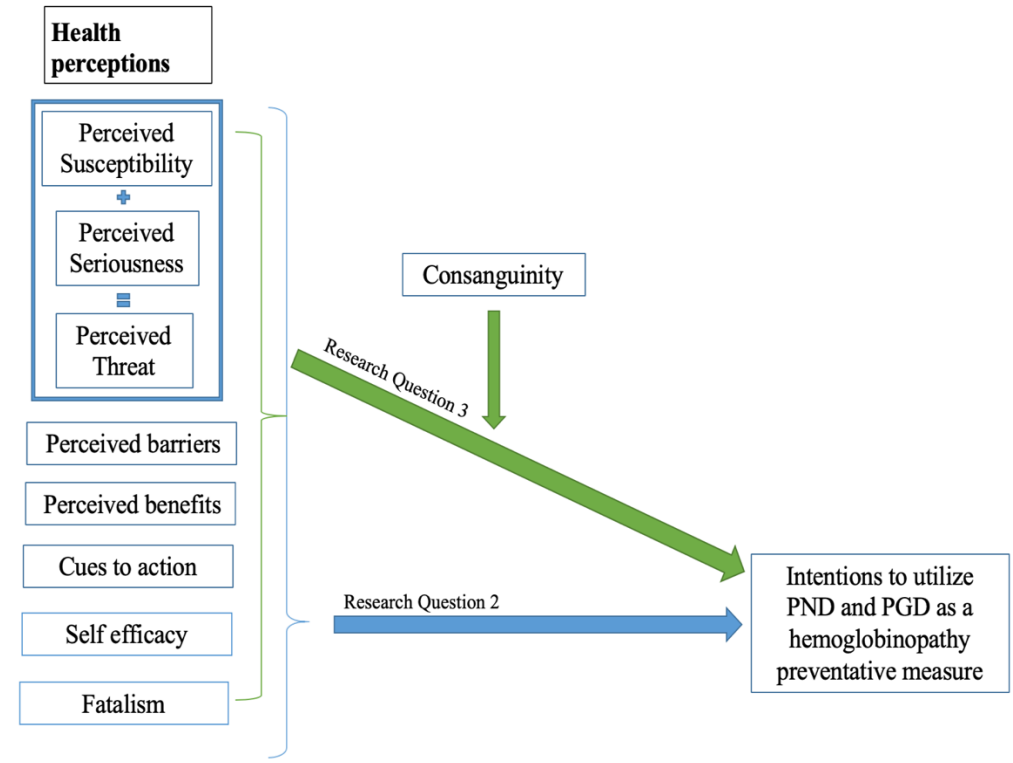



*Figure 2*. Modified health belief model and research component.

**Moderating Factors:**

In the original HBM there are multiple moderating factors that influence the relationship between health perceptions and the adoption of healthy behaviors, including cues to action that trigger an initiation of health behaviors, elevated perceptions of susceptibility and severity, increased sense of perceived threat, and personal

demographics. According to the model, when the perception of a threat is elevated, there is a corresponding increase in perceived susceptibility and severity (Champion & Skinner, 2008). Along with the moderating factors, such as cues to action or personal demographics, individuals will consider available interventions, and if the benefits of the intervention exceed its barriers, they will adopt a behavior that advances health (Strecher & Rosenstock, 1997). Additionally, if a person displays a high level of self-efficacy, it enhances likelihood of a behavioral change (Bandura, 1997).

In our study's modified model, we will analyze the consanguinity (first and second cousins) between partners as a moderator variable between health perception and intention to utilize PND or PGD. The rationale behind analyzing consanguinity as a moderator variable is because a high level of consanguinity in a tribal society such as Saudi Arabia (up to 50%; Rashed et al., 2005) can result in the preservation and transmission of hemoglobinopathies across generations and lead to a genetically homogenous community (Al-Odaib, Abu-Amero, Ozand, & Al-Hellani, 2003). Therefore, we will investigate the role of consanguinity and its impact on the relationship between health beliefs and intention to use PND or PGD as a hemoglobinopathy preventative measure.

**Intentions to utilize PND or PGD:**

Intention of health behavior is defined as "perceived likelihood of performing the behavior" (Montano, & Kasprzyk, 2015, p. 74). The concept of intentions and its role in predicting a health behavior is a cornerstone in the theory of reasoned action (TRA); intentions illustrate willingness and preparedness of an individual to implement a health behavior. According to the TRA, intentions have a direct impact on health behavior, and

are influenced by attitudes and subjective norms towards the behavior (Hausenblas, Carron, & Mack, 1997). The use of intentions to predict health behavior has a rich body of research confirming the crucial role intentions play in adopting a health behavior, and the TRA and theory of planned behavior (TPB) been applied across multiple health behaviors. Theories such as the TRA and TPB have been implemented in prediction of screening attendance across multiple diseases process such as cancer, (Cooke & French, 2008), condom use (Sheeran, & Taylor,1999), physical activity (Hausenblas, Carron, & Mack, 1997), unethical behaviors (Chang, 1998), HIV preventative behaviors (Fisher, Fisher & Rye, 1995), and breast self-exams (Lierman, Young, Kasprzyk, & Benoliel, 1990). Therefore, we chose intentions to utilize PND or PGD as our outcome, because it precedes the health behavior of actually performing PND or PGD. Since participants will be in their premarital stage and not yet able to perform PND or PGD, we will only be able to measure their intentions. Therefore, the aim of the study is to capture intentions to utilize hemoglobinopathies preventative behaviors (i.e., PND or PGD), and in future studies we can examine if and how such intentions and predict adoption of hemoglobinopathies preventative behaviors.

## Purpose

The purpose of this descriptive study is to examine how the components of the Health Belief Model (i.e., perceived susceptibility, perceived seriousness, perceived barriers, perceived benefits, cues to action, self-efficacy and fatalism) are associated with future intentions to utilize PND or PGD, among premarital Saudis at risk for having a future child with hemoglobinopathies.

## Theoretical Assumptions

Utilizing the HBM, we made several theoretical assumptions:

- Hemoglobinopathies are debilitating and preventable diseases in Saudi Arabia that can be avoided through the use of preventative measures such as PGD and PND in the family planning process.
- The health beliefs of high-risk individuals are an important tool that needs to be explored to capture their future intention to deliver healthy children by utilizing PND and PGD.
- participants who score high in threat perception, perceived benefits, and self-efficacy and score low in perceived barriers will be more likely to undertake preventative measures against hemoglobinopathies.
- The demographic variable of consanguinity will act as a moderator variable between health perception concepts portrayed by the HBM and the intention to utilize PGD and PND.
- Health care providers will be able to tailor individualized treatment plans based on the health beliefs and needs of their patients.

## Hypothesis

This study's hypothesis is as follows: Saudi Individuals at risk for having a child with hemoglobinopathies, will have elevated levels of perceived susceptibility, perceived seriousness, self-efficacy, and cues to action toward hemoglobinopathies in their future children. They will also perceive increased benefits and fewer barriers towards hemoglobinopathies preventative behaviors which will be associated with an increased likelihood in intentions to utilize PND or PGD to deliver unaffected children.

## Research Questions

Our research will be guided by the following questions:

(1) What are the health beliefs of hemoglobinopathy among premarital Saudis at risk for having a child affected with a hemoglobinopathy?

(2) Among the seven concepts of the HBM (i.e., perceived susceptibility, perceived seriousness, perceived benefits, perceived barriers, cues to action, self-efficacy, fatalism), which are associated with participants' likelihood of intention to use PND or PGD as a hemoglobinopathy preventive measure?

(3) What is the role of consanguinity as a moderator variable on the relationship between participants' health perceptions and intention to use PND or PGD as a hemoglobinopathy preventive measure?

## Significance

### Significance to Health

PND and PGD are advanced medical technologies that allow couples, who are at high risk for having a child with hemoglobinopathies, to deliver a healthy child (Kuliev, Pakhalchuk, Verlinsky, & Rechitsky, 2011; Theodoridou et al., 2008; Vrettou, Kakourou, Mamas, & Traeger-Synodinos, 2018). Researchers have established that the health beliefs of patients predict their willingness to adopt and maintain positive health behaviors (Calnan, 1984; Carpenter, 2010; DiMatteo, Haskard, & Williams, 2007; Jackson & Aiken, 2000; Turner, Kivlahan, Sloan, & Haselkorn, 2007). Nonetheless, no previous studies have examined the role of health beliefs on the intention of high-risk individuals to incorporate PND and PGD in family planning in Saudi Arabia. Our use of the HBM with high-risk participants will provide health care professionals with the tools necessary

to explore the health beliefs of high-risk Saudis and create individualized family planning based on their preferences. As a result, an effective understanding of health beliefs can create interventions and policies that have the potential to eliminate hemoglobinopathies in the community.

**Significance for Saudi's Social Structure**

Consanguineous marriages in Saudi Arabia are common and are part of the Saudi social structure. Up to 50% of marriages in Saudi Arabia are consanguineous marriages (Al-Abdulkareem, & Ballal, 1998; El-Hazmi et al., 1995). Yet, no study has examined the role of consanguinity on the health beliefs of hemoglobinopathy high risk individuals and its impact on their intention to utilize preventative measures against hemoglobinopathies in the premarital stage. Therefore, this study will shed light on consanguinity as an important social structure and on its role as a moderator variable in the relationship between health beliefs and intentions to utilize hemoglobinopathies preventative behaviors.

**Significance to Practice**

The Alsulaiman and Hewison (2006) study in Saudi Arabia confirmed that the acceptability of reproductive choices utilizing PND and PGD in the family planning process is based on personal preferences and available options. Hence, our study explores the health beliefs of premarital high-risk individuals regarding PND and PGD and the benefits and barriers of each therapy option prior to marriage. The utilization of HBM in genetic decision-making is in its early days, but this study will be the first to incorporate the HBM in a population of individuals with the hemoglobinopathy trait or the diseases.

This study is an initial examination to explore genetic decision-making and develop best practices to improve the rate of delivering hemoglobinopathy free children.

# Chapter II

## Literature Review

The purpose of this literature review is to investigate and dissect health beliefs and their role in whether people adopt healthy behaviors. This review will also dive into the current knowledge of hemoglobinopathies, specifically sickle cell and thalassemia; hemoglobinopathies' preventative measures (PND and PGD); and the health beliefs that potentially drive genetic decision-making in individuals at high risk for having a child with hemoglobinopathies.

## Hemoglobinopathies

Hemoglobinopathies are a set of disorders that affect hemoglobin, which is the main structure of the red blood cells responsible for transporting oxygen throughout the body, and these disorders are lifelong and debilitating (Hoppe, Mentzer, & Tirnauer, 2018). These disorders are inherited and are considered genetic abnormalities, and they affect the structure and amount of the globin chain in the hemoglobin. There are thousands of types of hemoglobinopathies; some are silent, but the most common hemoglobinopathies are SCD and thalassemia, both of which follow the pattern of autosomal recessive inheritance (Hoppe et al., 2018). The incidence of hemoglobinopathies around the world pose a global health burden. An estimated 300,000 (83% with sickle cell disease, 17% with thalassemia diseases) children are born yearly with inherited hemoglobinopathy disorders, with 80% of the hemoglobinopathies affecting children living in low- to medium-income countries (Weatherall, 2010). Modell

and Darlison (2008) accessed a genetic epidemiological database to capture the global rate of hemoglobinopathies, and 3.4% of deaths in children younger than 5 years are caused by hemoglobin disorders, and 7% of pregnant women around the globe carry a child with a form of hemoglobin disorder. Additionally, 1% of couples worldwide are at risk for having a child with hemoglobinopathies or already have a child diagnosed with a hemoglobinopathy; most of the affected children die from the disorder (Modell & Darlison, 2008).

**Sickle Cell Diseases**

Sickle hemoglobin is responsible for SCD**,** a mutation that occurs in the beta globin gene, causing the 17th nucleotide to become adenine instead of the normal thymine, and in the beta globin chain the 6th amino acid will be valine in the place of glutamic acid (Bunn, 1997). As a result, the mutation causes an abnormal binding between beta 1 and beta 2 chains because of the hydrophobic motif of the deoxygenated sickle hemoglobin's tetramer. Therefore, the binding between these chains produces a polymer nucleus that leads to a disruption in the structure of the erythrocytes, its flexibility and initiation of cellular dehydration, and oxidative stress (Brittenham, Schechter, & Noguchi, 1985). The two main manifestations of SCD are vascular occlusion, causing ischemia reperfusion, and hemolytic anemia (Bunn, 1997; Frenette, 2002; Kato, Gladwin, & Steinberg, 2007). Vascular occlusion in SCD occurs when erythrocytes and leucocytes become trapped in the peripheral circulation, causing ischemia and tissue damage. Consequently, patients will experience periodic pain, infarction, and irreversible tissue and organ damage (Bunn, 2017). Hemolytic anemia in SCD causes multiple complications, and it induces anemia, cholelithiasis, fatigue, and

vasculopathy. As patients with SCD age, vasculopathy can lead to pulmonary hypertension, systemic hypertension, dysfunction of the endothelium, and leg ulcers (Gladwin et al., 2004; Pegelow et al., 1997). Furthermore, patients with SCD are at a higher risk for developing infections, infarction of the spleen, and abscesses (Bunn, 2017).

Worldwide, approximately 275,000 babies are born with SCD (Modell, & Darlison, 2008), and countries with malaria have the highest rate of SCD, specifically Africa (40% of the population has SCD), the Middle East, and South Asia (Piel et al., 2013). In the Middle East, 0.84 babies per 1,000 births are born with SCD annually (an estimated number of 7,389 babies; Modell & Darlison, 2008). In Saudi Arabia, the prevalence of the sickle cell trait is 49.6 per 1,000 births. An assessment of sickle cell over the past five years indicates this rate is increasing, from 42.3 in 2011 to 49.8 in 2015. These statistics highlight the need to implement health care interventions aimed at decreasing the prevalence rate of the sickle cell trait and SCD (Alsaeed et al., 2018).

**Thalassemia**

Thalassemia is characterized as either alpha or beta based on the location of the affected or absent globin chain (Hoppe et al., 2018). Beta thalassemia is more common than alpha thalassemia in areas such as the Middle East (Al Hamdan et al., 2007), which is characterized by decreased levels in the beta globin chain caused by a point mutation that disturbs the gene expression of the beta globin chain (Hoppe et al., 2018).

Beta thalassemia has three classifications: thalassemia major, thalassemia intermedia, and thalassemia minor. Thalassemia major (known as Cooley's anemia or Mediterranean anemia) is when the beta globin chain is severely decreased or diminished;

such patients are dependent on blood transfusions for survival (Benz, Schrier, & Tirnauer, 2018). In thalassemia intermedia, the anemia is less severe than thalassemia major, and patients do not require blood transfusions for survival if their anemia is mild or moderate, but if their anemia is severe, they might become dependent on transfusions as they age. Finally, in thalassemia minor (known as the thalassemia trait), the patient is a carrier and will be asymptomatic or might present with mild anemia (Benz et al., 2018).

Beta thalassemia causes severe anemia; therefore, the body attempts to compensate by increasing the release of erythropoietin, causing erythroid hyperplasia and an expansion of bone marrow (Benz & Edward, 2018). As a result, beta thalassemia delays growth, and children develop "chipmunk" facial features, fracture of long bones and vertebra, hepatosplenomegaly, ulcers in legs, accumulation of gallstones, congestive heart failure, increased risk for infections, and dysfunction of the endocrine system (Benz & Edward, 2018). Blood transfusion is crucial for survival, but it can lead to iron overload and potentially cause the demise of patients by the time they reach 30 years old (Benz & Edward, 2018).

The prevalence of beta thalassemia worldwide, on an annual basis, can reach up to 65,000 patients with major thalassemia and 30,000 who need a blood transfusion to survive (Modell & Darlison, 2008). In the Middle East, beta thalassemia ranges from 2–18% (Modell & Darlison, 2008), and, in Saudi Arabia 13.6 children (12.9 children per 1,000 have the thalassemia trait and 0.7 children per 1,000 have thalassemia disease) per 1,000 live births are born with beta thalassemia (Alsaeed et al., 2018).

Beta thalassemia and SCD inheritance follow an autosomal recessive pattern, and every pregnancy attempt by a heterozygote couple (known as carriers of thalassemia or

the sickle cell trait) will have a 25% chance of having a child affected by SCD or beta thalassemia, a 25% chance of having a child who is not affected or a carrier, and a 50% chance of having a child who is a carrier of the disorder (Galanello & Origa, 2010). Therefore, it is imperative to utilize interventions aimed at individuals with high risk for hemoglobinopathies (possess the trait or the disease) to ensure the delivery of healthy children.

**Saudi Perception and Knowledge Towards Hemoglobinopathies:**

Hemoglobinopathies are prevalent in Saudi Arabia and multiple studies have explored the population's knowledge of and perception towards these blood disorders. Alghamdi, et al (2018) conducted a study to examine the Saudi perception in Al Baha region towards SCD. The result revealed a widespread but basic knowledge about SCD, but specific gaps in knowledge were identified, in terms of the diseases inheritance pattern, its complication and the impact of diet on the disease process were all lacking. Mousa, Al Jaber, and Al-Ghaith (2019) also assessed the knowledge and health beliefs of Saudis in Al-Hasa region towards SCD, demonstrating that almost 62% of the population had limited knowledge of SCD. However, almost 54% of the population expressed fear towards hemoglobinopathies and were less confident about forming a family. On the other hand, Olwi, Merdad, & Ramadan (2018) examined the knowledge of Saudi college student towards thalassemia. The result of the study showed that almost 48% of the population has not heard of thalassemia diseases, and that only 50% of those who were married and underwent premarital screening knew about the diseases.

These studies suggest a lack of knowledge towards hemoglobinopathies and reveal a gap in literature about the beliefs and perception of Saudi towards hereditary

blood disorders. New studies should examine knowledge and develop interventions to increase awareness of hemoglobinopathies in the Saudi population.

**Premarital Screening**

Premarital screening programs are national services provided by the government to the public in an effort to reduce the rate of hemoglobinopathies, provide genetic counseling for high-risk couples, and increase knowledge about genetic risks (Al-Aama, Al-Nabulsi, Alyousef, Asiri, & Al-Blewi, 2008). Premarital screening is available to the population in multiple countries with a high rate of hemoglobinopathy, such as Iran (Karimi et al., 2007), Turkey (Guler & Karacan, 2007), India (Tamhankar et al., 2009), Pakistan (Ishaq, Hasnain Abid, Akhtar, & Mahmood, 2012), Iraq (Al Allawi & Al Dousky, 2010), Nigeria (Abioye-Kuteyi, Oyegbade, Bello, & Osakwe, 2009) and the United Arab Emirates (Belhoul, Abdulrahman, & Alraei, 2013). Even though the premarital screening program increased knowledge about hemoglobinopathies and risk status, the program was not associated with a decreased rate of high-risk marriages. Saffi and Howard (2015) conducted a systemic review regarding premarital screening programs to explore their effectiveness in reducing at-risk marriages. They evaluated 21 articles from 7 countries in the Middle East. The review concluded the premarital screening program was not effective at reducing high-risk marriages, but it was a good tool for the identification of hemoglobinopathies. Additionally, in India, 99% of high-risk couples got married despite being aware of their high-risk status (Tamhankar et al., 2009). In Saudi Arabia, 90% of high-risk couples know they are high risk and continue with their marriage plans anyway (Alhamdan et al., 2007; Al Sulaiman et al., 2010; Alswaidi et al., 2012).

Future recommendations are needed to enhance the premarital screening program and achieve its main objective to decrease the rate of hemoglobinopathies. According to Saffi and Howard (2015), premarital screening decreased the rate of hemoglobinopathies through technologies such as PND but did not decrease marriage among high-risk couples. Additionally, premarital screening in every country should be tailored based on the needs of its culture and medical framework to enhance the premarital screening program (Colah et al., 2008). Modifications need to be made based on the health beliefs, preferences, and health practices of the target community (Cousens, Gaff, Metcalfe, & Delatycki, 2010).

**Consanguineous Marriage and Hemoglobinopathies**

One of the main factors behind the ongoing transmission of hemoglobinopathies across generations is consanguineous marriages (Rajab & Patton, 1997). SCD and thalassemia are autosomal recessive inheritance disorders, which require both partners to be carriers of the disorder, and this is usually the case among consanguineous couples because they carry similar genetic makeup (Baysal, 2001). Consanguineous marriage is defined as a "union between two individuals who are related as second cousins or closer" and is considered an undesirable form of marriage in Western cultures (Bittles, 2001). However, countries in the Middle East and Pakistan prefer consanguineous marriages, specifically in Saudi Arabia, where consanguineous marriages reach up to 50% (El-Hazmi et al., 1995). According to El-Hazmi et al. (1995), societal and cultural factors were the main reasons behind the high rate of consanguinity among the Saudi population because these factors emphasize the need to maintain property within the same family

and the belief that couples who were raised by the same family name and raised in the same environment will have a more stable marriage.

Alkuraya and Kilani (2001) attempted to explore the attitudes of families ($N = 32$) who have a child with hemoglobinopathies, and 71.9% of these couples were consanguineous. After an educational intervention, the participants were asked about their attitudes toward consanguinity, and 53.1% of participants expressed a negative attitude toward it, and 37.5% of participants changed their attitudes toward consanguinity from positive to negative after the birth of a hemoglobinopathy-affected child. Therefore, acknowledging the high rate of consanguinity among the Saudi population by health care providers is a crucial factor in health education, as well as their beliefs (Alkuraya & Kilani, 2001).

**The Dor Yeshorim program: A success story**

Prevention of autosomal recessive diseases that have devastative consequences on a community is an ongoing problem. Based in New York, the Dor Yeshorim program is a carrier testing program aims at reducing serious human genetic diseases such as Tay-Sachs disease. It was first inducted in metropolitan New York area where Orthodox Jewish communities live in 1983 (Ekstein,& Katzenstein, 2001). The program provides voluntary and anonymous testing for its Jewish community, while taking into consideration religious practices and health beliefs about family. The Dor Yeshorim program operated as a premarital screening program, it offered testing to high school students, because the average age of marriage in Jewish communities is twenty years old, and where 90% of the carrier testing occurred (Ekstein,& Katzenstein, 2001). The Dor Yeshorim was endorsed by religious leaders, and community members, therefore

increased numbers of family members whom their loved one was affected by genetic disorder started to come forwards for carrier testing and genetic education. As a result, the Dor Yeshorim program empowered the Jewish community to create compatible couples based on their carrier status in an attempt to avoid having a child diagnosed with genetic disorders. In 1996, the New York area has not seen a single case of Tay-Sachs diseases in their children hospital units, and the communities who implemented the Dor Yeshorim program rarely see a child with genetic diseases (Ekstein,& Katzenstein, 2001).

## Preventative Measures for Hemoglobinopathies

The American College of Obstetricians and Gynecologists (ACOG, 2007) issued multiple recommendations for families at high risk for having a child with hemoglobinopathies, which included reinforcing genetic counseling and education about hemoglobinopathies and their risk and disease management. Most important, PND and PGD medical technologies are a valuable tool for high-risk families to ensure they have a hemoglobinopathy-free child (ACOG, 2007).

### Prenatal Diagnosis

PND is defined as "the science of identifying congenital abnormalities, aneuploidies, and other genetic syndromes in the fetus" (Cunningham et al., 2018). Amniocentesis and CVS, and, on rare occasions, fetal blood sampling, are procedures that fall under the term PND. Each procedure has a different approach aimed at diagnosing genetic abnormalities and hemoglobinopathies (Cunningham et al., 2018). Amniocentesis is performed between 15 and 20 weeks of gestation, and CVS is performed between 10 and 13 weeks of gestation (Cunningham et al., 2018). These procedures collect samples that enable the diagnosis of hemoglobinopathies from the

fetal DNA through the amplification of a polymerase chain reaction (Benz & Edward, 2018). A needle will be used in amniocentesis, guided by ultrasound, to aspirate amniotic fluid from the uterine cavity. CVS collects placental villi through transcervical or transabdominal access into the placenta (Hamilton et al., 2010). A prenatal diagnosis will provide the couple with two possible options. First, if the fetus was affected with hemoglobinopathies, parents can choose to terminate the pregnancy or continue with the pregnancy and create an appropriate plan of care by incorporating family support and preparing for the child's treatment after delivery. Second, if the fetus is healthy, parents will receive reassurance (Benn & Chapman, 2010).

Hemoglobinopathies are prevalent in countries where Islam is the dominant religion and abortion is not a preferred practice to prevent these diseases; however, a combination of genetic counseling and education about the religious ruling in regard to abortion under certain circumstances has allowed couples to change their attitudes toward abortion (Alkuraya & Kilani, 2001; El-Beshlawy et al., 2012).

Implementation of PND to prevent hemoglobinopathies is a popular practice in multiple countries. Sinan Beksac et al. (2011) conducted a study in Turkey over 25 years to capture the benefits of PND in the prevention of hemoglobinopathies. A total of 947 fetuses underwent PND, where 47.2% were carriers, 27.5% were affected, and 25.2% were normal. The study showed that PND detected a wide variety of hemoglobinopathy mutations, and 261 affected pregnancies were interrupted and 19% of women requested PND for their following pregnancies. According to Murad, Moassas, Jarjour, Mukhalalaty, and Al-Achkar (2014), in Syria, PND was conducted on 55 families with a high risk of hemoglobinopathies, and 25.45% affected fetuses were identified, with

58.18% carriers and 14.54% normal. PND accuracy is as high as 98.2%. Therefore, utilization of PND as a preventative measure against hemoglobinopathies has proven to be an effective method for decreasing the rate of hemoglobinopathies, and empower parents of an affected child to create a plan of care prior to birth to decrease the burdens of hemoglobinopathies.

**Preimplantation Genetic Diagnosis**

As means to prevent hemoglobinopathies, high-risk individuals can benefit from preimplantation genetic diagnosis (PGD) to deliver healthy children. This procedure harvests a disease-free embryo to be implanted (McCarthy & Mendelsohn, 2017). Intracytoplasmic sperm injection of an oocyte is then performed, and the fertilized ovum is genetically analyzed usually on day three with the use of genetic analysis of the DNA that is extracted from polar bodies or blastomeres of the fertilized embryo (Patrinos et al., 2005). The implementation of PGD is an appropriate alternative for first or second trimester PND because it ensures pregnancy with a healthy fetus and helps avoid termination of pregnancy (Vrettou et al., 2004).

Kuliev et al. (2011) published the results of the application of 395 PGD cycle to evaluate its effectiveness in the prevention and treatment of hemoglobinopathies. Implementation of PGD resulted in the birth of 98 healthy children, along with seven ongoing pregnancies. One third of these PGD cycles were human leukocyte antigen (HLA) types that were compatible with an affected sibling, which led to a successful stem cell transplantation on a dozen affected siblings to treat hemoglobinopathy. PGD displayed 99.7% accuracy upon transfer and 99% upon birth. Similar studies, completed across multiple countries, have evaluated the effectiveness of PGD as a means to prevent

hemoglobinopathies, finding similar successful results. PGD has been performed in China (Jiao et al., 2003), Brazil (Figueira et al., 2012), Turkey (Milachich et al., 2013), and Hong Kong (Chow et al., 2015). Therefore, the use of PGD to prevent hemoglobinopathies is an appropriate intervention for couples who oppose pregnancy termination, and HLA typing compatibility can cure an affected sibling as well.

Therefore, early utilization of PND and PGD in the family planning process is crucial to delivering a healthy child or minimize diseases burden. However, additional exploration of the perceptions of high-risk individuals with either the trait or the diseases, needs to be conducted prior to implementing such interventions.

**Ethical implication of PND and PGD:**

Utilization of PND and PGD have ethical implications that must be addressed to capture the full impact of hemoglobinopathies preventative measures. In terms of PND, parents are faced with two equally conflicted ethical principles: 1) respecting the life of the unborn by avoiding abortion and giving life to the affected fetus; or 2) suffering avoidance, by bringing a fetus to full term, and accepting responsibility of the child suffering (García, Timmermans, & van Leeuwen, 2008). Currently in Saudi Arabia, PND is not available for hemoglobinopathies high-risk pregnant women, because health care providers and medical organizations take into consideration the Islamic religion and the undesirable views toward abortion (Alkuraya, & Kilani, 2001). Nevertheless, intentionally withholding medical service like PND can take away a patient's right to know, limit utilization of medical resources, and limit the chance to undergo genetic education and counseling (Petrou, & Modell,1995).

Prior to recommending medical technology like PGD, health care workers and parents must understand the ethical dilemmas they may face and tools they have to address them. Medical procedures like PGD provide comprehensive genetic information, and its potential use for non-medical purposes such as behavioral tendencies or sex selection is unacceptable (Botkin, 1998). Also, PGD ignites the debate about the moral value, and right of a fertilized embryo, most of scholars and organization bodies regard the fetus as having a moral value but not equivalent to fully developed human being. Therefore, utilization of PGD and selective implantation of unaffected fetuses, can be challenging for those who believe that fertilized embryos hold the same values of a human being (Botkin, 1998). On the other hand, based on ethical grounds fertilized embryos have less moral value than a fetus. Therefore, PGD is ethically preferable over PND because in PGD selection of embryos for implantation is more morally acceptable, than the consequences of aborting a fetus (Geraedts, & De Wert, 2009). Those who believe in "gradualism" acknowledge that as the fetus advance in its stages of development, their moral value increase as well (Geraedts, & De Wert, 2009). Therefore, its crucial for health care workers to educate the high-risk Saudi population about the concept of gradualism because it is congruent the Islamic views (the soul enter the fetus as they grow, not during fertilization). If the couples regard their fertilized eggs to have a moral value, then affected embryos need to be discarded prior to 14 days' gestation.

**Implication of Saudi culture on patient's decision making:**

Culture is defined as a set of shared ideologies, values and behaviors by a group of humans (Banks, 2015). Culture is influenced by multiple aspects, like environment, race, religion, economic and education. In Saudi Arabia the most dominant factor

influencing the Saudi culture is the religion of Islam, and its impact on all aspects of health is undeniable. Muslims view disease as a part of fate that occurs with the will of god, and disease is a form of atonement, and cleansing from sins rather than punishment (Al-Shahri, 2002). Therefore, health care workers must incorporate the Saudi culture when caring for these patients, specifically in the care and prevention of genetic disorders.

The consistently elevated rate of hemoglobinopathies in Saudi Arabia is indirectly related to the society's culture and practices. Specifically, the Saudi family dynamic, tradition and loyalty to its tribe influences decisions of marriage (Al Sulaiman et al., 2010). Therefore, health care programs aimed at preventing genetic disorders created within a culturally sensitive framework is needed to ensure success of health promotion program (Al Aqeel, 2007).

## Health Belief Model

The HBM historically originated in the 1950s from the negative and positive forces that surround individuals on a daily basis; to fend off negative forces, individuals will act according to their health beliefs (Rosenstock, 1974). These beliefs include the personal beliefs of disease susceptibility and its damaging impact on at least one aspect of life; the belief that adopting a particular action is beneficial in warding off the disease or in minimizing its severity; and the belief that adopting a healthy action will not cause psychological barriers, such as costs or embarrassment. The health behavior is triggered according to the intensity of a cue, which also influences the levels of susceptibility and severity. The model hypothesizes that, if these health beliefs are present, adopting a

healthy behavior is more likely to occur (Rosenstock, 1974). In 1988, the concept of self-efficacy was added to the model to describe the differences in health behavior between individuals (Rosenstock, Strecher, & Becker, 1988).

**Health Belief Model in Behavioral Health Research**

In an attempt to capture the driving forces of health behavior, researchers have used the HBM extensively as a conceptual framework in research to understand the changes in behavior and to guide health interventions (Skinner et al., 2015). The HBM has been used in numerous cancer preventative behaviors to predict the adoption of a health behavior or its application in intervention studies. Ersin and Zuhal (2011) conducted a systematic review to evaluate the effectiveness of an HBM-based intervention aimed at promoting the early detection of breast cancer, and a sample of nine studies met the inclusion criteria. The systematic reviews demonstrated that use of the HBM facilitates that positive health behaviors were enforced. Health interventions should identify triggering factors and then utilize them to conduct early diagnostic behaviors. These triggering factors can be recognized with the use of the HBM prior to designing a health intervention. Additionally, the health perceptions identified via the HBM aid in predicting a corresponding health behavior (Ersin & Zuhal, 2011). Johnson, Mues, Mayne, and Kiblawi (2008) conducted a systematic review of factors that influence cervical cancer screening among ethnic minorities with the use of the HBM as a conceptual framework. A total of 55 articles met the inclusion criteria, and all of the articles examined the health beliefs of immigrants and minorities toward cervical cancer screening. The study's results provided a unique health perception and an overview of the beliefs and attitudes of a population with a different background. The HBM helped health

care workers explore the health beliefs of their patients to provide health care services that are culturally appropriate and tailor health care interventions according to the health beliefs of patients (Johnson et al., 2008). Austin, Ahmad, McNally, and Stewart (2002) performed a literature review of the HBM in a population of Hispanic women for breast and cervical cancer screening. The results of the review identified a health belief that was specific to that population of Hispanic women, which included linguistic barriers and the perception of decreased susceptibility to cancer. These beliefs helped explain the declining rate of cancer screenings. The review established the crucial role the HBM plays in identifying specific cultural beliefs that drive disease prevention behavior and explained the poor compliance rate (Austin et al., 2002).

Utilization of the HBM is applicable to any health promotion intervention, and its use in advancing sexual and reproductive health is popular in explaining health behavior. Hall (2012) conducted a literature review to examine the use of the HBM as a social cognitive framework for predicting the use of contraceptive behavior. Hall assessed a total of 10 articles and concluded the effectiveness of the HBM in practice and research. The customization of the HBM in the family planning process can enhance reproductive health (Nathanson & Becker, 1983). Utilization of the HBM facilitates culturally sensitive health interventions and enforces the use of multiple learning strategies (Hall, Castaño, Stone, & Westhoff, 2010), provides insight into the patient's health perceptions, and incorporates the changing dynamic associated with the patient's beliefs. As a result, the model has the potential to advance reproductive health and improve compliance with contraceptive behaviors (Hall, 2012).

In an attempt to capture the smoking health beliefs in a youth population, Mantler (2013) conducted a systematic review, using the HBM as a theoretical framework, to evaluate the perception of smoking, addiction, and health risks among young adults. The review examined 10 studies with a total of 2,500 participants and concluded that young adults perceive that the barriers to quitting smoking are more significant than the benefits of quitting. As a result, the review highlights the crucial part of incorporating self-examined health beliefs in designing smoking cessation interventions because the beliefs and attitudes of young adults toward smoking are illogical and represent a false, optimistic view toward the health risks of smoking (Mantler, 2013).

DiMatteo et al. (2007) conducted a meta-analysis to evaluate the effectiveness of health beliefs in predicting adherence to medical treatment. The study analyzed 116 articles, with different medical conditions and treatments, and the result of the analysis demonstrated that patients' perception of disease severity significantly, and positively, correlated with treatment adherence. Additionally, patients with less serious health conditions who report poorer health, display a better adherence to treatment than patients with more serious health conditions who also report poor health. Therefore, the analysis shed light on the importance of exploring the health beliefs of patients because it can give insight on potential treatment adherence, and it can be utilized in health education to advance patient health (DiMatteo et al., 2007).

Overall, the literature review supports HBM use by health care workers in health promotion and disease prevention programs. The HBM enables health care personnel to dive into personal health perceptions, which guide behavior and explore the individual patient beliefs toward their own health. As a result, an intervention to promote health,

based on internal and external factors, can be tailored to a population's specific health beliefs.

## Health Belief Model and Genetics Decision-Making

Decision-making in the field of genetics can be quite challenging for individuals with the hemoglobinopathy diseases or trait. Patients are usually faced with multiple options, which require self-reflection, counseling, and an evaluation of personal preferences and beliefs, before making a decision (Shiloh, 1996). HBM use in genetics decision-making is well established and efficacious because the model enforces the use of a patient's health beliefs, incorporates cultural norms, and facilitates individualized intervention by health care personnel. The literature review illustrated the HBM could be used in multiple stages of genetics decision-making. It can be applied to the patient's willingness to obtain a genetic screening after establishing the presence of a genetic medical condition and in seeking preventative health care in the intervention stage.

### HBM and Willingness to Obtain a Genetic Screening

The use of the HBM assists in gaining a comprehensive understanding of a population's willingness to participate in disease prevention behavior and genetic screening. Multiple studies examine intent to undergo genetic testing for different diseases among different populations through the use of the HBM as a theoretical framework.

The HBM was used in the genetic screening of autosomal recessive diseases such as SCD and cystic fibrosis. Gustafson et al. (2007) used the HBM to understand the causes behind the low uptake of sickle cell screening in a population of African American women. The study examined the health perceptions of 101 African American women,

and the results of the study displayed that these women acknowledge the severity of SCD, the benefits of sickle cell screening, and express low barriers to the screening. In contrast, the participants displayed a low level of disease susceptibility in their future children, and, based on the HBM, patients need to perceive themselves as high risk to adopt the screening behavior. As a result, the HBM can help explain the rationale behind the low rate of sickle cell screening among African American women (Gustafson et al., 2007). Chen and Goodson (2007) conducted a systematic review to capture the factors that influence the decision to accept or decline genetic screening for cystic fibrosis. The factors used to capture the acceptance rate of the screening behavior are based on the concepts of the HBM. Overall, 40 studies were included in the review, and the major factors that explain the high acceptance rate of cystic fibrosis screening are a high perception of benefits and a low perception of barriers. Therefore, the HBM is an important tool for capturing the causes behind a low or high rate of screening behaviors.

In genetics screening for cancer, the HBM is popular for exploring the patient's intention to seek screening. Cyr, Dunnagan, and Haynes (2010) used the HBM to predict colorectal carcinoma genetic screening behaviors among a population living in a rural area. They recruited a total of 558 participants for the study, and the study results showed that the perceived benefits are the strongest predictor of a patient seeking colorectal cancer genetic screening, followed by the perceived barriers and cues to action (Cyr et al., 2010). Bosompra et al. (2000) wanted to examine the intent to undergo genetic testing for cancer in the general population, with HBM use as a guiding theoretical framework. They examined the health beliefs of 622 adults, and the results illustrated elevated levels of perceived benefits, perceived susceptibility, and pessimism, along with a decreased

level of perceived barriers—the strongest predictors of whether an individual would undergo genetic testing for cancer (Bosompra et al., 2000).

Additionally, the HBM has been used in the genetic testing of common diseases such as hypertension. Taylor, Peternell, and Smith (2013) conducted a study to examine the health beliefs of African American women toward the genetic testing of hypertension. They analyzed the health beliefs of 183 women and showed a high rate of perceived benefits for genetic testing and a positive attitude toward the prevention of hypertension, specifically among the elderly population (Taylor et al., 2013).

The above studies were conducted across multiple genetic screenings, each with different diseases and populations, and they indicated the crucial role the HBM plays in understanding the health beliefs that drive genetic screening behaviors.

**HBM in Genetic Conditions and Preventative Health Care**

The HBM has been used to examine the rationale behind seeking or declining a screening (Rosenstock, 1974). As the model improves, its uses will expand and be applied to the field of genetics for preventative behavior, specifically for populations who were already identified as having a genetic risk or a predisposed risk to their future children.

French, Kurczynski, Weaver, and Pituch (1992) examined the intention to seek PND among women of advanced maternal age, using the HBM as a theoretical framework. The study examined the health beliefs of 96 women, finding that 61 participants expressed an intention to undergo amniocentesis, 22 declined it, and 13 expressed uncertainty. Perceived benefits were the strongest predictor in seeking amniocenteses, and the study showed that knowledge alone does not predict behavior;

however, health beliefs do, which highlights the significance of examining health beliefs in preventative disease behaviors (French et al., 1992).

Rowley, Loader, Sutera, Walden, and Kozyra (1991) applied the HBM in the prenatal screening of hemoglobinopathies. Women who are carriers of hemoglobinopathy face three decisions: accept genetic counseling; refer their partner for testing; and, in case both are high risk for having a child with hemoglobinopathy, identify an intention to use PND. The HBM identified the following concepts could predict partner testing, which includes a decreased perception of the barriers, a belief that a partner is also a carrier, and a perceived seriousness. Additionally, knowledge, living with the partner, and a pregnancy of less than 18 weeks of gestational age also predicted partner testing. The HBM identified the intention to undergo PND with the following: perception of disease threat, increased age, and intention to have more children (Rowley et al., 1991).

The HBM was utilized in a variety of genetic conditions, and all produced successful outcomes in predicting the intention to seek disease prevention. Khouzam, Kwan, Baxter, and Bernstein (2015) utilized the HBM to examine the low rate of individuals seeking genetic services in patients with hypertrophic cardiomyopathy. The study recruited 306 participants diagnosed with hypertrophic cardiomyopathy, or at risk for developing it, and 37% obtained genetic counseling while 53% performed genetic testing. Based on the HBM, the strongest predictors for genetic testing were cues to action, low perception of barriers, and an elevated perception of benefits (Khouzam et al., 2015). Evers-Kiebooms and Decruyenaere (1998) wanted to examine the different health beliefs of individuals who tested for Huntington's disease versus those who did not underwent testing, to capture the HBM concepts related to seeking genetic testing.

Among the study participants, 63 tested for Huntington's disease and 50 did not. The study demonstrated that the perceived severity was present in both groups, and the barriers to testing were an inability to cope with the result and a lack of treatment in case the test was positive for Huntington's disease. However, the perceived barriers to testing were a sense of relief and the ability to make reproductive decisions and inform their children of their risks (Evers-Kiebooms & Decruyenaere, 1998).

As genetic technologies advance, the HBM can help anticipate clinical issues that might arise in the future. Erickson et al. (2014) examined health beliefs in regard to a hypothetical emergence of genetic testing that diagnoses a future predisposition for mood disorders with HBM use. The study assessed the health beliefs of 53 patients, diagnosed with depression or bipolar disorder, and the results showed that 87% of participants were willing to employ the test for their children if it existed. The HBM thus illustrates its applicability to the future implications of genetic testing (Erickson et al., 2014).

Utilizing the HBM in seeking disease prevention behavior among individuals at risk for developing a condition, or who pose a risk for transmitting a condition to their children, has proven to be an effective model in understanding health beliefs as driving behaviors, which is a step closer to using the HBM in customizing a health intervention.

**HBM-Based Intervention in Genetic Decision-Making**

The use of the HBM in the field of genetic decision-making has proven to be an applicable model in exploring health beliefs as driving behaviors. The HBM has been used to explore health beliefs and to create health care interventions to advance health and prevent diseases. Kia, Karami, Mohamadian, and Malehi (2018) designed HBM-based educational sessions for couples at risk for having a child with β-thalassemia in an

attempt to monitor any changes in the health beliefs of couples, the uptake of PND as a hemoglobinopathy preventative measure, and to evaluate the success of an HBM-based intervention. They randomly assigned recruitment of 224 β-thalassemia carriers and high-risk couples to control and intervention groups. The intervention group consisted of an educational session based on HBM concepts (i.e., perceived susceptibility, perceived seriousness, perceived benefits, perceived barriers, cues to action, and self-efficacy). The intervention lasted 30 mins, and the authors conducted it weekly, within a 1-month period, providing a questionnaire before and after the intervention to both groups. The results of the study confirmed a significant difference between the groups in regard to health beliefs and the uptake of PND in favor of the intervention group. Therefore, HBM-based interventions benefit health care providers, providing insight into genetic decision-making, and they assist in guiding health care interventions (Kia et al., 2018). Nishigaki, Tokunaga-Nakawatase, Nishida, and Kazuma (2014) conducted a similar study on a population of individuals at high risk for type 2 diabetes, and they implemented an intervention with the use of the HBM in a genetic counseling session. The study results showed a successful outcome (Nishigaki et al., 2014).

Therefore, multiple studies have demonstrated a successful applicability of the HBM across multiple phases of genetic counseling: the screening phase, the disease prevention behavior phase, and the intervention phase. All of these phases are vital and the HBM can play in advancing health care by incorporating the model into genetic decision-making.

**Key Findings**

Hemoglobinopathies, specifically SCD and β-thalassemia, are lifelong diseases that have detrimental effects and require patients to be dependent on blood transfusions for survival (Benz & Edward, 2018; Bunn, 2017). Based on epidemiological studies, the rate of hemoglobinopathies in Saudi Arabia is not declining, even with the use of premarital screening as a preventative measure (Alsaeed et al., 2018; Alswaidi et al., 2012). Because 50% of marriages in Saudi Arabia are consanguineous (El-Hazmi et al., 1995), which facilitates the survival of the hemoglobinopathy gene across generations, studies have shown the high rate of marriage among high-risk couples is 90% (Alhamdan et al., 2007; Al Sulaiman et al., 2010; Alswaidi et al., 2012). Therefore, the high rate of marriages among high-risk couples indicates that premarital screening is beneficial in advancing awareness but does not decrease the rate of hemoglobinopathies. As a result, implementation of preventative measures against hemoglobinopathies is crucial. PND and PGD medical technologies are a valuable tool for high-risk individuals to deliver a hemoglobinopathy-free child (ACOG Committee on Obstetrics, 2007). PND allows for the diagnosis of a fetus through the use of CVS or amniocentesis. If the diagnosis is confirmed, couples can terminate the pregnancy or continue the pregnancy and create a plan of care (Benn & Chapman, 2010; Benz & Edward, 2018). In PGD, embryos are diagnosed prior to implantation, and a hemoglobinopathy-free embryo will be implanted in the uterus (Patrinos et al., 2005). Examining the health beliefs of individuals with the trait or the disease, with the use of the HBM is crucial to be implement prior to the utilization of preventative measures against hemoglobinopathies. The HBM facilitates genetic decision-making and enables health care workers to examine the health beliefs that drive behaviors, and it incorporates cultural and personal beliefs in the decision-

making process (Shiloh, 1996). The literature has clearly demonstrated the applicability of the HBM in predicting behavior, its usefulness in genetic decision-making, and its applicability as a guiding framework in genetic counseling.

**Future Research**

Future research should examine multiple important aspects in the hemoglobinopathy-affected population. An exploration of the health beliefs of individuals with either the trait or the disease, along with their potential to have a hemoglobinopathy affected children is important in guiding genetic decision-making because health beliefs provides a comprehensive understanding of the perception of risk, provides background on the intention to utilize hemoglobinopathy-preventative behavior, and assists in tailoring health specific interventions. As a result, interventional studies can be conducted based on health beliefs, because previous interventions like premarital screening and knowledge of high-risk status did not alter behavior in regard to marriage plans and highlight the need to explore a high risk individuals' perceptions about the health of their future child and their perceptions toward hemoglobinopathy preventative measures such as PND and PGD.

Additionally, future research aimed at exploring cultural, societal, and religious aspects in Saudi communities is important because it can uncover the health beliefs of a population. Based on the literature, health decision-making in Saudi Arabia is shaped by family culture and Islam, which require research to generate knowledge aimed to guide the practice on health care.

There is limited HBM utilization in genetic decision-making, specifically in the population of high-risk for hemoglobinopathy because not all potential parents are

affected by it, but it will make them think about the burden of disease for their sick child. Such a study will generate knowledge by decoding human behavior and trigger the need to adopt preventative behaviors against hemoglobinopathies.

Finally, future research needs to examine the political aspects of providing preventative measures against hemoglobinopathies to high-risk population. There are limited studies in examining and comparing the financial and psychological burdens associated with PND or PGD versus the cost of not providing the intervention.

**Conclusion**

Hemoglobinopathies are debilitating, yet preventable diseases, with the appropriate utilization of PND and PGD in the family planning process. For these interventions to be adopted by hemoglobinopathy high-risk individuals, exploring health beliefs is crucial to capturing their perception toward hemoglobinopathies to predict the adoption of preventative behaviors against hemoglobinopathies. Therefore, additional research is important to characterize the health beliefs and the intention to utilize preventative behavior against hemoglobinopathies in Saudi high-risk population. As a result, future interventions to eradicate hemoglobinopathies from the community should be based on established knowledge about a high-risk population's health perceptions. The goal of the proposed research study is to improve the genetic decision making, initiate the adoption of preventative measures against hemoglobinopathies, and alleviate the burden of disease in families and communities.

## Chapter III

The purpose of this study is to determine the association between the health beliefs of high-risk population for having a child with hemoglobinopathies and intentions

to utilize the HBM as a preventative measure. We hypothesized that participants who display health beliefs that incorporate elevated threat perception (elevated perception of susceptibility and seriousness), self-efficacy, cues to action, benefits, and low perception of barriers will be more inclined to undergo PND or PGD to ensure they have healthy children. In addition, we tested the role of consanguinity as a moderator variable on the relationship between participants' health perceptions and intentions to undergo hemoglobinopathy-preventive measures. To test this hypothesis, we measured high-risk individuals' (hemoglobinopathy trait or disease) health beliefs via Champion's Health Belief Model Scale (CHBMS; Champion, 1993). Participants then completed a self-reported survey to gauge their intentions to utilize hemoglobinopathy-preventive measures to determine the nature of the relationship between participants' health beliefs toward hemoglobinopathies and their intentions to adopt preventative measures. To facilitate implementation of the study design, we created specific aims to guide the research:

**Aim 1:** Illustration of health beliefs based on HBM (i.e., perceived susceptibility, perceived seriousness, perceived barriers, perceived benefits, self-efficacy, cues action and fatalism) among premarital Saudis at risk for having a child with hemoglobinopathies. We administered Arabic versions of the CHBMS to Saudi individuals in the premarital stage with the trait or the diseases. We also collected demographic (e.g., consanguinity, SES, educational level, age, sex, previous experience with hemoglobinopathies, children from previous marriages) information.

**Aim 2:** Based on the seven concepts of the HBM, we identified the concepts that are associated with participants' likelihood of intentions to utilize hemoglobinopathy-preventive measures.

**Aim 3:** We tested consanguinity as a moderator variable on the relationship between participants' health perception identified by the CHBMS and intentions to utilize hemoglobinopathy-preventive.

## Research Design

We conducted a descriptive, cross-sectional study using the HBM as a theoretical framework to capture health beliefs toward having a future child with hemoglobinopathies and examined its predictive ability regarding hemoglobinopathy high-risk population's intentions to undergo PND or PGD. A cross-sectional design is defined as "describing the status of a phenomenon or describing a relationship among phenomena at a single point in time" (Polit & Beck, 2012, p. 208).

There are several reasons for using this method. Our target population are young individuals applying for marriage certificates who have been identified as being at high risk for having a child with hemoglobinopathies. The cross-sectional design captured the health beliefs of this population during the premarital screening process as a means to evaluate their perceptions regarding the health of their future children, as well as perception regarding early access for family planning.

This study is an initial attempt to determine the applicability of the HBM in genetic decision making and health promotion studies with the aim of enhancing the use of hemoglobinopathy-preventive measures. The study further explained the role of the HBM in genetic decision-making and how it is used as a tool in promoting a

community's future health. The current state of knowledge promotes the use of the HBM in behavior modification across multiple diseases and cultural settings and reaffirms its applicability in genetic decision-making. Currently the use of the HBM in high risk population for having a child with hemoglobinopathies and understanding its role in promoting hemoglobinopathy-preventive measures among the Saudi population is nonexistent; therefore, our study aimed to close the gap in the literature regarding the role of health beliefs in genetic decision-making and in future intentions to utilize hemoglobinopathy-preventive measures. The results of this initial study could be used to follow participants after marriage and capture the exact relationship between their expressed intentions to utilize PND or PGD and their actual adoption of these medical technologies. This study will facilitate future interventions to promote the health of future children, a step toward increasing the accessibility of PND and PGD in Saudi Arabia and eventually eradicating hemoglobinopathies.

## Setting

We recruited participants for this study from each of four clinics in two main population centers in Saudi Arabia in the western and eastern regions of the country. In the western region, we conducted our research at two premarital screening facilities established by the Saudi government. We included the western region in the research project because the cities of Jeddah, Makkah and Madinah combined constitute the second-largest population center in the country; this study is the first conducted in the country's western region (General Authority for Statistics Saudi Arabia, 2017). All the recruitment locations are clinics operated under the Saudi Ministry of Health (MOH). The screening locations in Jeddah will be the Maternal and Pediatric Hospital and Jeddah

regional lab; in Madinah, the locations will be the premarital screening clinic in Al Khalidiah.

In the eastern province, we accessed two premarital screening clinics in two cities for our research: the Premarital screening Clinic in the city of Dammam, and Al Khobar. We included these clinics because the eastern province displays the highest prevalence of hemoglobinopathies in the country (AlHamdan, AlMazrou, AlSwaidi, & Choudhry, 2007; Alsaeed et al., 2018; Ziad, Tariq, & Mohamad, 2011).

Using all of these facilities we recruited our desired sample size. Nationwide, about 700 couples undergo premarital screening every day; each of our recruitment facilities tests approximately 70 couples per day (Affet et al., 2012). The above-mentioned facilities provide free-of-charge screening to all applicants for marriage certificates (AlHamdan et al., 2007) and use established protocol adhering to standard laboratory diagnostic procedures (Al-Odaib, Abu-Amero, Ozand, & Al-Hellani, 2003).

We hired three research assistants (RA) to assist the Primary investigator (PI) in data collection. One RA was stationed Jeddah and, another in Al Madinah. An additional RA was hired to collect data in eastern region (covering Dammam, and Khobar). The rationale behind recruiting three research assistants to cover these areas is because these cities are close to each other in proximity, which is feasible for the RAs to collect data. The PI trained all the RAs on the purpose of the study, data collection procedures based on study's protocol (while ensuring privacy and confidentiality), and to seek help from the PI if faced with a problem.

## Study Sample

After we obtained ethical approval from the MOH IRB and the CWRU IRB, we began recruiting participants. Convenience sampling of high-risk individuals was accomplished using the electronic records from the premarital screening database. Nonprobability convenience sampling can pose a limitation to a study's generalizability and introduce bias due to the subjective method of sample recruitment. Nonetheless, because our study requires specific participant biological characteristics (i.e., hemoglobinopathy trait or disease), which can be easily identified via a premarital screening clinic, convenience sampling is the ideal type of nonprobability sampling for our study (Etikan, Musa, & Alkassim, 2016).

The study aimed to enroll 146 participants (with hemoglobinopathy trait or disease) identified as high risk. The inclusion criteria for the study participants will be 1) a member or both couples in which partners are carriers of the autosomal recessive gene (25% risk for an affected child; 50% of children will be carriers), or 2) a member or both couples in which one is a carrier and the other has the disease (50% risk for an affected child, 50% will be carriers; Griffiths, Wessler, Carroll, & Doebly, 2015*),* 3) Individuals 18 years or older with hemoglobinopathy trait or disease in the premarital stage. Participants must provide written consent and be willing to participate, able to speak and read Arabic. The exclusion criteria will include non-high-risk status, use of premarital screening outside the participating facilities, inability to read or speak Arabic, or if both partners have the disease, in which case 100% of children will be affected and PND or PGD will be ineffective. A potential limitation to study's generalizability might occur due to the sampling method, specifically if both members of the couple agree to

participate, in which there is a chance that both might influence each other responses to the questionnaires.

Recruitment of participants occurred from May 3, 2019, to August 30, 2019. We have selected these dates because couples typically seek marriage certificates between these dates to plan for wedding ceremonies during the summer vacation (Alswaidi et al., 2012).

## Determination of Sample Size and Power Analysis

### Overview of Power

Statistical power is the probability of rejecting a false null hypothesis, power = 1 – ß (Polit & Beck, 2012). By increasing the study's statistical power, the probability of making a type II error (the probability of failing to reject a false null hypothesis) will decrease (Hulley, Cummings, Browner, Grady, & Newman, 2013). The power of statistical tests depends on the effect size, α-level, and sample size (Field, 2009, p. 70). We will discuss the determinants of statistical powers in the following sections:

### Effect Sizes Between the Constructs of the HBM and Health Behavior

There are no published studies that examine the effect sizes of all seven concepts of the HBM (perceived susceptibility, severity, barriers, benefits, cues to action, self-efficacy and fatalism) and their predictive role in genetic decision-making. Harrison, Mullen, and Green (1992) conducted a meta-analysis to evaluate the relationship of four components of the HBM (e.g., perceived susceptibility, seriousness, barriers, and benefits) and their predictive value with regard to adopting a health behavior. Based on this meta-analysis, the effect sizes of the HBM displayed a low level of Pearson's *r*— 0.15 for susceptibility, 0.08 for severity, 0.13 for benefits, and 0.21 for barriers. Abraham

and Sheeran (2005) directly critiqued that meta-analysis, however, stating that the concepts within the HBM should be combined to produce a larger effect size and pointing out that the analysis included 16 studies, which is insufficient to capture the true effect size of the model; furthermore, they noted that the heterogeneity of effect size was the result of different designs and measurements across the studies. The literature review by Harrison et al (1992) confirmed the importance of the HBM in advancing health behavior, but inconsistent utilization of the model across studies can influence the magnitude of effect size (Abraham & Sheeran, 2005). Due to the descriptive nature of our proposed study and the lack of an established effect size from previous studies, we will utilize a medium effect size for our statistical test of linear regression (Cohen, 1992).

**Sample Size Estimation**

For our descriptive study, we set our significance level of alpha as 0.05, and power of 0.80, which is consistent with previous studies examining associations between HBM concepts and intentions to undergo genetic screening (French, Kurczynski, Weaver, & Pituch, 1992; Cyr, Dunnagan, & Haynes, 2010) to calculate sample size and estimate power analysis. We determined the power analysis with the use of G*Power. This study was the first to examine the relationship between HBM concepts and intentions to adopt hemoglobinopathy-preventive behaviors among premarital high-risk individuals. As a result, no effect size was found to be used in conducting power analysis. Cohen (1988) stated that in cases like our study where effect size was not reported in the literature, estimation of effect size will be based on logic and judgment. French et al. (1992) and Cyr et al. (2010) studied different dependent variables than our study, but they exhibited the role the HBM plays in genetic decision-making. Therefore, we utilized a

medium effect size of 0.15, power of 0.95, and alpha significance level of 0.05 to guide our statistical analysis, with a sample size of 146 individuals.

### Justification of Sample Size

French et al. (1992) established a positive relationship between the HBM and healthy genetic decision-making. As a result, we hypothesized the presence of a relationship between health perceptions illustrated in the HBM and intentions to adopt hemoglobinopathy-preventive behaviors. For our exploratory study, we estimated the required sample size with the use of G*Power and used the following values to compute sample size: a medium effect size = 0.15, power of 0.95, and alpha significance level of 0.05, with seven predictors. Therefore, a total sample size of $N = 146$ participants is needed to detect significance.

## Instruments

### Champion's Health Belief Scale

We measured the constructs of the HBM using an Arabic version of Champion's Health Belief Model Scale (CHBMS; Champion, 1993). The purpose of the CHBMS is to capture patients' health perceptions using a single scale measuring the HBM constructs, which include perceived susceptibility, perceived seriousness, perceived benefits, perceived barriers, cues to action, and self-efficacy. Every item in the scale has a total of five responses (5-point Likert scale), ranging from strongly disagree (score of 1 point), disagree (2 points), neutral (3 points), agree (4 points), and strongly agree (5 points). Increased scores are associated with positive health behavior, except perceived barriers, for which the scale is reversed. The CHBMS was designed to measure the six concepts of the HBM, with 5 items measuring perceived susceptibility, 7 items for perceived

seriousness, 6 items for perceived benefits, 6 items for perceived barriers, 11 items for self-efficacy, 7 items for cues to action, (Champion, 1990; 1993). Mikhail and Petro-Nustas (2001) translated the CHBMS into Arabic to establish its validity and reliability; their translation was psychometrically evaluated in a study on Jordanian women to assess their health perceptions regarding breast cancer and breast self-examination. The reliability of the Arabic version of the CHBMS scored a Cronbach's alpha ranging from 0.65 to 0.89. The authors also examined construct validity by subjecting the Arabic version to factor analysis using a principal component analysis. In the statistical test, we loaded each of the factors examined (i.e., perceived susceptibility, perceived barriers, and perceived benefits) on their respective scale in the CHBM scale, establishing the construct's validity.

In addition, the authors added an item to the perceived barriers scale to measure fatalism in the Arab population. Due to the spiritual and cultural nature of the Arab population, the belief of fatalism highlights the role of God in health and illness (Aboul-Enein, 2010; Shah, Ayash, Pharaon, & Gany, 2008).

Using the CHBMS in breast cancer screening has been proven valid and reliable across multiple languages and different cultures. The instrument has been translated into Malay (Parsa, Kandiah, Mohd Nasir, Hejar, & Nor Afiah, 2008), Farsi (Taymoori & Berry, 2009), and Korean (Lee, Kim, & Song, 2002), and it has also been conducted with different disease processes, such as medication adherence in heart failure patients (S. J. Bennett, Milgrom, Champion, & Huster, 1997).

Because our study is the first to translate the CHBMS into Arabic and apply it to population at risk for having a hemoglobinopathy-affected child, we used qualitative

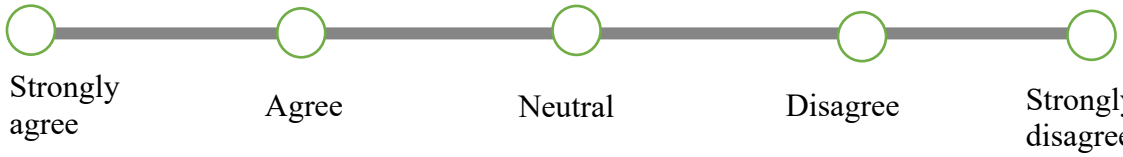
methodology to ensure that the instrument captures health beliefs in our population of interest.

We assessed the content validity of the questionnaire by a total of $N = 10$ Arabic-speaking Saudi individuals: five Arabic-speaking female nurses or other women with a graduate level of education, and five Arabic-speaking males with higher levels of education. The participants assessed the scale for relevance, redundancy, and clarity. Once content validity was established, we utilized concurrent and retrospective interviewing to confirm the comprehensibility and simplicity of the survey; we interviewed a total of $N = 5$ individuals in our study population. In concurrent interviewing, we asked participants to think out loud as they fill out the questionnaire to help the PI gain insight into the clarity of the scale. As in retrospective interviewing, we provided a probing question to respondents after they fill out the questionnaire (Dillman, 2011). The purpose of this procedure was to ensure that the questionnaire is easily comprehensible and that the flow of the questions is not confusing. We also made adjustments to the questionnaire based on the results of retrospective and concurrent interviews. We didn't evaluate the construct validity of the scale, however, but we calculated a Cronbach's alpha to determine the internal consistency of the scale.

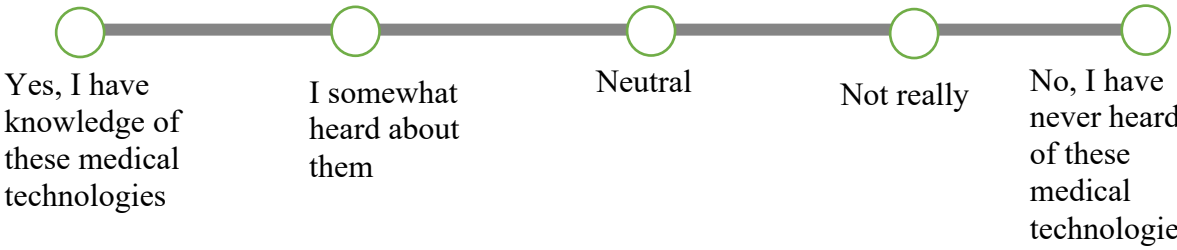
**Intention to Undergo PND or PGD in the Future**

We provided a short 5-item questionnaire, in Arabic and using a 5-point Likert scale, along with simple vignette to explain PND and PGD to the participants, aiming to explore the participants intentions regarding the use of hemoglobinopathy-preventive behaviors in the family planning process in an attempt to ensure they have healthy children. The questionnaire asked the following:

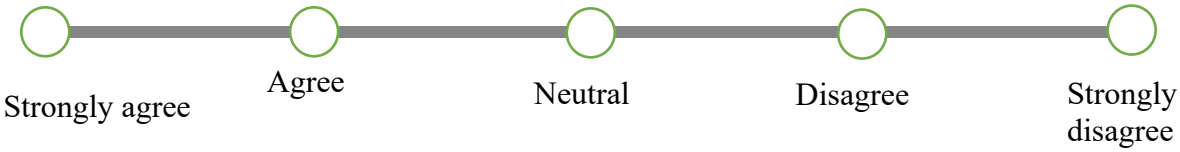
1. After learning about your increased risk to pass on your genetic predisposition for sickle cell diseases or beta thalassemia to your children, does this information impact your choice for a genetically compatible life partner?



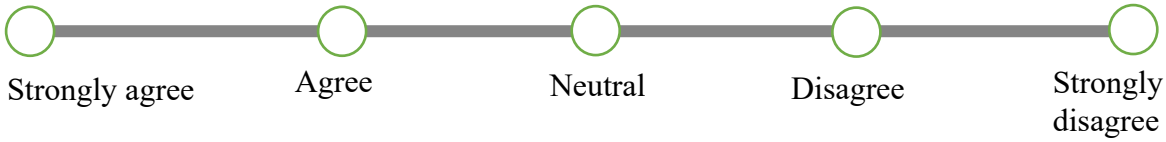

2. Have you ever heard of medical technologies (prenatal diagnosis or preimplantation genetic diagnosis) used for hereditary blood disorders among high risk couples to deliver healthy children in the future?



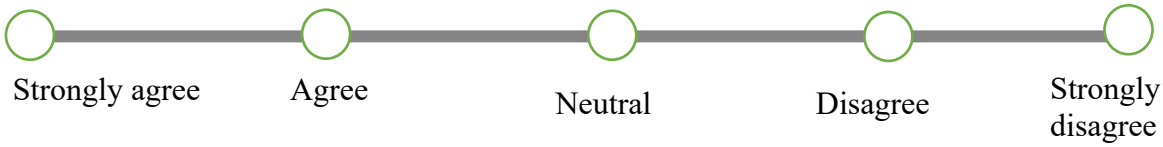

3. In case prenatal diagnosis procedure performed to terminate pregnancy for your affected child were offered to you, would you intend to use them?



4. In case prenatal diagnosis procedure to assists you in creating an appropriate plan of care for your affected child were offered to you, would you intend to use them?




5. In case preimplantation genetic diagnosis were offered to you to have a healthy child, would you intend to use it?




Prior to using the scale, we reviewed it for accuracy and design. We first assessed the CHBMS itself for content validity, then we examined the scale by $N = 5$ high-risk individuals, with the results captured by retrospective and concurrent interviewing.

The questionnaire was available via electronic copy, to access the partners who are affected or carrier with hemoglobinopathies but weren't able to come to the premarital screening clinic.

See Appendix A for English version, and Appendix B for Arabic version of CHBMS.

**Demographic and Other Covariates**

Participants' demographic information was collected from the premarital screening database and a self-reported demographic survey. We obtained demographic

factors such as age, sex, consanguinity, and previous experience with the disease from the premarital screening database. We acquired demographics that are not reported in the database (i.e., income level, educational level, and previous marriage with children diagnosed with hemoglobinopathies) via a self-reported survey. The purpose of collecting information on demographic variables is to run descriptive statistics and control the effects of demographic data on our statistical analysis. The demographic information was reported as follows:

1. *Age:* Participants' age was recorded in years. Therefore, level of measurement (LOM) will be a ratio.
2. *Sex:* Participants' sex was categorized as male or female. LOM will be nominal.
3. *Consanguinity:* Participants' preexisting family relationships with their partners was classified as no relationship between the couple, first cousin, or second cousin. LOM will be nominal.
4. *Previous experience with hemoglobinopathy:* Participants' experience with hemoglobinopathy was reported in personal and familial medical history. These include the following: personally, diagnosed with hemoglobinopathy (yes or no), undergone medical treatment for hemoglobinopathy (yes or no), has a family member diagnosed with hemoglobinopathy (yes or no). LOM will be nominal.
5. *Income level:* Participants' monthly income was categorized into one of five levels. LOM will be ordinal.

6. *Educational level:* Participants' education was categorized into one of four levels. LOM will be ordinal.
7. *Hemoglobinopathy affected children:* Participants' experience with a hemoglobinopathy-affected child from a previous marriage was reported as yes or no. LOM will be nominal.

Table 1. illustrates brief description of the variables to be measured in the study.

Table1.

*Summary of the Concepts, Variables, Definitions, Instruments, and Level of measurements*

| **Concept** | **Variable** | **Operational Definition** | **LOM** |
|---|---|---|---|
| Perceived threat of disease | Perceived susceptibility<br><br>Perceived seriousness of hemoglobinopathies | Total score of perceived threat within CHBMS | Ordinal |
| Perceived barriers & perceived benefits | Benefits and barriers of PND &PGD | Total score of perceived benefits and barriers within CHBMS | Ordinal |
| Cues to action | Triggers in seeking PND & PGD | Total score of cues to action in CHBMS | Ordinal |
| Self-efficacy | Confidence seeking of PND & PGD | Total score of self-efficacy in CHBMS | Ordinal |
| Fatalism | Role of fate | Score of fatalism | Ordinal |
| Intention | Intention in adoption of hemoglobinopathies preventative behaviors | Score of intentions to seek PND & PGD | Ordinal |

## Procedure

### Plans for Subject Recruitment

After obtaining approval from the Institutional Review Board (IRB) of Case Western Reserve University in the United States and from the participating premarital screening clinics in Saudi Arabia. The PI and the RA's introduced themselves to the premarital screening clinic staff, specifically the genetic counselor. All staff were told about the objective of the study and were given copy of the questionnaire to take home and read it in their free time.

We identified potential participants via the premarital screening database; recruitment occurred when participants came to collect their premarital screening results, identifying them as being at high risk for having a child with hemoglobinopathies. The researchers were stationed in the premarital screening clinics, and they approached participants who met the inclusion criteria after they have been made aware of their screening results. If the participants agreed to enroll in the study, they were taken to a private room where the PI discussed and explained the consent; consent forms were handed to the participants.

An additional option, an electronic version of the survey via Redcap will be available to the participants for multiple reasons:

- In some cases, not all couples come together to pick up their premarital screening results. Therefore, questionnaires cannot be administered to those who did not come to the clinic to pick up their results, for many reasons like being out of the city or for cultural reasons.
- In some cases, participants were not aware of their hemoglobinopathy trait that were confirmed via premarital screening. This may have caused emotional distress or additional concerns which limited their ability to complete the survey in the clinic. In this case, the provision of an electronic survey allows participants to complete the survey at their convenience after they accepted the diagnosis.

For those electing to complete the electronic survey, electronic informed consent followed the same template of the informed consent filed to the IRB committee. Electronic signature occurs via typing their name, along with checking a box next to the following statement: “by checking this box and typing my name I hereby sign this informed consent electronically”. Researchers’ contact information will be available in case questions were raised of the study. Electronic data were protected and stored in a computer protected by two passwords. See flow chart figure 3

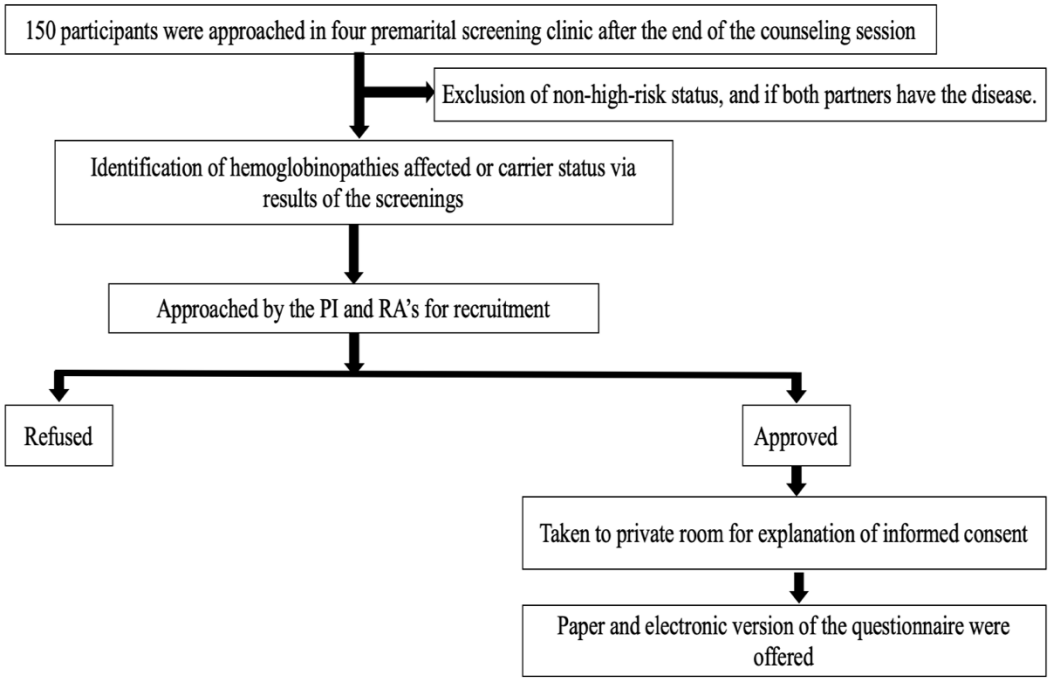



*Figure. 3* Recruitment Process

**Training Research Assistants for Data Collection**

A total of three RAs were hired for data collection at the premarital screening clinics. One was stationed in Jeddah regional lab premarital screening clinic, another RA was stationed to cover the cities of Dammam and Khobar due to their proximity. Lastly, another RA was stationed at Madinah premarital screening clinic. An information session was created for each RA separately which aimed at introducing the objective of the study. Also, the training session followed a specific protocol, which include education about inclusion criteria, explanation of the informed consent, information sheet, and the questionnaire. The RA's were instructed not to give additional education to the participants but simply explain the objective of the study based on the information sheet to help standardize method of data collection. Weekly meetings between each RA and PI were performed via phone or online to get feedback on the process and strategies to enhance data collection.

All of the RA's are health care workers, their jobs ranged from social worker to genetic counselor to nursing student. The education provided to each RA during their training about the diseases and hemoglobinopathies preventative measures were not novel information to the RA's. In addition, each RA were allowed to collect data based on their schedule availability, data collection continued from the month of May 2019 until August 2019.

### Data Collection Method

Once informed consent was obtained, we collected demographic information from the participants' themselves. The Arabic version of the CHBMS was administered to measure the participants' health beliefs and perceptions, followed by a scale to capture their future intentions to use hemoglobinopathy-preventive measures in the family planning process. These scales measured the participants' health perceptions toward having a future child diagnosed with hemoglobinopathies, established if these health perceptions predict their future intentions to undergo PND or PGD, and established the role consanguinity plays in moderating the relationship between health perceptions and healthy genetic decision-making. The two questionnaires together will take about 10 to 15 min to complete, depending on the participants' speed in answering them. Participants were informed that they will receive compensation of 30 Saudi Riyal (equivalent to $8 USD) in the form of a gift card after they complete the questionnaire, the amount of incentive is consistent with local research norms.

## Data Management

### Data Storage

Participants' data were de-identified; we assigned each participant an identification number associated with the questionnaire. Because the study's design is descriptive and cross-sectional in nature, the primary researcher did not collect patient contact information. Participants' names appeared only on their consent forms to protect confidentiality.

After collection, we entered all de-identifiable data electronically into a computer protected by two passwords. Participants' health information and questionnaires were stored in a locked drawer in a teaching assistant office in King Saud University's Nursing School, located in Jeddah. Once the data were analyzed, we destroyed participants' health information and questionnaires, as per IRB protocol.

**Data Entry**

We imported the collected data into the newest version of IBM's Statistical Package for Social Sciences (SPSS) in a password-protected computer for statistical analysis. We evaluated the data for the presence of outliers, cleaned the data to ensure accurate analysis, and entered the data twice to minimize any inconsistencies. If missing data are were present, we reviewed the original questionnaire again.

**Data Analysis**

Prior to data analysis, we ran frequencies to detect entry errors, missing data, and outliers. In addition, we examined the overall characteristics of the data by extracting the means, standard deviation, and distribution (Polit & Beck, 2012). This done, we ran multiple linear regression tests to answer our proposed research questions about the relationships among our independent predictor variables (IPVs), health beliefs, and our

outcome dependent variable, the intention to undergo hemoglobinopathy-preventive behaviors.

Identification of missing data, whether affecting pattern or rate, was carefully examined. The rate of missing data does not have a clear cutoff point, but if missing data ranges between 5–10%, the rate is considered to be low (Cohen, Cohen, West, & Aiken, 1983); likewise, if 40% of the missing data is present in a variable it is considered to be high, which can also be problematic (Raymond & Roberts, 1987).

The pattern of missing data will help uncover the root of the problem and solve it accordingly. A pattern of missing data is classified as systematic missing data (that is, a missing data point that is dependent on another variable or an unobserved missing value), which may be categorized as either missing completely at random (true random missing data) or missing at random (some type of nonrandom missing data). Pairwise deletion and mean substitution are not recommended methods to correct missing data (Schlomer, Bauman, & Card, 2010), but there are multiple other statistical techniques for this purpose. If missing data are identified in our data set, we will utilize full information likelihood because it provides a more accurate description of the statistics than other methods, is less biased, and adjusts the standard error of the missing data points.

**Multiple Linear Regression Analysis**

To answer our research questions, we used a linear regression for our statistical analysis. The following section will detail the important aspects of running a linear regression:

Multiple linear regression is used to explain the nature of the relationship between outcome predictive variable (OPV) (LOM is continuous) and multiple Independent

predictors variables (IPVs) (LOM can be continuous or categorical; Polit & Beck, 2012). Regression analyses allow researchers to fit a linear model into their data set and use it to predict OPV values from multiple IPVs; the equation of the linear regression will be as follows:

$$Y' = (a + b_1x_1 + b_2x_2 + \ldots + b_kx_{k)} + e_i$$

$Y'$ is the outcome variable, $x_1$ to $x_k$ are the IPVs in our model, $b_1$ to $b_k$ are the coefficients of our IPVs, and $e_i$ is the error of our $i$th participant (Field, 2013, p. 298).

**Assumption for Multiple Linear Regressions**

To capture the predictive ability of IPVs on OPV, several assumptions that might affect the statistical procedure in establishing the relationship between the IPVs and OPV need to be addressed, and a correction needs to be done in case any of the assumptions were violated. Assumptions are classified as primary and secondary.

Three *primary assumptions* are assumptions that apply to the descriptive statistics:

1. Variables must vary; all IPVs have some variance.
2. There will be no outliers or influential cases because these cases distort descriptive statistics and impact inferential statistics.
3. The relationship between the IPVs and OPV is linear.

Two *secondary assumptions* mostly affect inferential statistics (that is, the level of significance, or confidence interval):

1. Constant error variance around the prediction line (homoscedasticity)
2. Normality of error around the prediction (least square) line (Hair, Black, Babin, & Anderson, 2010).

**Moderation Analysis**

We used moderation analysis to examine whether an IPV influences the strength or direction of the relationship between any other IPV and OPV, as shown in Figure 4. This type of IPV is known as a moderator (J. A. Bennett, 2000). In the beginning of the analysis, a moderator variable will be assessed like any other IPV in a multiple-regression model. But subsequent analyses may reveal two distinct regression slopes in the data based on the value of the moderator, indicating the moderator variable's interaction with IPV, causing the relationship between the IPV and OPV to be weaker or stronger (Cohen et al., 1983).

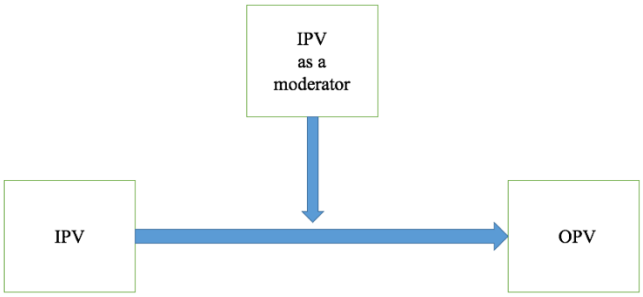



*Figure 4.* Model of a moderator variable.

**Data Transformation**

Prior to conducting the statistical analyses, we conducted an examination of the data distribution and note the presence of any violation of assumptions. If the data are not normally distributed or assumptions like linearity are violated, we will perform a data transformation, which "occurs when points existing within specific sequence are moved to another sequence by numerical manipulation, in an attempt to solve problems associated with the shape or distribution of the data" (Ferketich & Verran, 1994). There are three types of data transformation:

1. **Linear monotonic:** A mathematical function concerning a constant; causes a minor change in scale values.
2. **Nonlinear monotonic:** Maintains the direction of the variable, but stretches or compresses the data points.
3. **Nonmonotonic:** Causes a change in the data points, their position, and the distances between them (Ferketich & Verran, 1994).

## Addressing the Proposed Research Questions

Once the data were examined and were found to be normally distributed with no assumptions violated, we performed a series of multiple regression tests to answer the proposed research questions:

**RQ1**. What are the health beliefs of hemoglobinopathy among premarital Saudis at risk for having a child affected with a hemoglobinopathy?

To explore perceptions toward hemoglobinopathies in a population of premarital Saudis at high risk for having a child with hemoglobinopathies, we used descriptive statistics (e.g., percentages, frequencies, means, and standard deviations) to explore participants' demographic characteristics and their health beliefs regarding hemoglobinopathies and the related preventative measures (Field, 2009).

**RQ2.** Among the seven concepts of the HBM (i.e., perceived susceptibility, perceived seriousness, perceived benefits, perceived barriers, cues to action, self-efficacy, fatalism), which are associated with participants' likelihood of intention to use PND or PGD as a hemoglobinopathy preventive measure?

Based on the seven dimensions of the HBM (perceived susceptibility, perceived seriousness, perceived benefits, perceived barriers, cues to action, self-efficacy, and

fatalism), we identified the most significant concept(s) associated with likelihood to adopt PND and PGD. We ran multiple linear regressions by characterizing intentions to utilize PND or PGD as an OPV, which is a continuous variable. Then we placed the HBM constructs as IPVs, running multiple linear regressions and identifying which concepts explain most of the variance (Field, 2009).

**RQ3**. What is the role of consanguinity as a moderator variable on the relationship between participants' health perceptions and intention to use PND or PGD as a hemoglobinopathy preventive measure?

To test the moderating effects of consanguinity on the relationship between health perception and intentions to use PND or PGD in the family planning process, we tested for an interaction using a hierarchical multiple regression analysis. In the first step, we ran a regression using all seven health belief concepts along with consanguinity as IPVs. Consanguinity as an IPV does not need to be a statistically significant predictor of OPV (intentions to use PGD or PND) to test for interactions in the next step. Next, we created an interaction term (the outcome between each of the health beliefs as IPVs and consanguinity as a moderator variable) and enter it into our analysis. If the interaction term explains a statistically significant variance in the OPV, then consanguinity will be present in our model as a moderator (J. A. Bennett, 2000).

## Human Subject Protection

After IRB of Case Western Reserve University granted approval and the participating premarital clinics filed their approval letters, study procedures began. Each

participant was handed an informed consent document laying out the study's purpose, process, confidentiality measures, and incentives.

**Potential Risks and Benefits**

We first notified potential participants about the voluntary nature of participation, its descriptive purpose, and its lack of implication on future treatment. Participation in the study involves minimum risks. Nonetheless, the questionnaire has the potential to spark a sense of discomfort, stress, and fear about the health of future children. We thus informed participants that they can discontinue the study at any time.

Participation in the study didn't not have direct benefits to the those who enrolled, yet the result of the study will benefit the population of Saudi's at high risk for having a future child with hemoglobinopathies by creating a better understanding of the role of health belief in adopting preventative behaviors. The results of the study will help the health care team and health systems to use health beliefs to create health interventions in our population of interest to advance the health of future children.

**Confidentiality and Privacy Issues**

To ensure privacy, we gave the questionnaires to participants in a private room after they receive their premarital screening results. To maintain the confidentiality of the participants, we assigned each participant a code number on the questionnaire; each code will be linked to the participant's name on a separate codebook. The questionnaires and the code book were locked in a cabinet, and electronic data will be stored in a computer protected by two passwords. We only used the collected data for this study, and we granted access to study personnel only.

For those electing to complete the electronic survey, electronic informed consent followed the same template of the informed consent filed to the IRB committee. Electronic signature occurs via typing their name, along with checking a box next to the following statement: “by checking this box and typing my name I hereby sign this informed consent electronically”. Researchers’ contact information were available in case questions were raised of the study

**Incentives**

We gave each participating individual $8 (30 Saudi riyals) as compensation in the form of a gift card and clearly state the incentives on the informed consent document.

**Special Protection**

The study does not entail any form of video or audio recordings. The study protocols were reviewed by the Case Western Reserve University IRB and the premarital clinics administration.

**Threats to Internal and External Validity**

**External validity** refers to the generalizability of the results from particular people, settings, and times and how they apply across types of people, settings, and times (Higgins & Straub, 2006). There are four factors associated with statistical interaction effects: interaction of subject selection and treatment, interaction of setting and treatment, interaction of history and treatment, and interaction of multiple treatments (Higgins & Straub, 2006). Due to the fact that our study aims to utilize convenience sampling in the recruitment process, sampling bias might occur because the entire population consists of

high-risk individuals who share some characteristics, and all participants have the potential to decline participation in the study.

Nonetheless, this potential disadvantage in our study is acceptable because our study is exploratory in nature, and is the first to be implemented in population of hemoglobinopathies high risk population.

**Internal validity "**is concerned with the congruence between theoretical assertions and the statistical relationship between two variables" (Higgins & Straub, 2006). Threats to internal validity may include one of the following: history, maturation, testing, regression toward the mean, differential selection of participants, differential loss of participants, diffusion to treatment, ambiguity about the causal relationship between the variables, compensatory equalization of the treatment, compensatory rivalry among the subjects, and demoralization of the control subjects (Higgins & Straub, 2006). Because our study is a descriptive cross-sectional study, ambiguity about the direction of the causal relationship between health beliefs and the intention to undergo PND or PGD is an internal threat to our proposed study. In addition, history or concurrent events, such as the premarital awareness campaign currently happening in Saudi Arabia, have the potential to influence the study's results and cause a threat to the internal validity of our study.

However, temporal ambiguity can be managed in our study because variables within health belief model have been studied heavily, and the relationship among the study variable have indicated that health belief guide adoption of healthy behavior. See figure. 1.

In addition, the premarital awareness campaign has the potential to influence the result of the study, but these campaigns have been going on since induction of the premarital screening law but failed to alter health behavior among high risk premarital couples.

**Timeline**

| Time | 2 months | 1 month | 4 months | 2 months | 2 months |
|---|---|---|---|---|---|
| IRB | → | | | | |
| Enrollment | | → | | | |
| Data collection | | | → | | |
| Data analysis | | | | → | |
| Dissemination | | | | | → |

**Study's implications in nursing practice, research and policy**

The result of the study has multiple implications for science, nursing practice, and policy. As a result of the study, nurses working in genetic counseling clinics and community health nurses will better understand health beliefs and their role in genetic decision making, and will also gain insight on drivers of health behavior for a population of Saudis at risk for having a future child diagnosed with hemoglobinopathies.

Since this study is exploratory in nature, it will guide future research on this population and interventions aimed at improving genetic decision making. Lastly, the result of the study has positive implication on premarital screening policy in Saudi Arabia. Currently premarital screening policy goal is to prevent marriage among high risk couples, but the policy was unsuccessful. Therefore, incorporation of policy to provide alternative

solution to prevent hemoglobinopathies like PND or PGD can decrease the rate of hemoglobinopathies and allow high risk couple to marry.

CHAPTER IV

# Results

Chapter 4 will summarize the sample characteristics and answer the study's research questions. The aim of the study was to use the health belief model (HBM) to capture intention to use hemoglobinopathy preventive behaviors such as prenatal diagnosis (PND) or preimplantation genetic diagnosis (PGD). Among premarital individuals who either carry the genes for or are affected with hemoglobinopathies, we examined how health beliefs affect intention to adopt hemoglobinopathy preventive behaviors.

The research questions are as follows:

(1) What are the health beliefs of hemoglobinopathy among premarital Saudis at risk for having a child affected with a hemoglobinopathy?

(2) Among the seven concepts of the HBM (i.e., perceived susceptibility, perceived seriousness, perceived benefits, perceived barriers, cues to action, self-efficacy, fatalism), which are associated with participants' likelihood of intention to use PND or PGD as a hemoglobinopathy preventive measure?

(3) What is the role of consanguinity as a moderator variable on the relationship between participants' health perceptions and intention to use PND or PGD as a hemoglobinopathy preventive measure?

## Sample Characteristics

Throughout the enrollment period from May 3, 2019, to August 30, 2019, a total of 150 participants from four Ministry-of-Health-operated premarital screening clinics were approached and screened for participation in the study. Potential participants were

identified by the premarital screening system as a carrier of or as affected with hemoglobinopathy when they applied for marriage certificates. Before obtaining their health clearance documents, which were needed to issue a marriage certificate, the computer system referred potential participants to the genetic counseling clinic. At the clinic, a physician conducted a genetic counseling session to notify potential participants about their hemoglobinopathy carrier or affected status and educate them about their future risk of having a child affected with hemoglobinopathies. After the counseling session ended, a researcher approached the potential participants for enrollment, explained the study process, asked the participants to sign an informed consent document, and offered the participants a hard copy of the questionnaire or an electronic copy via Redcap.

A total of 49 individuals refused to participate because they did not have the time, or because they were overwhelmed after been identified as carriers status during the counseling session. The majority of the participants who refused to participate had limited knowledge about their carrier status, and were more emotionally distressed when their partner was also a carrier Those patients displayed extreme psychological and emotional distress, they were hard to approach because they are faced with many uncertainties. In addition, the elevated refusal rate in Jeddah and Dammam, when compared to other cities, is because these cities have a higher population. Therefore, it attracts more participants, perform more screening, and display high refusal rate. But in fact, the refusal rate is similar to the other cities of Madinah and Khobar who have lower population rate.

A total of 101 questionnaires were collected. Figure 5 demonstrates the process of sample enrollment.

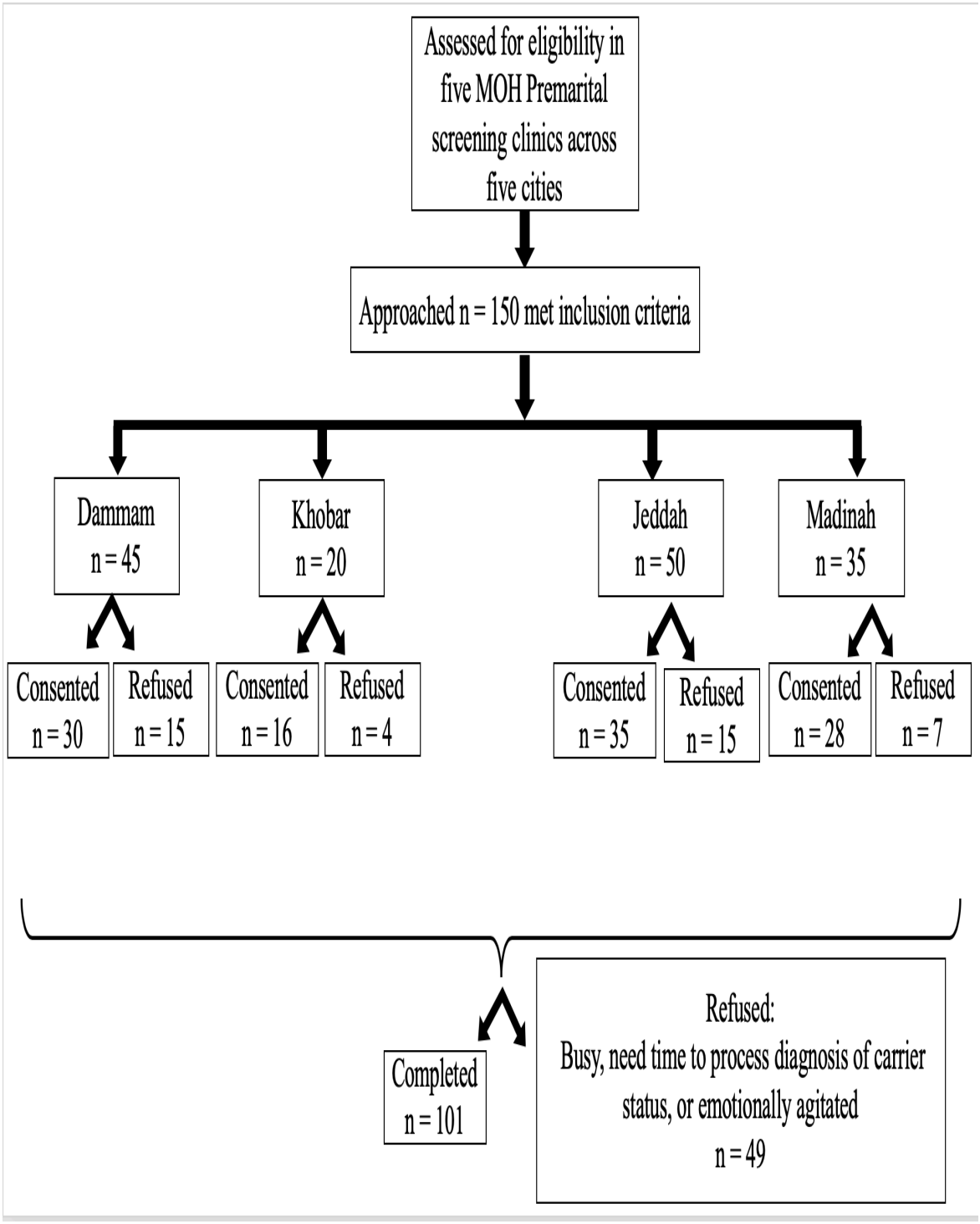



*Figure 5*. Sample enrollment process.

In this descriptive study, 101 individuals with hemoglobinopathies, either with a carrier status or affected status, were enrolled. Table 2 presents the main characteristics of the sample. Participants' demographics were self-reported and included age, sex, educational level, income, consanguinity with intended partner, support of consanguineous marriages, carrier or affected with sickle cell disease, carrier or affected with beta thalassemia disease, on current medical treatment for hemoglobinopathies, family history of hemoglobinopathies, and hemoglobinopathy-affected children from previous marriages.

The mean age of the sample was 31.39 years ($SD$ = 8.65, $n$ = 70), and 56.7% were male ($n$ = 55). The majority of the sample were educated, with 42% having graduated college with a bachelor's degree ($n$ = 40), and 24% reporting a monthly income lower than 3,000 riyal ($n$ = 23). In terms of consanguinity, unlike in the previous literature (Alharbi et al., 2015; Middle, 2007; Warsy, 2014), 71.3% of the participants were not consanguineous with their intended partners ($n$ = 67), and 65.7% did not support consanguineous marriages ($n$ = 65). All the participants were premarital, and most of them had the sickle cell trait (74.2%, $n$ = 72), followed by sickle cell disease (29.3%, $n$ = 29). Meanwhile, fewer participants were carriers and affected with beta thalassemia than with sickle cell. A total of 29.2% participants were carriers of beta thalassemia, and 12.1% participants were affected with beta thalassemia, $n$ = 12. A total of 76% of the participants are not on medical management of hemoglobinopathies ($n$ = 76). Additionally, 58 (59.2%) participants reported a family history of hemoglobinopathies, and 89.9% reported not having children affected with hemoglobinopathies from a previous marriage ($n$ = 88).

Table 2

| **Demographic Characteristics of the Participants (*n* = 101)** | **Frequency (%)** |
|---|---|
| Education | |
| High School Degree | 27 (28.4%) |
| Diploma Degree | 19 (20%) |
| Bachelor's Degree | 40 (42%) |
| Higher Graduate Degree (Master's or PhD) | 9 (9.5%) |
| Gender | |
| Male | 55 (56.7%) |
| Female | 42 (43.3%) |
| Monthly Income | |
| Less than 3000 Riyal | 23 (24%) |
| Between 3000 and 4990 Riyal | 20 (20.8%) |
| Between 5000 and 7990 Riyal | 19 (19.8%) |
| Between 8000 and 11990 Riyal | 15 (15.6%) |
| More than 12000 Riyal | 19 (19.8%) |
| Consanguineous with Partners (if Applicable) | |
| No | 67 (71.3%) |

| | |
|---|---|
| Yes | 27 (28.7%) |
| Support Consanguineous Marriage | |
| No | 65 (65.7%) |
| Yes | 34 (34.3%) |
| Affected with Sickle Cell Disease | |
| No | 70 (70.7%) |
| Yes | 29 (29.3%) |
| Affected with Beta Thalassemia Disease | |
| No | 87 (87.9%) |
| Yes | 12 (11.9%) |
| Currently on Medical Treatment for Hemoglobinopathy | |
| No | 76 (76.8%) |
| Yes | 23 (23.2%) |
| Sickle Cell Trait | |
| No | 25 (25.8%) |
| Yes | 72 (74.2%) |
| Beta Thalassemia Trait | |

| | |
|---|---|
| No | 68 (70.8%) |
| Yes | 28 (29.2%) |
| Family Medical History of Hemoglobinopathies | |
| No | 40 (40.8%) |
| Yes | 58 (59.2%) |
| Hemoglobinopathy-affected Children from Previous Marriage | |
| No | 88 (89.8%) |
| Yes | 10 (10.2%) |

**Psychometric Analysis of Study Instruments**

We measured the internal consistency (Cronbach's alpha) of the Arabic version of the champion health belief model scale (CHBM), which measures health beliefs regarding hemoglobinopathies and their preventive measures (PND or PGD). Table 3 demonstrates Cronbach's alpha of each scale within the HBM. In the Saudi population—either those affected with or carriers of hemoglobinopathies—each scale had a Cronbach's alpha above the value of 0.80, indicating sufficient internal consistency reliability (Mikhail, & Petro-Nustas, 2001). Because of the high value of Cronbach's alpha in CHBM scales, especially in perceived susceptibility (.90) and self-efficacy scales (.92), there was a strong possibility of repetitive items in the survey battery.

Further, prior to distributing the questionnaire, content validity was established via qualitative methods. A total of 10 Arabic speaking Saudis reviewed the questionnaire for relevance, redundancy, and clarity. Participants were asked to score each item within the CHBMS from 1 to 10 (low to high) in terms of the three. The results demonstrated that the questionnaire was clear and relevant, but three individuals commented that some of the items seemed redundant. Therefore, these items were rewritten to eliminate redundancy.

Once content validity was established, retrospective and concurrent interviewing of five participants in the population was conducted to evaluate the questionnaire for simplicity and comprehensibility. The five participants stated that they the questionnaire was simple and that they were able to understand the goal of the questions.

Table 3

*Reliability Coefficients for Study Instruments*

| Scales | Item Means | Cronbach's Alpha | *N* | Number of Scale Items |
|---|---|---|---|---|
| Perceived Susceptibility | **2.76** | **.900** | **99** | **5** |
| Perceived Seriousness | **2.98** | **.881** | **99** | **7** |
| Perceived Benefits of PND or PGD | **3.43** | **.897** | **96** | **5** |

| | | | | |
|---|---|---|---|---|
| Perceived Barriers of PND or PGD | **3.31** | **.801** | **94** | **8** |
| Self-Efficacy | **3.44** | **.922** | **95** | **6** |
| Cues to Action | **4.20** | **.886** | **95** | **4** |
| All Subscales of CHBMS | **3.31** | **.897** | **88** | **35** |

## Analysis of Research Questions

**Research Question 1: What are the health beliefs of hemoglobinopathy among premarital Saudis at risk for having a child affected with a hemoglobinopathy?**

To answer research question 1, frequency, normality, and descriptive statistics were calculated and analyzed. All the variables were normally distributed (skewness ranges between 3 and -3, skewness between 8 and -8). Perceptions toward hemoglobinopathies were self-reported via CHBMS. All perceptions had scores ranging from 1 to 5 (lowest to highest). The scoring criteria were as follows: 1–2 indicated low perceptions of the construct, 2–3 indicated moderately low perceptions of the construct, 3–4 indicated moderately high perceptions of the construct, and 4–5 indicated high perceptions of the construct.

The sample's perceived personal susceptibility to having a child affected with hemoglobinopathies had a mean score of 2.77 ($SD$ = 1.00), and perceived seriousness of

the diseases had a mean score of 2.99 (*SD* = 0.99). Additionally, the perceived benefits of hemoglobinopathy preventive measures (PND or PGD) had a mean score of 3.43 (*SD* = 0.98), and perceived barriers to adopting preventive measures had a mean score of 3.31 (*SD* = 0.70). Cues to action are personal signs that trigger adoption of hemoglobinopathy preventive measures; they had a mean score of 4.20 (*SD* = 0.82). Last, the sample's perceived self-efficacy and confidence of adopting preventive measures had a mean score of 3.45 (*SD* = 0.85). Table 4 provides descriptive statistics of the study's main variables.

Table 4

*Descriptive Statistics of Main Variables*

| Variable | Mean | Median | Skewness | Kurtosis | N |
|---|---|---|---|---|---|
| Perceived Susceptibility | 2.77 | 2.80 | -.118 | -.782 | 99 |
| Perceived Seriousness | 2.99 | 3.14 | -.209 | -.704 | 99 |
| Perceived Benefits of PND or PGD | 3.43 | 3.60 | -.720 | .246 | 96 |
| Perceived Barriers of PND or PGD | 3.31 | 3.31 | .140 | -.120 | 94 |
| Self-Efficacy | 3.45 | 3.50 | -.669 | .590 | 95 |
| Cues to Action | 4.20 | 4.25 | -1.374 | 2.247 | 95 |
| **Fatalism** | 3.01 | 3.00 | -.215 | -1.094 | 98 |

| | | | | | |
|---|---|---|---|---|---|
| **Risk of Hemoglobinopathy-affected Child Impacting Choice of Spouse** | 3.79 | 4.00 | -.806 | -.420 | 96 |
| **Previous Knowledge of PND and PGD** | 1.93 | 2.00 | 1.313 | 1.054 | 95 |
| **Perception of Terminating Pregnancy via PND** | 3.18 | 3.00 | -.362 | -.421 | 95 |
| **Intention to use PND and PGD in Family Planning** | 3.90 | 4.00 | -.632 | .528 | 96 |
| **Intention to Use PND and PGD if Offered** | 3.72 | 4.00 | -.485 | -.006 | 95 |

To fully understand the nature of participants' health beliefs, we examined the relationship among the main study variables. Pearson's correlation coefficient was used to analyze the relationships between the main variables. However, before conducting the analysis, we ensured that the main assumptions of Pearson's correlation, including the variables of a continuous level of measurement, normal distribution, linearity, and homoscedasticity, were not violated. Field (2013) was used as a guideline when

evaluating and analyzing the results of Pearson's correlation effect sizes: +/- .11–.35 was a low to moderate effect size, +/- .36–.50 was a strong effect size, and +/- .51–.79 was an extremely strong effect size. Table 5 illustrates the correlation coefficients of the study's variables.

The correlation coefficients demonstrated that the variable of self-efficacy ($r$ =.674; $p < .01$) had the highest positive correlation with intention to use PND or PGD to have a healthy child, followed by perceived benefits of PND or PGD and intention to use PND or PGD as hemoglobinopathy preventive measures ($r$ = .562; $p < .01$), and by perceived seriousness and intention to use PND or PGD ($r$ =.503; $p < .01$). Further, there was a high positive correlation between self-efficacy and perceived benefits ($r$ =.705; $p < .01$), followed by perceived seriousness and perceived benefits ($r$ =.584; $p < .01$), and by cues to action and perceived benefits ($r$ =.534; $p < .01$).

At the same time, fatalism, which is the belief that having a hemoglobinopathy-affected child is the result of fate, had a negative moderate relationship with perceived barriers ($r$ = -.316; $p < .01$), followed by a low, negative relationship with perceived benefits (r = -.187; p < .05)

Table 5

*Correlation Among Main Variables (n = 87)*

| | Variable | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. |
|---|---|---|---|---|---|---|---|---|---|
| **1.** | Intention to use PND or PGD | - | | | | | | | |
| **2.** | Perceived Susceptibility | .262* | - | | | | | | |
| **3.** | Perceived Seriousness | .503*** | .300*** | - | | | | | |
| **4.** | Perceived Benefits | .562*** | .329*** | .584*** | - | | | | |
| **5.** | Perceived Barriers | .011 | -.282*** | -.354*** | .006 | - | | | |
| **6.** | Self-Efficacy | .674*** | .304*** | .447 *** | .705*** | .127 | - | | |
| **7.** | Cues to Action | .437*** | .177** | .402*** | .534*** | -.179** | .538*** | - | |
| **8.** | Fatalism | -.172** | .037 | -.133 | -.187** | -.316*** | -.024 | .101 | - |

*Note. *p<.1,**p<.05, ***p<.01*

**Research Question 2: Among the seven concepts of the HBM (i.e., perceived susceptibility, perceived seriousness, perceived benefits, perceived barriers, cues to action, self-efficacy, fatalism), which are associated with participants' likelihood of intention to use PND or PGD as a hemoglobinopathy preventive measure?**

Multiple linear regression was used to answer research question 2. This research question enquired about the health beliefs within the HBM that predict intention to use PND or PGD as a hemoglobinopathy preventive measure in a Saudi population at risk for having hemoglobinopathy-affected children. Before conducting linear regression, the assumptions of this statistical test, including primary assumptions of linearity, variation of variables, and no influential cases and secondary assumptions of constant error variance and normally distributed error variance, were examined.

The assumption of linearity requires the relationship between the independent predictor variable (IPV) and dependent outcome variable (DOV) to be linear, and the presence of influential cases might influence linearity. To examine assumptions of linearity, partial plots were used as an omnibus test by adding three lines of fit to these plots (linear, quadratic, and cubic). If the difference between these lines exceeded .02, the assumption of linearity was violated. In our study, five variables (i.e., perceived benefits, perceived barriers, perceived susceptibility, fatalism, and self-efficacy) had a line of fit with a difference exceeding .02. Therefore, to confirm the potential violation of linearity, the four IPVs were transformed (squared and cubed). After the transformation, the $R^2$(.526) remained the same as in the original model, indicating that the assumption of linearity was not violated.

Next, to assess variation of variables, the frequency of health belief variables was analyzed. None of the variables in the study exceeded 90% of each of the health beliefs, indicating that the variables did not violate the assumption of variability. Cook's D was used to evaluate the presence of influential cases. If a Cook's D value exceeds 1.0, influential cases are present. In our study, the maximum value of Cook's D was 0.578, so the assumption of no influential cases was not violated.

Regarding secondary assumptions, constant error variance evaluated the difference between predicted and observed scores for participants, and the ratio between highest and lowest variance needed to be 3:1. None of the study's variables violated the assumption of constant error variance. Last, studentized deleted residual was used, indicating normal distribution of residual with skewness of .576 and kurtosis of 1.634. This confirmed that the assumption of normal distribution of error variance was not violated.

Multicollinearity data were examined because multicollinearity can decrease the amount of variance explained by the IPV's and increase standardized error. In our study, all the IPVs had a tolerance value greater than 0.1 and variance inflation factor less than 10, confirming the absence of multicollinearity.

When running multivariate linear regression, the variable of intention to use hemoglobinopathy preventive behavior was set as DOV. Additionally, the following variables were set as IPVs: perceived susceptibility, perceived seriousness, perceived benefits, perceived barriers, cues to action, self-efficacy, and fatalism. The overall model displayed that 48.4% of the DOV variance (intention to use PND or PGD as

hemoglobinopathy preventive behavior) is explained by the all the IPVs (health beliefs within the HBM).

The regression results (Table 6) indicated that self-efficacy was the sole significant predictor in intention to adopt hemoglobinopathy preventive behaviors (β = .538, $p < .01$). Thus, an increase of one point of self-efficacy led to a 0.538 point increase in DOV of intention to adopt hemoglobinopathy preventive measures. Followed by the IPV of perceived seriousness (β = .212, $p$ =.06), with an increase of one point of perceived seriousness led to .212 increase of intention to adopt hemoglobinopathy preventative measure.

Meanwhile, the health perception of fatalism had an inverse yet not statistically significant relationship with intention to use hemoglobinopathy preventive behaviors (β = -.147, $p$ = .103). Table 6 presents the regression results.

Table 6

*Regression Analysis Summary for Health Beliefs Predicting Intention to Adopt PND or PGD*

| **Variable** | **B** | **SE B** | **β** | **t** | **p** |
|---|---|---|---|---|---|
| **Constant** | .837 | .839 | | .998 | .321 |
| **Fatalism** | -.112 | .068 | -.147 | -1.649 | .103 |
| **Perceived Susceptibility** | .034 | .091 | .033 | .371 | .712 |
| **Perceived Seriousness** | .215 | .113 | .212 | 1.911 | .060 |

| | | | | | |
|---|---|---|---|---|---|
| **Perceived Benefit** | -.025 | .133 | -.024 | -.190 | .850 |
| **Perceived Barriers** | -.006 | .152 | -.004 | -.041 | .967 |
| **Self-efficacy** | .621 | .143 | .538 | 4.345 | < .001 |
| **Cues to Action** | .104 | .124 | .084 | .836 | .406 |

**Research Question 3: What is the role of consanguinity as a moderator variable on the relationship between participants' health perceptions and intention to use PND or PGD as a hemoglobinopathy preventive measure?**

To answer research question 3, multiple linear regression was used to identify the role of consanguinity as a moderating factor between health beliefs (perceived susceptibility, perceived seriousness, perceived benefits, perceived barriers, cues to action, self-efficacy, and fatalism) and intention to use hemoglobinopathy preventive measures. Because the assumptions of linear regression were not violated, multiple linear regression analysis was presumed appropriate.

A total of seven interaction terms were computed to assess whether consanguinity acted as a moderator between each of the health beliefs within the HBM and intention to adopt PND or PGD. Afterwards, each interaction term was compared with the final adjusted model to determine whether the adjusted $R^2$ increased in the presence of the interaction term compared to in the original model. A total of seven regressions were analyzed. Each regression had two blocks, the first one with the original model (research

question 2) and the second one with the interaction term. Then evaluation of the adjusted $R^2$ between the two models and the significant increase of $R^2$ in the second block (interaction term) indicated that consanguinity acted as a moderator variable.

The results of the regressions are listed in Table 7, which shows that consanguinity did not moderate the relationship between all health beliefs within the HBM and intention to use PND or PGD. None of the interaction terms were significant when compared to the original model, with no to negligible increases of the adjusted $R^2$ . This suggested that consanguinity did not act as a moderator.

Table 7

| ***Linear Model of Predictors of Intention to Use PND or PGD*** | **b** | **SE B** | **β** | **t** | **P** |
|---|---|---|---|---|---|
| **Perceived Susceptibility** | .025 | .111 | .024 | .227 | .821 |
| **Consanguinity** | -.443 | .672 | -.190 | -.660 | .512 |
| **Perceived Susceptibility * Consanguinity** | .081 | .214 | .113 | .379 | .706 |
| **Perceived Seriousness** | .193 | .124 | .187 | 1.55 | .124 |
| **Consanguinity** | -.193 | .701 | -.083 | -.276 | .784 |
| **Perceived Seriousness * Consanguinity** | -.002 | .226 | -.003 | -.010 | .992 |

| | | | | | |
|---|---|---|---|---|---|
| **Perceived Benefit** | -.058 | .154 | -.057 | -.379 | .705 |
| **Consanguinity** | -.190 | .684 | -.082 | -.277 | .782 |
| **Perceived Benefit * Consanguinity** | -.003 | .199 | -.004 | -.015 | .988 |
| | | | | | |
| **Perceived Barriers** | .089 | .165 | .059 | .538 | .592 |
| **Consanguinity** | 1.34 | .996 | .578 | 1.351 | .181 |
| **Perceived Barriers * Consanguinity** | -.478 | .302 | -.681 | -1.582 | .118 |
| | | | | | |
| **Cues to Action** | -.049 | .154 | -.040 | -.321 | .749 |
| **Consanguinity** | -1.20 | .857 | -.515 | -1.401 | .166 |
| **Cues to Action * Consanguinity** | .250 | .209 | .436 | 1.199 | .235 |
| | | | | | |
| **Self-Efficacy** | .623 | .159 | .540 | 4.00 | P < .001 |
| **Consanguinity** | -1.66 | .801 | -.716 | -2.08 | P < .05 |
| **Self-Efficacy * Consanguinity** | .435 | .230 | .643 | 1.88 | .063 |
| | | | | | |
| **Fatalism** | -1.00 | .076 | -.129 | -1.326 | .189 |
| **Consanguinity** | -.466 | .574 | -2.00 | -.812 | .420 |

| | | | | | |
|---|---|---|---|---|---|
| **Fatalism* Consanguinity** | .085 | .172 | .121 | .494 | .623 |

**Summary of Findings**

Our data provided insight into the health beliefs of premarital Saudis at risk for having a child with hemoglobinopathies. Our results indicated that participants had moderately low perceptions of the seriousness of and susceptibility to having a future child with hemoglobinopathies. Perceived barriers to and benefits of using PND or PGD were moderately high, and participants reported high levels of perceived self-efficacy and cues to action.

An evaluation of health beliefs in the population of premarital Saudis at risk for having a hemoglobinopathy-affected child has never been conducted before. We found that self-efficacy was significantly associated with intention to adopt hemoglobinopathy preventive behaviors. Of all the health beliefs, self-efficacy had the highest and most positive correlation with the dependent variable of intention to use PND or PGD, followed by perceived benefits of PND or PGD and perceived seriousness of hemoglobinopathies. Therefore, our study confirmed the importance of tailoring interventions by health care providers to patients' self-efficacy and of genetic counselors gaining insights into patients' intention and willingness to use PND or PGD to prevent hemoglobinopathies in their future children.

We used the HBM's predictive ability to capture future intention to use PND or PGD as a hemoglobinopathy preventive measure. Self-efficacy was a significant predictor of intention to adopt PND or PGD after controlling for demographic

characteristics. The positive relationship between self-efficacy and intention to adopt health behaviors was consistent with the previous literature (Kim & Park, 2012; Lippke, Wiedemann, Ziegelmann, Reuter, & Schwarzer, 2009; Luszczynska & Schwarzer, 2003; Sheeran, Maki, Montanaro, Avishai-Yitshak, Bryan, Klein, ... & Rothman, 2016; Sherman, Mann, & Updegraff, 2006). This indicates that self-efficacy plays a crucial role as an antecedent of adopting health behaviors. Our findings add to the literature by demonstrating the role of self-efficacy in advancing health behavior in the understudied population of premarital Saudis at risk for having a future child with hemoglobinopathies.

Additionally, the results of this study highlighted assessment and targeting of patients' self-efficacy as a valuable tool in genetic counseling. Last, they showed that consanguineous relationships did not moderate the relationship between health beliefs and intention to adopt hemoglobinopathy preventive measures.

# CHAPTER V

## Discussion

Chapter five contains a discussion of the study's main findings and their impact on nursing research and practice. The chapter also addresses the limitations of the study and makes recommendations for future research.

Hemoglobinopathies, specifically sickle cell disease (SCD) and beta thalassemia, are autosomal recessive genetic conditions that are common in Saudi Arabia; they are lifelong and preventable anemia diseases (Al-Saleh & Hussain, 1992). In Saudi Arabia, 2% to 27% of people are carriers of the sickle cell trait, and 1.4% of the population has SCD (Jastaniah, 2011). Additionally, 3.2% of the population is a carrier of the thalassemia trait, and 0.07% has thalassemia (Alhamdan et al., 2007). After the Ministry of Health implemented a mandatory premarital screening program, researchers wanted to assess the program's success. They found that 90% of high-risk couples knew about their high-risk status and yet continued with their marriage plans (Alhamdan, Almazrou, Alswaidi, & Choudhry, 2007; Al Sulaiman et al., 2010; Alswaidi et al., 2012).

Advanced medical technologies such as prenatal diagnosis (PND) and preimplantation genetic diagnosis (PGD) help high-risk couples produce children free of hemoglobinopathies or better prepare them to manage their affected children (Arnett, Greenspoon, & Roman, 2013). However, evaluation using HBM of health beliefs regarding hemoglobinopathies and their preventive measures can provide insights into the likelihood of premarital Saudis using preventive measures to reduce the risk of having hemoglobinopathy-affected children. The HBM has been used extensively in research because health beliefs are a valuable examination tool and facilitate identifying barriers

and willingness to adopt health behaviors. Evaluations of health perceptions toward diseases and disease prevention behaviors play a crucial role in promoting health and can be incorporated into patients' health plans (Skinner, Tiro, & Champion, 2015). Therefore, the aim of this study was to characterize health beliefs regarding hemoglobinopathies and the use of PND and PGD as preventive measures. We also examined health beliefs within the HBM and their relationship with the intention to use hemoglobinopathy preventive measures and explored the role of consanguinity as a moderator between health beliefs and intention to use hemoglobinopathy preventive measures.

## Psychometric Analysis of Study Instruments

All the scales within the HBM (perceived susceptibility, perceived seriousness, perceived benefits, perceived barriers, cues to action, and self-efficacy) were measured using the Arabic version of the champion health belief model scale (CHBMS), and were internally consistent, based on the Cronbach's alpha (α) values. The CHMBS has not been tested before on adults who are affected or are carriers of hemoglobinopathies. The internal consistency reliability of all the subscales within the CHBMS was high (α = .897). Each of the subscales also had high internal consistency reliability, perceived susceptibility (α = .900), perceived seriousness (α = .881), perceived benefits of PND and PGD (α = .897), perceived barriers of PND and PGD (α = .801), self-efficacy (α = .922), and cues to action (α = .886). The elevated levels of Cronbach's alpha in the CHBMS were consistent with those in previous studies that used CHBMS in different languages than English and that had different populations (Lee, Kim, & Song, 2002; Mikhail and Petro-Nustas, 2001; Parsa, Kandiah, Mohd Nasir, Hejar, & Nor Afiah, 2008; Taymoori & Berry, 2009).

## Discussion of the Research Questions

### Research Question One

The first research question explored the health beliefs of Saudis at the premarital stage who were confirmed via a premarital screening clinic to be either a carrier of or to be affected with hemoglobinopathies (sickle cell or beta thalassemia).

No examination of health beliefs among premarital Saudi adults who are carriers of or are affected with hemoglobinopathies has previously been conducted. Nonetheless, the results of this study were similar to those of previous studies on health beliefs regarding premarital counseling and genetic conditions in different populations (Karimzaei et al., 2015; Gustafson, Gettig, Watt-Morse, & Krishnamurti, 2007; Shaimaa, Samah, & Hanan, 2017).

The results of the present study agreed with those of Shaimaa et al. (2017), who performed a quasi-experimental study evaluating health beliefs regarding premarital counseling to prevent genetic conditions among 340 premarital Arabic speaking females in Benha University, Egypt, and examining their intention to seek premarital genetic counseling. Shaimaa et al. evaluated health beliefs and knowledge before and after an educational intervention that was designed based on the HBM. The results demonstrated that participants' health beliefs regarding premarital counseling prior to the intervention were similar to the health beliefs of our participants toward hemoglobinopathies and their preventive measures (PND and PGD). Both populations scored moderately low in perceived susceptibility and seriousness, indicating that they hold similar health beliefs regarding genetic conditions at the premarital stage. The results of Shaimaa et al. showed that the application of HBM intervention enhances health beliefs and increases the uptake

of premarital genetic counseling. This highlights the important role of health beliefs in the uptake of genetic counseling.

The use of HBM to explore health perceptions toward hemoglobinopathies and their preventive measures can clarify the decreased or increased uptake of genetic counseling and hemoglobinopathy preventive measures. Gustafson et al. (2007) used the HBM to explore health beliefs regarding SCD among African American women. Their aim was to investigate the low uptake of genetic testing and counseling. The health beliefs regarding SCD of 101 African American women, along with their perceived susceptibility and severity and their perceptions of barriers and benefits toward genetic counseling, were assessed. The results for perceived susceptibility and perceived benefits were similar to ours. Both populations scored moderately low in perceived susceptibility toward having a future child diagnosed with SCD. At the same time, both populations scored moderately high in perceived benefits toward hemoglobinopathy preventive behaviors.

The populations in Gustafson et al. (2007) and this study scored differently in other health beliefs such as perceived seriousness. In Gustafson et al.'s study, African American women scored high in perceived severity of SCD, whereas our population of premarital Saudis scored moderately low on perceived seriousness of hemoglobinopathies. The reason for the different scores in the perception of seriousness toward hemoglobinopathies between the two populations is unknown, but it can be attributed to different demographic variables such as culture and race. Some health beliefs regarding hemoglobinopathies in a population can vary, and some can be similar.

Therefore, it is important to explore health beliefs and develop educational programs based on the knowledge and health beliefs of a specific population.

Karimzaei et al. (2015) conducted a descriptive study investigating the health beliefs of 100 marriage partners who were confirmed to be carriers of thalassemia in Iran. Like in our study, the participants in Karimzaei et al. were recruited from a premarital screening center after they were referred to genetic counseling because of their susceptibility to having a thalassemia-major-affected child. The results of Karimzaei et al. were similar to ours in that the perceived susceptibility of both populations to having a child diagnosed with hemoglobinopathies was moderately low. Further, both studies had similar correlations for certain health beliefs:

- A positive strong correlation between perceived seriousness and perceived benefits. This indicated that an elevated level of perceived seriousness of hemoglobinopathy positively correlates with perceived benefits of hemoglobinopathy preventive measures.
- A positive low correlation between perceived susceptibility to hemoglobinopathies and perceived benefits of their preventive measures.
- A negative low correlation between perceived susceptibility and perceived barriers. Participants had a low but inverse relationship between perceived susceptibility to hemoglobinopathies and barriers of adopting their preventive measures.
- A positive low correlation between the perceptions of self-efficacy and perceived barriers.

The authors highlighted the crucial role of HBM in exploring health beliefs and creating health educational plan accordingly. Both Karimzaei et al.'s and our study's participants had low perception of perceived susceptibility toward having a future child with hemoglobinopathies. Because of the strong positive correlation between perceived seriousness and perceived benefits, educational programs should be tailored to the populations in both studies to increase the perception of susceptibility and seriousness of having a future child with hemoglobinopathies.

In summary, the previous literature on health beliefs regarding hemoglobinopathies differs based on the population. However, one aspect of the literature is congruent with the results of our study: low perceived susceptibility toward having a future child with hemoglobinopathies is a common health belief. Therefore, educational interventions should focus on the perception of susceptibility to increase knowledge of hemoglobinopathies.

**Research Question Two**

The second research question examined health beliefs (perceived susceptibility, perceived seriousness, perceived benefits, perceived barriers, cues to action, self-efficacy, fatalism) within the HBM that are associated with an increased likelihood of intention to use PND or PGD as a hemoglobinopathy preventive measure.

In the population of premarital Saudis who were carriers of or were affected with hemoglobinopathies, the health belief of self-efficacy was associated with the increased likelihood of the intention to use PND or PGD to prevent hemoglobinopathies in future children. The positive relationship between self-efficacy and intention to adopt health

behaviors was consistent with the previous literature (Luszczynska & Schwarzer, 2003; Sherman et al., 2006; Sheeran et al. 2016).

Luszczynska and Schwarzer (2003) conducted a longitudinal study exploring the role of self-efficacy in adopting and regularly conducting breast self-exams. Risk perception, self-efficacy, and intention to adopt health behaviors were examined in 418 women in Poland. The researchers classified self-efficacy into three phases: preaction self-efficacy, maintenance self-efficacy, and recovery self-efficacy. The impact of self-efficacy can differ based on the stage of behavioral implementation. Like in our study, preaction self-efficacy was the greatest predictor of behavioral intention. Luszczynska and Schwarzer (2003) confirmed that self-efficacy enhances the intention of adopting health behaviors, and this intention predicts the implementation of health behaviors. Therefore, self-efficacy has an indirect effect on behavior through intentions. This current study did not follow participants to the stage of behavioral implementation, but measured intentions to adopt health behaviors in the future. According to Luszczynska and Schwarzer (2003), this is a requirement for the actual implementation of such behaviors.

Sherman et al. (2006) examined the role health messages play in dental flossing as a health behavior. A total of 67 participants received health messages designed to enhance self-efficacy in dental flossing. The results are in line with our findings and confirm the presence of a pathway starting from self-efficacy, intention, and health behavior. Self-efficacy increases the intention to perform the health behavior and eventually implement the health behavior. Sherman et al. found that motivation through health messages can enhance self-efficacy beliefs and intentions and induce behavioral

change. Therefore, the incorporation of self-efficacy in health educational plans can serve as an important tool to eventually trigger behavioral change.

Sheeran et al. (2016) conducted a meta-analysis of the role of attitudes, norms, and self-efficacy on intention and behavior. A total of 204 studies were analyzed to evaluate the effect sizes of these cognitions on intention and behavior. The results of the analysis found that self-efficacy among other cognitions had a causal effect on the intention to perform a health behavior and stimulating a change in self-efficacy had a reliable effect on intention and behavior. Similar to the results of this study, of all the health beliefs, self-efficacy in Sheeran et al. was highly associated with increased intention to use PND or PGD as a hemoglobinopathy preventive behavior. Additionally, Sheeran et al. hypothesized that enhancing self-efficacy among other cognitions is sufficient to change intention and behavior, and that it is considered to be a crucial determinant of health. Sheeran et al. also found that self-efficacy had a smaller effect on frequent behaviors (health behaviors performed on a daily or weekly basis) than infrequent behaviors. Due to the fact that PND or PGD are preventive behaviors that are considered to be infrequent in nature, meaning they occurs during family planning, either pregnancy as a result of PGD, or incorporation of PND after pregnancy occur. Both are considered infrequent incidents, and don't happen on daily bases. Therefore, self-efficacy has a greater effect on infrequent health behaviors such as PND or PGD to prevent hemoglobinopathy-affected children.

**Research Question Three**

The third research question examined the moderating role consanguinity plays between health beliefs and intention to use PND or PGD. In this population of premarital

Saudis who were carriers of or affected with hemoglobinopathies, consanguineous relationships with intended partners did not moderate the pathway between each of the health beliefs and intention to use PND or PGD. Inability of consanguinity to moderate the relationship between health beliefs and intentions can be attributed to the low number of participants who were consanguineous with their intended partner (28.7%). Further, the sample showed a lack of support for consanguineous marriages, with 65.7% of participants not supporting them. The findings of the study are thus inconsistent with the previous literature (Alharbi et al., 2015; Middle, 2007; Warsy, 2014), which found a high rate of consanguineous marriages in Saudi population (up to 60%). There is a potential rationale behind the low rate of consanguinity and the support for it in our study participants compared to those in the previous literature. Much of the literature examined consanguinity in the Saudi population as a whole rather than Saudi people who are carriers of or are affected with hemoglobinopathies. Our sample was affected with hemoglobinopathies. The participants were either themselves affected or had a family history of hemoglobinopathy (59.2%). Therefore, previous exposure to hemoglobinopathy and the role consanguinity play in the transmission of genetic conditions made consanguinity less preferable in this sample.

## Implications of the Study Findings

### Implications for Nursing Science

In Saudi Arabia, hemoglobinopathies are common. SCD and thalassemia are debilitating and have devastating effects on patients and their families. The use of PGD ensures the delivery of hemoglobinopathy-free children, and the use of PND helps parents determine whether their child is affected with hemoglobinopathies and helps

prepare them to create an appropriate plan of care to alleviate the health consequences. To fully capture views toward hemoglobinopathies and their preventive measures in premarital Saudis who are carriers of or are affected with hemoglobinopathies, an examination of health beliefs with the use of HBM is important. The results of this study provided empirical data on the abstract concept of health beliefs regarding hemoglobinopathy. They confirmed the role of self-efficacy as a health belief in enhancing the intention to perform hemoglobinopathy preventive behaviors.

Further, no examination of the health beliefs of premarital Saudis has been conducted in the Saudi literature. Therefore, the findings of this study shed light on health beliefs that influence intentions and behaviors in the Saudi population, where culture and religion have a significant impact on health. In addition, the results of this study will be shared with the participating premarital screening clinics to share the with the providers the impact of health beliefs on health behavior.

**Implications for Nursing Practice**

The proposed study has an important impact on nursing practice and the practices of other health care workers. The results of this study shed light on health beliefs in the population of premarital Saudis who are carriers of or are affected with hemoglobinopathies. They identify the low perception of personal susceptibility and the seriousness of having a future child with hemoglobinopathies. Additionally, the findings show that the role of self-efficacy as a health belief increases the likelihood of the intention to adopt hemoglobinopathy preventive measures. These findings can influence nurses and other health care workers working in genetic counseling to tailor educational

interventions aimed at enhancing perceived susceptibility and seriousness and enforce self-efficacy beliefs.

The results of the study also confirmed the need to explore health beliefs prior to tailoring educational interventions because health beliefs are related to personal beliefs, which can differ based on many cultural, religious and intellectual factors. Developing personalized educational interventions based on health beliefs rather than standardized educational plans can improve health care practices and promote health.

**Implications for Health Policy**

The findings of this study have implications for health policy in Saudi Arabia. The previous literature evaluating premarital screening laws in Saudi Arabia confirmed the success of the laws in identifying high-risk individuals. However, it also identified the high rate of marriage between at-risk couples. Therefore, the findings of this study provide a rationale for the marriage of hemoglobinopathy at-risk individuals: the low perception of the susceptibility and seriousness of hemoglobinopathies.

Another health policy implication of the study is related to hemoglobinopathy preventive measures. The study findings highlighted elevated levels of perceived benefits and decreased perceptions of barriers toward PND and PGD, which are medical services that are currently available in Saudi Arabia but are not provided to hemoglobinopathy at-risk couples. Therefore, these findings can shed light on the importance of providing PGD to ensure the delivery of healthy children. PND after pregnancy can help keep parents informed and help them plan appropriate care methods prior to the arrival of their child.

## Study Limitations

The study was the first to examine the health beliefs of premarital Saudis toward hemoglobinopathies and their preventive measures (PND and PGD). Thus, it is a novel contribution to the Saudi literature and is not yet acceptable to health care workers in premarital screening clinics. One limitation of the study pertains to sampling. Even after we obtained IRB approval, one premarital screening clinic refused to participate in the study. As a result, the desired number of 149 participants was not reached. However, given the medium effect size, the effectiveness of the results was not affected.

Additionally, data were collected from premarital screening clinics in the western and eastern regions of Saudi Arabia only because of a lack of time. Thus, the study findings are less generalizable to premarital Saudis living in the north or south regions of the country.

Another potential limitation is sampling bias due to cultural and religious norms. At-risk couples did not come to the counseling clinic together because they were not yet married and could not go anywhere together without the father or brother of the female partner present. As a result, most of the participants who came to the premarital screening clinic were males. They filled out the questionnaire by hand. Most of the females, meanwhile, filled the electronic copy of the questionnaire because they were not able to come with their partners to the premarital screening clinic. Even though the electronic copies of the questionnaire had an information sheet and electronic informed consent form, the conditions in which the females answered the questionnaire could not be controlled.

Another limitation of the study was the low number of participants in consanguineous relationships. This may have impacted the results of the study, specifically research question three, which evaluated the role of consanguinity as a moderator between health beliefs and intention to use hemoglobinopathy preventive measures. Unlike the previous literature, which confirmed the high rate of consanguinity in the Saudi population, in this study, most of the participants were not consanguineous. The effects of consanguinity as a moderator between health beliefs and intention to use preventive measures may have been different if the number of participants in a consanguineous relationship was higher.

The use of self-report measures limited the findings of the study because self-reports can induce social desirability bias. This can be overcome through the use of more vigorous and objective measures. However, due to financial and time constraints, self-reports were used to measure the variables of health beliefs and intentions. The impact of social desirability via self-report methods can be attributed to the low number of consanguineous relationships, participants could report that they are not in consanguineous relationship, and do not support the practice because of the unfavorable view of the medical community towards this form of marriages.

Another limitation was the study's cross-sectional design. Cross-sectional study designs create ambiguity about the direction of the causal relationship between health beliefs and the intention to undergo PND or PGD. This posed an internal threat to our study. At the same time, HBM has been studied extensively. The relationships among the study variables indicated that health beliefs are an antecedent to healthy behaviors.

## Recommendations for Future Research

### Intention and Health Behaviors

The findings of this study confirmed the role self-efficacy in enhancing intention to adopt hemoglobinopathy preventive behaviors (PND or PGD). However, further evaluations of actual implementation of health behaviors and their relationship to intentions need to be conducted. Future research should examine the relationship between intention to adopt hemoglobinopathy preventive measures and implementation of these behaviors in the postmarital period. Such studies' designs will be longitudinal in nature and will follow participants from the premarital phase to the post marital phase, to the actual delivery of the child of parents at risk of hemoglobinopathies. Therefore, future research should facilitate changes in clinical practice to assist at-risk couples in having a healthy child.

### The Role of Culture in Health Beliefs and Hemoglobinopathies

The objective of the study was to explore health beliefs regarding hemoglobinopathies among premarital Saudis who were carriers or were affected with hemoglobinopathies. The results highlighted the moderately low perception of susceptibility and seriousness toward having a future child with hemoglobinopathies. There is a need to incorporate health and cultural beliefs in tailoring educational interventions. Culture has a major influence in Saudi society, including in the area of health.

Future research needs to explore the impact of culture on health beliefs and health practices. Because each region in Saudi Arabia has different cultural practices, research

that aims to incorporate the impact of culture on health can guide clinical practices and health education based on patients' health beliefs and cultural backgrounds.

As the findings of this study confirmed the role of fatalism in the health belief model. Future intervention studies should aim to incorporate the role of spirituality and religion in the health belief model, for a population of Saudis and evaluate its impact on genetic decision making. Such interventions should be created to enhance perception of susceptibility and seriousness of hemoglobinopathies, and incorporate religious interventions to help modify health behavior.

**Mediator and Moderator Variables in the HBM**

The study evaluated the role of consanguinity as a moderator variable between health beliefs and intention to adopt hemoglobinopathy preventive behaviors. The results confirmed that consanguinity does not act as a moderator variable. Therefore, further research is needed to explore the role mediator and moderator variables play in the population of premarital Saudis at risk for having a child with hemoglobinopathies. Future research incorporating mediator and moderator variables in their health models can explain the multiple aspects of the model and determine why, how, and when a health phenomenon occurs (Bennett, 2000). Examinations of moderator and mediator variables in the population of at-risk Saudis should be based on previous literature reviews. Variables like knowledge of diseases, family histories, and carrier versus affected status can act as moderators or mediators.

**Intervention Studies**

The findings of this study assist in directing and designing the next phase in this program of research, which is the development and testing of interventions. The

recruitment process revealed a high prevalence of psychological stress among those identified by screening as a high risk for having a child with hemoglobinopathies. Future research should aim at enhancing the well-being of the population of high-risk couples, by creating an intervention aim at alleviating psychological stress these patients experience.

**Hemoglobinopathies Preventative Behaviors**

These data highlight the lack of knowledge towards PND and PGD in Saudi population. But due to the fact each of PND and PGD are implemented on different stages of the family planning process, both have different moral implications, and are performed based on patients' preference and health conditions. Future research should be implemented to examine each procedure separately. Examination of the perceptions, preferences, and implications of PND and PGD should be performed independently to fill gaps in the literature.

As medical technologies advance, future reproductive technologies like noninvasive prenatal diagnosis, genetic sequencing, and genetic editing via clustered regularly interspaced short palindromic repeats, should be examined in future studies among population of Saudis at risk for having a child with hemoglobinopathies.

**Larger Sample Size**

The data of this study was collected from participants residing in cities that are urban and modern, whom population are very educated, with 48% have a bachelor's degree. Future studies conducted at the national level, should target rural areas with a larger sample size to enhance generalizability, increase statistical power, and detect

significant relationships. Recruitment of hemoglobinopathy-affected individuals in rural areas is crucial to capture health beliefs in populations who lack access to health care.

## Conclusion

This study made novel contributions by examining health beliefs using HBM in a population of premarital Saudis who were carriers of or were affected with hemoglobinopathies (SCD, beta thalassemia). The population's perception toward having future children with hemoglobinopathies was examined. The findings revealed a moderately low perception of susceptibility and seriousness toward hemoglobinopathy. They also identified self-efficacy as a health belief that is highly associated with the intention to adopt PND or PGD as a hemoglobinopathy preventive measure. Further, consanguinity did not act as a moderator variable between health beliefs and intention to adopt hemoglobinopathy preventive measures despite the previous literature's confirmation of the high rate of consanguineous marriages in Saudi Arabia.

Based on the findings of the study, enhancing self-efficacy in a population of at-risk couple for having a child with hemoglobinopathy can increase the uptake of PND or PGD to prevent hemoglobinopathies or alleviate its burden on health. Therefore, this study has taken a step toward empowering premarital Saudis to have healthy families.

Exploring health beliefs with the use of HBM can provide a conceptual understanding of the high rate of hemoglobinopathies in Saudi Arabia. The results of this study highlight the crucial role health beliefs play in advancing health and transforming clinical practice by incorporating health beliefs and patients' preferences in treatment plans.

## Appendix A

**The modified CHBM scale in English language:**

The research project is approved by

King Saud University for health sciences

Case Western Reserve University

Dear marriage applicant

This research project aims to examine the health beliefs for those identified as high risk for having a future child with hemoglobinopathies (specifically sickle cell diseases and thalassemia), and health beliefs toward hemoglobinopathies preventative measures like:

Prenatal diagnosis: is a medical procedure performed by your doctor, the aim of the procedure is to give you an insight whether your child is affected or unaffected by sickle cell diseases or thalassemia and is performed in the first trimester. The prenatal diagnosis procedure can either be chorionic villus sampling or amniocentesis:

- Chorionic villus sampling: the procedure aims to obtain a sample from the placenta to be analyzed for sickle cell diseases or thalassemia.

-Amniocentesis: The procedure aims to obtain a sample from the fluid surrounding your baby within the uterus for analysis.

As a result, if your child is unaffected it will provide reassurance, but you are faced with options in case you have an affected child:

1) Terminate pregnancy.
2) Presume pregnancy and create an appropriate plan of care for your child prior to his or her arrival.

Preimplantation genetic diagnosis: is a medical procedure you will implement when you and your spouse decide to become pregnant. With the use of In Vitro Fertilization (IVF) technique, multiple fertilized ovum will be genetically analyzed, and only the unaffected fertilized ovum will be implanted in the female uterus, to ensure delivery of a baby uneffaced by sickle cell disease or thalassemia.

Please Answer the following questions by placing a mark that best reflects your answer, please know that your answers will be confidential and to be used for research purposes only.

Thank you

Samaa Al Anazi

1- Name:

2- City:

3- Phone number:

4- Age in years:

5- Educational level:

   1) High school graduate

   2) Diploma

   3) Undergraduate level

   4) High education (master's degree or doctorate degree)

6- Gender:

   1) Female

   2) Male

7- Monthly income level:

   1) Less that 3000 Riyals.

   2) Between 3000-4990 Riyals

   3) Between 5000-7990 Riyals

   4) Between 8000-11990 Riyals

   5) Above 12000 Riyals

8- Consanguinity between the couples if applicable:

1) Yes

2) No

Type of consanguinity:

9- Are you in favor of consanguineous marriages?

1) Yes

2) No

10- Are diagnosed with hemoglobinopathy (Sickle cell diseases or thalassemia):

1-Yes, with Sickle cell diseases

2-Yes, with thalassemia.

3- No

11- Are you receiving any medical treatment for hemoglobinopathy (Sickle cell diseases or thalassemia):

1) Yes

2) No

12- Are you a carrier for a hemoglobinopathy:

1-Yes, with Sickle cell diseases

2-Yes, with thalassemia.

3- No

13 – Do you have children diagnosed with hemoglobinopathy (Sickle cell diseases or thalassemia) from previous marriage:

1) Yes

2) No

Please answer the following questions by placing a mark on the answer that best reflect your health belief:

| Health Beliefs | Strongly agree | Agree | Neutral | Disagree | Strongly disagree |
|---|---|---|---|---|---|
| 1) I think its quite possible for me to have a child diagnosed with hemoglobinopathy in the future | | | | | |
| 2) I feel that I'm personally susceptible to have a future child diagnosed with hemoglobinopathy | | | | | |
| 3) There is a big possibility that I will have a child diagnosed with hemoglobinopathy in the next 10 years. | | | | | |
| 4) I think I have greater chances to have a child with hemoglobinopathy | | | | | |
| 5) I think I'm more susceptible to have a child with hemoglobinopathy than other people | | | | | |
| 6) Just thinking about my future child being sick with hemolgobinopathy scare me | | | | | |
| 7) When I think about my child being sick with hemoglobinopathy my heart rates go up | | | | | |
| 8) Just thinking about hemoglobinopathy scares me | | | | | |
| 9) I think the problems that might occur in case I have a child with hemoglobinopathy, will cause me suffering for a long period of time. | | | | | |
| 10) If I have a child diagnosed with hemoglobinopathy, it will influence my relationship with my spouse. | | | | | |
| 11) If my child has hemoglobinopathy, I think it will change my entire life. | | | | | |
| 12) If my child have hemoglobinopathy, he or she will not have long life span | | | | | |

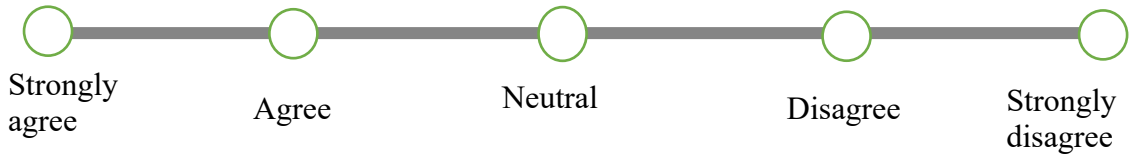
| | | | | | |
|---|---|---|---|---|---|
| 13) if I underwent prenatal diagnosis or preimplantation diagnosis, I will be satisfied with myself. | | | | | |
| 14) ) If I underwent preimplantation diagnosis or prenatal diagnosis, it will reduce my fear of having a child diagnosed with hemoglobinopathy | | | | | |
| 15) If I underwent prenatal diagnosis, it will help me to detect sooner whether my child has hemoglobinopathy | | | | | |
| 16) If I underwent prenatal diagnosis and terminated the pregnancy, it will reduces my chances of having hemoglobinopahty affected child | | | | | |
| 17) If I underwent preimplantation diagnosis prior to pregnancy, it will reduces my chances to have a child with hemoglobinopathy | | | | | |
| 18) I feel if I undertake prenatal diagnosis or pre implantation diagnosis is absurd | | | | | |
| 19) If I underwent prenatal diagnosis, it will make me worry every time I get pregnant/ my wife gets pregnant | | | | | |
| 20) Preimplantation diagnosis takes a long time to get pregnant | | | | | |
| 21) Preimplantation diagnosis cost a lot of money | | | | | |
| 22) If I underwent preimplantation diagnosis, it will exhaust me and my spouse physically, emotionally and psychologically | | | | | |
| 23) If I underwent prenatal diagnosis and pregnancy is terminated, it will exhaust me and my spouse physically, emotionally and psychologically | | | | | |
| 24) I feel angry and sad if I undergo prenatal diagnosis or preimplantation diagnosis | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 25) Prenatal diagnosis and terminating pregnancy contradict my Islamic beliefs | | | | | |
| 26) prenatal diagnosis and preimplantation diagnosis is not is not preferable or acceptable | | | | | |
| 27) I think that my child diagnosis of hemoglobinopathy is fate meant for me and him or her, and performing prenatal diagnosis or preimpantation diagnosis don't change his fate | | | | | |
| 28) I'm confidant that I will seek prenatal diagnosis early in the pregnancy | | | | | |
| 29) I'm confidant that I will seek preimplantation diagnosis | | | | | |
| 30) If I were pregnant / my wife were pregnant with child diagnosed with hemoglobinopathy, I plan to discover it early | | | | | |
| 31) I'm confident in my ability to adopt hemoglobinopathire preventative measures. | | | | | |
| 32) I can adopt preimplantation diagnosis before I get pregnant/ my wife get pregnant to have a healthy child | | | | | |
| 33) I can adopt preimplantation diagnosis before I get pregnant/ my wife get pregnant to have a healthy child | | | | | |
| 34) I can adopt prenatal diagnosis, and terminate pregnancy in case my child is affected with hemoglobinopathy | | | | | |
| 35) I would like to detect early in the pregnancy if my child have hemoglobinopathy | | | | | |
| 36) Having a healthy child is very important for me | | | | | |

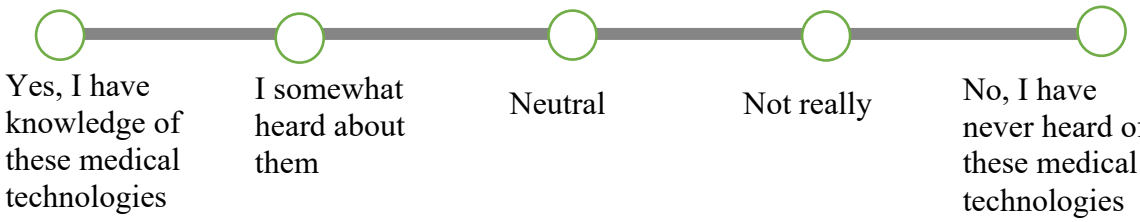
| | | | | | |
|---|---|---|---|---|---|
| 37) I'm always looking for information to enhance the health of my future child | | | | | |
| 38) I plan to undergo regular medical check up prior of planning to get pregnant | | | | | |

Intentions to undergo PND or PGD in the future:

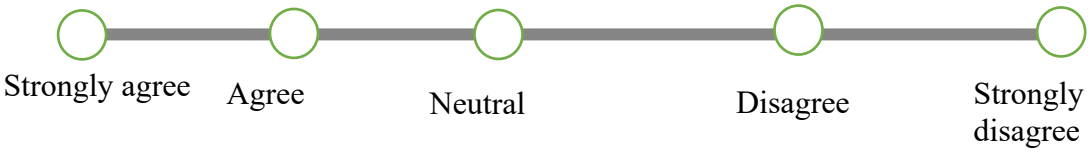
1. After learning about your increased risk to pass on your genetic predisposition for sickle cell diseases or beta thalassemia to your children, does this information impact your choice for a genetically compatible life partner?



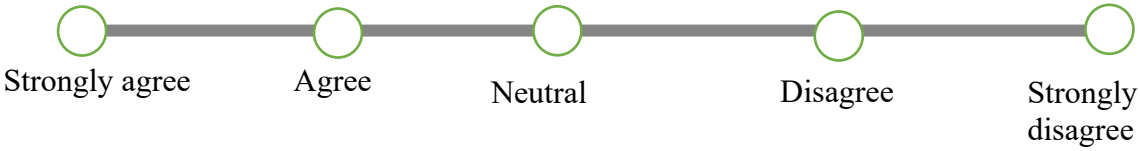

2. Have you ever heard of medical technologies (prenatal diagnosis or preimplantation genetic diagnosis) used for hereditary blood disorders among high risk couples to deliver healthy children in the future?



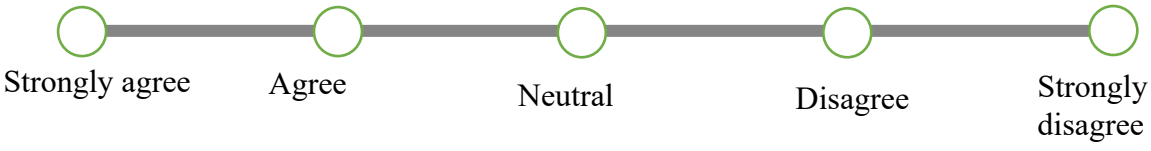
3. In case prenatal diagnosis procedure performed to terminate pregnancy for your affected child were offered to you, would you intend to use them?




4. In case prenatal diagnosis procedure to assists you in creating an appropriate plan of care for your affected child were offered to you, would you intend to use them?




5. In case preimplantation genetic diagnosis were offered to you to have a healthy child, would you intend to use it?



Appendix B

**Arabic modified version of CHBM:**

بسم الله الرحمن الرحيم

جامعه الملك سعود للتخصصات الصحيه
ريسيرف

جامعه كايس وسترن

عزيزي المقبل/عزيزتي المقبله على الزواج

تستطيع المشاركة في البحث اذا كنت في مرحله الاقبال علي الزواج، وتكون حامل او مصاب بأمراض الدم الوراثية كالأنيميا المنجلية او الثالاسيميا.

يختص هذا البحث بقياس مدي المعرفه والمعتقدات (لأشخاص معرضين لزواج غير آمن) عن أمراض الدم الوراثيه كالانيميا المنجليه والثالاسيميا، والتقنيات الطبيه الحديثه التي تساعد على إنجاب طفل سليم وهي كالتالي:

١) تقنية تشخيص ما قبل الولادة: سيتم اجرائها من قبل دكتور مختص، الهدف منها هو تشخيص الجنين بإمراض الدم الوراثية كالأنيميا المنجلية اوالثالاسيميا في مرحله مبكرة من الحمل. تقنية تشخيص ما قبل الولادة يتم تنفيذها عن طريق أخذ عينه من زغابة المشيمه او فحص السائل الأمنيوسي.

- أخذ عينه من زغابة المشيمة: سيتم اخذ عينه من المشيمة وتحليلها لتشخيص انيميا المنجلية اوالثالاسيميا لدى الجنين.
- فحص السائل الأمنيوسي: سيتم اخذ عينه من السائل الأمنيوسي الذي يحيط بالطفل داخل الرحم وتحليلها لتشخيص انيميا المنجلية اوالثالاسيميا لدى الجنين.

تقنية تشخيص ما قبل الولادة تبلغك اذا كان الجنين سليم من امراض الدم الوراثية، لكن في حاله اثبات ان جنينك مصاب فإن التقنية تساعدك في مرحله مبكرة من الحمل للتخطيط العائلي

كإنهاء الحمل مبكرا او تجهيز خطه طبيه قبل ولادة الطفل المصاب.

٢) تقنية التشخيص الوراثي للأجنة خارج الرحم: عمليه طبيه يتم تنفيذها بأمر من قبل الزوجين قبل الحمل. عن طريق التخصيب في المختبر، يتم جمع عدد من البويضات المخصبة وتحليلها جينيا من امراض الدم الوراثية، بعد ذلك يتم زرع البويضات السليمة في رحم الام كوسيله مؤكده لإنجاب طفل سليم.

الرجاء الإجابة على الأسئلة التاليه بالكامل وذلك بوضع علامة علي الإجابة المناسبة لك، علما بان جميع الاجابات سوف تعامل بسريه تامه ولأغراض البحث العلمي فقط

مع جزيل الشكر
الباحثه سماء العنزي

الاسم:
رقم الجوال:
المدينه:

١- العمر بالسنوات:

٢- التعليم:
١- ثانويه عامه ٢- دبلوم
٣- بكالوريوس ٤- دراسات عليا (ماجستير او اعلي)

٣- الجنس:
١- انثي ٢- ذكر

٤- مستوى الدخل الشهري:
١-اقل من ٣٠٠٠ ٢- ما بين ٣٠٠٠-٤٩٩٠
٣- ما بين ٥٠٠٠-٧٩٩٠ ٤- ما بين ٨٠٠٠-١١٩٩٠
٥- ١٢٠٠٠ وفوق

٥- قرابة بين العروسين( فقط اذا ينطبق عليك):
١- نعم ٢- لا
صفه القرابة:

٦- هل تؤيد زواج بين الأقارب:
١- نعم ٢- لا

٧-هل انت مصاب بمرض دم وراثي (الانيميا المنجلية اوالثالاسيميا)
١- نعم، مصاب بالأنيميا المنجلية ٢- نعم، مصاب بالثالاسيميا ٢- لا

٨- معالاجات دوائيه حاليه:
١- نعم ٢- لا

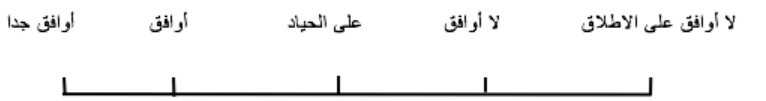
٩- هل انت جينيا حامل بمرض دم وراثي (الانيميا المنجلية اوالثالاسيميا)
١- نعم، حامل بالأنيميا المنجلية ٢- نعم، حامل بالثالاسيميا

١٠- في التاريخ الطبي العائلي هل يوجد فرد او أكثر مشخص بمرض الدم الوراثي:
١- نعم ٢- لا

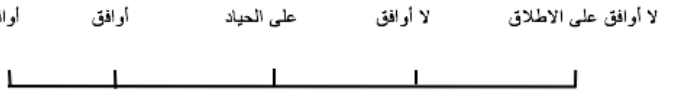
١١- هل لديك اطفال مصابين بمرض الدم الوراثي من زواج سابق:
١- نعم ٢- لا

الرجاء الادلاء في الاقوال (المعتقدات) التاليه بوضع دائره على ألاختيار المناسب من الإختيارات المقابلة لكل جمله من الجمل الآتيه:

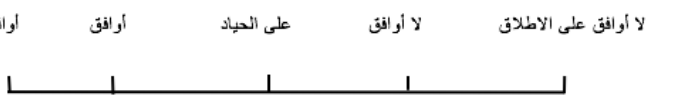
١٢- اعتقد أنه من الممكن أن يكون طفلي المستقبلي مصاب بأحد أمرض الدم الوراثية.



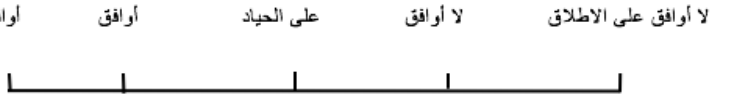

١٣- اشعر بأنني شخصيا معرض | معرضة لإنجاب طفل مصاب بأمراض الدم الوراثية في المستقبل.



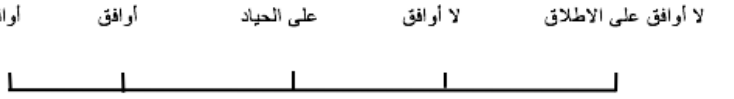

١٤- يوجد احتمال كبير أن ارزق بطفل مريض بأحد أمراض الدم الوراثية خلال العشر السنوات القادمة.



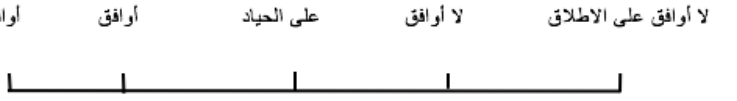

١٥- اعتقد أن فرص إصابة طفلي بأحد أمراض الدم الوراثية كبيرة.



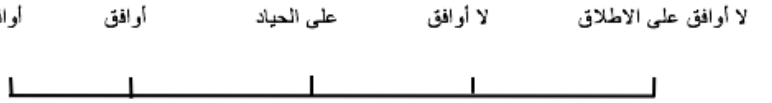

١٦- اعتقد بأني معرض | معرضة اكثر من غيري لإنجاب طفل مصاب بمرض دم وراثي.




١٧- إن مجرد التفكير في أن يكون طفلي مصاب بمرض الدم الوراثي يخيفني.

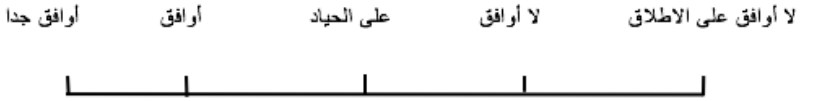



١٨- عندما يخطر في بالي احتمالية إصابة طفلي بمرض

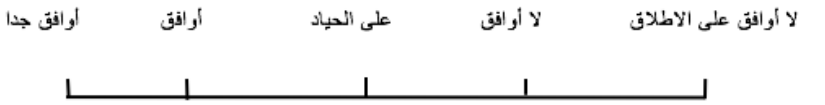


الدم الوراثي تتسارع دقات قلبي.

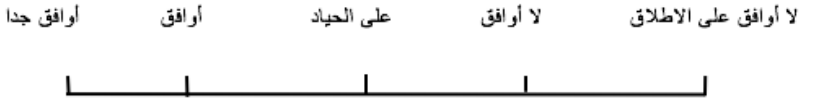
١٩- من مجرد التفكير بأمراض الدم الوراثية اشعر بالخوف.



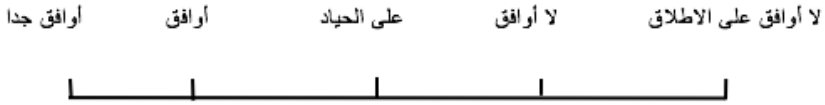

٢٠- اعتقد أن المشاكل التي ممكن أن أعاني منها سوف تستمر لفترة طويل إذا حدث وأصيب طفلي بمرض الدم الوراثي.



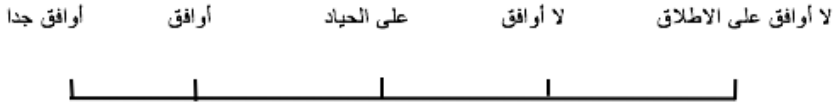

٢١- في حالة إنجاب طفل مصاب بمرض الدم الوراثي فإن ذلك قد يؤثر في العلاقة بيني وبين زوجي | زوجتي.



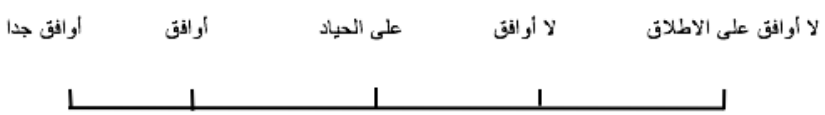

٢٢- في حالة إنجاب طفل مصاب بمرض الدم الوراثي فإنني اعتقد أن حياتي كلها سوف تتغير.



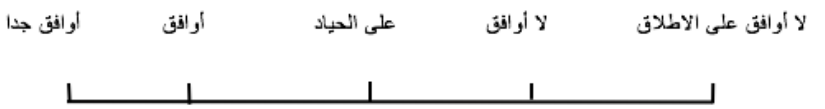

٢٣- في حالة إنجاب طفل مصاب بمرض الدم الوراثي فإنني اعتقد أنه لن يعيش فترة طويلة من عمره.




٢٤- إذا خضعت لتقنية تشخيص قبل الولادة او تقنية التشخيص الوراثي للأجنة خارج الرحم سأكون راضيا عن نفسي.

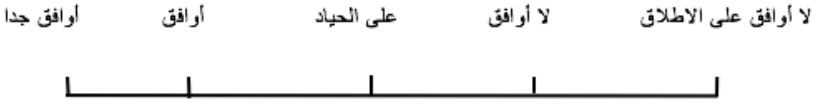



٢٥- إذا خضعنا لتقنية التشخيص الوراثي للأجنة خارج الرحم أو تقنية تشخيص ما قبل الولادة فإن

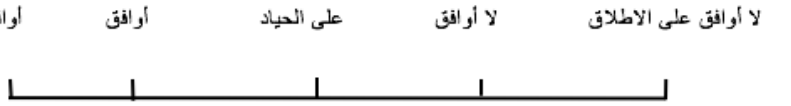


ذلك يخفف من قلقي حول إنجاب طفل مريض بأمراض الدم الوراثية.

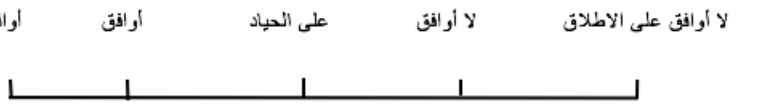
٢٦- إذا خضعت بالتشخيص الوراثي قبل الولادة فإن ذالك سيساعدني بالكشف المبكر في حالة إصابة طفلي بمرض الدم الوراثي.



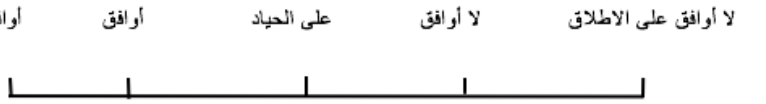

٢٧- إذا خضعت لتقنية التشخيص الوراثي قبل الولادة وإضطررت إلى إنهاء الحمل مبكرا ، فإن ذلك سيمنع فرص إنجابي لطفل مصاب بمرض الدم الوراثي.



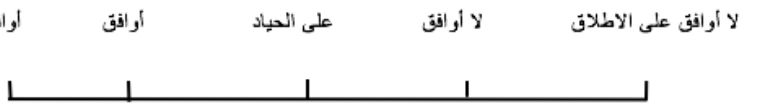

٢٨- إذا خضعت لتقنية التشخيص الوراثي للأجنة خارج الرحم سوف اقلل فرص إنجابي بطفل مصاب بمرض الدم الوراثي.



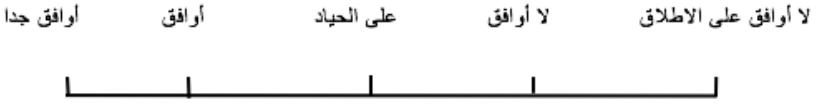

٢٩- أشعر أن استخدام التشخيص الوراثي قبل الولادة أو التشخيص الوراثي للأجنة خارج الرحم شيء تافه.



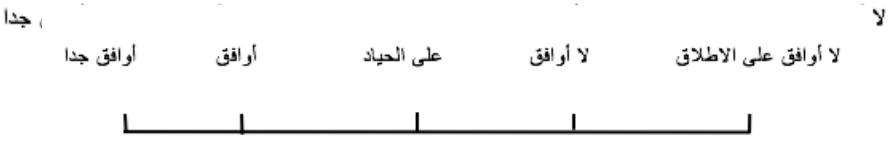

٣٠- إذا خضعت بالتشخيص الوراثي ما قبل الولادة سوف يجعلني قلق في كل حمل باحتمال إصابة طفلي بمرض الدم الوراثي.



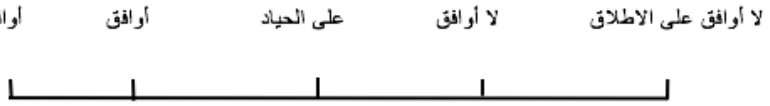

٣١- إن خضعت بالتشخيص الوراثي للأجنة خارج الرحم فإن ذلك سيرهقني نفسيا وعاطفيا.



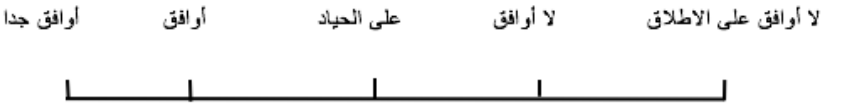
٣٢- أشعر بمشاعر سلبية (حرج، حزن، او غضب) تجاه استخدام تقنيات طبيه لإنجاب طفل سليم من امراض الدم الوراثية.



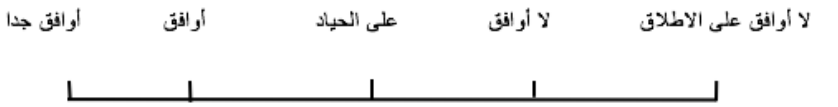

٣٣- في حال خضوعي للتشخيص الوراثي وانهاء الحمل مبكرا فإن ذلك يتعارض مع قيمي الإسلامية.




٣٤- خضوعي للتشخيص الوراثي للأجنة خارج الرحم سيستغرق وقتا طويلا.

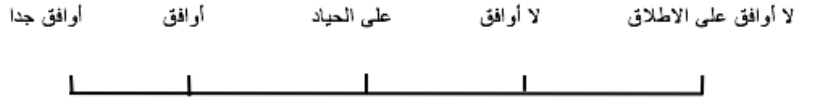



٣٥- خضوعي للتشخيص الوراثي للأجنة خارج الرحم سيكلف مبالغ طائلة.

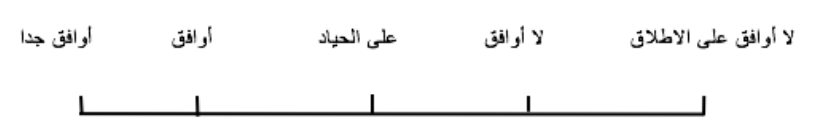



٣٦- استخدامي لتقنيات التشخيص الوراثي قبل الولادة أو التشخيص الوراثي للأجنة خارج الرحم غير مقبول او مستساغ.


٣٧- اعتقد أن إصابة طفلي بمرض الدم الوراثي هو قدر مكتوب لي وله وأن قيامي بالتشخيص لن يغير من هذا القدر بغض النظر عن استخدامي لتقنيات التشخيص.

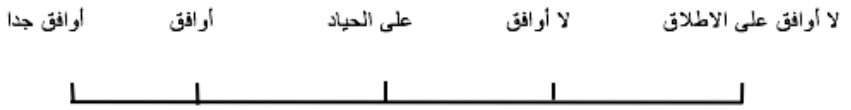



٣٨- انا واثق بأنني سأستخدم تقنية التشخيص الوراثي قبل الولادة في مرحلة مبكرة من الحمل إن استلزم الأمر.




٣٩- أنا واثق بأنني سأستخدم التشخيص الوراثي للأجنة خارج الرحم.

٤٠- في حالة الحمل فإنني أنوي أن احصل على تشخيص مبكر.



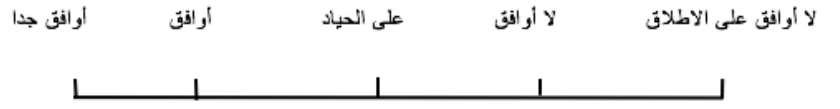

٤١- أنا متأكد من قدرتي على إستخدام تقنيات التشخيص لإنجاب طفل سليم من امراض الدم الوراثية.


٤٢- أنا متأكد من قدرتي على استخدام تقنيات التشخيص الوراثي للأجنة خارج الرحم في كل حمل.


٤٣- أنا متأكد من قدرتي على تبني واستخدام تقنية التشخيص الوراثي ما قبل الولادة.

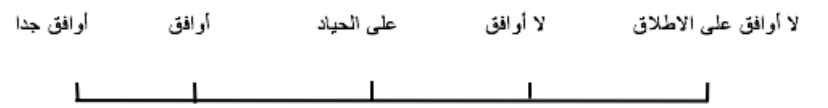

٤٤- أنا أرغب باكتشاف حالة طفلي الصحية بمرحلة مبكرة من الحمل.


٤٥- إنجاب طفل سليم من امراض الدم الوراثية شيء مهم جدا لدي.



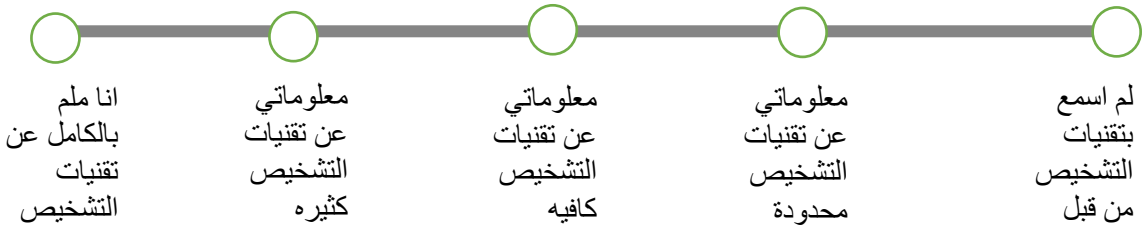

٤٦- إنني أبحث دائما عن معلومات جديدة تحسن من وضع صحة طفلي المستقبلية.


٤٧- سأقوم بإجراء فحص طبي منتظم قبل محاولة الحمل والإنجاب



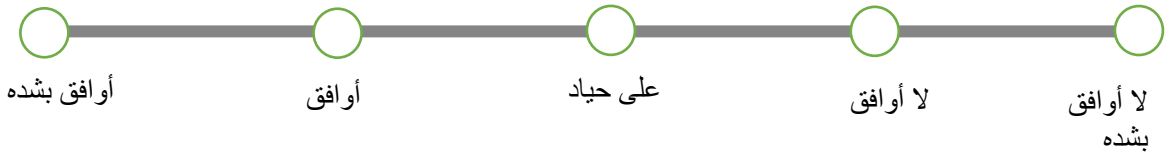
١. بعد علمك على قابليتك لإنجاب طفل مصاب بأمراض الدم الوراثية كالأنيميا المنجلية او الثالاسيميا، هل يؤثر ذلك في اختيارك لشريك حياتك بحيث يكون جينيا غير حامل او غير مصاب بأمراض الدم الوراثية؟


٢. هل سمعت من قبل بتقنيات التشخيص الوراثي قبل الولادة أو التشخيص الوراثي للأجنة خارج الرحم لإنجاب طفل سليم من أمراض الدم الوراثية لدى زوجين لديهم قابليه عالية لإنجاب طفل مصاب؟




٣. في حال تم عرض عليك تقنيه التشخيص الوراثي قبل الولادة لإنهاء حمل طفل مصاب بأمراض الدم الوراثية، هل تنوي استعمالها؟


٤ . في حال تم عرض عليك تقنيه التشخيص الوراثي قبل الولادة لمساعدتك في تخطيط الرعاية المناسبة لطفل مصاب بأمراض الدم الوراثية، هل تنوي استعمالها ؟




٥. في حال تم عرض عليك التشخيص الوراثي للأجنة خارج الرحم لإنجاب طفل سليم من أمراض الدم الوراثية، هل تنوي استعمالها؟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شكرا لمشاركتك

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