

The Development and Psychometric Analysis of the MU- Fertility Knowledge Assessment Scale

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THE DEVELOPMENT AND PSYCHOMETRIC ANALYSES OF THE MU-
FERTILITY KNOWLEDGE ASSESSMENT SCALE

by

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ABSTRACT
THE DEVELOPMENT AND PSYCHOMETRIC ANALYSES OF THE MU-
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Marquette University, 2017

Young women between the ages of 18 to 24 experience disproportionately high rates of negative sexual and reproductive health outcomes. Inadequate and inaccurate fertility knowledge can hinder a young woman's self-care abilities in managing her sexual and reproductive health. There is no validated instrument to assess young women's fertility knowledge.

The primary purpose of this study is to develop and evaluate the psychometric properties of the MU-fertility knowledge assessment scale (MU-FKAS) for young women. The secondary purpose is to explore the relationships among young women's individual and contextual factors, self-perceived fertility knowledge, actual fertility knowledge, and fertility health risks. A three-phase, multiple method design was used for the study.

The MU-FKAS contains 26 items measuring knowledge of female fertility changes within the menstrual cycle and throughout the lifecycle, and the impact of lifestyle factors and female age on female fertility and conception. The Kuder-Richardson 20 (KR20) coefficient was .74 indicating acceptable internal consistency. Known group comparison between young women who used fertility awareness based method (FABM) vs. non-FABM users showed a significant difference in their fertility knowledge level supporting its construct validity. Exploratory factor analysis supported a two-factor structure. Item analysis provided evidence for refinement of individual items.

The sample consisted of 342 young women between the ages of 18 to 24 ($M=21.87$; $SD=1.88$). They were primarily White and heterosexual. Young women's actual fertility knowledge ranged from 27 to 100 ($M=78.04$, $SD=14.36$). Their self-reported fertility risk factors spanned from 0 to 12. A significant regression equation was found ($F(8,331)=6.053$, $p<.0001$) with an R^2 of .13. Using a FABM, self-perceived fertility knowledge, and actual fertility knowledge were statistically significant in predicting young women's fertility health risks. Young women's age, education level, or pregnancy experience were not significant in predicting their fertility health risks.

The MU-FKAS demonstrated acceptable validity and reliability as a newly developed instrument. The significant relationships between young women's fertility knowledge and their fertility health risks highlighted the importance of assessing and teaching young women about their fertility as an important component of their preconception care.

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Qiyang Mu, BSN, RN

“Fertility is a collective gift over which we have dominion but not absolute control...In this vision, fertility is not a problem for couples and the wider human family, but a gift and a mystery to be cherished, protected and respected” (Notare, 1994, p. 3). This dissertation is a dedication to every woman who values her fertility and wants to live with her body fully and beautifully. I am thankful for all the young women who took the time to complete my survey and sent me their thoughts and thank-you notes. I also want to thank the following content experts (Kimberly Aumack-Yee, Mary L. Barron, Judith Daniluk, Garcia Desiree, Kerry Hampton, Dana Rodriguez, Mary Schneider, Ann Sherman, Bochar Thomas, Aleena M. Wojcieszek) for their contributions to the Delphi study phase of the project. It is with your encouragement and inspiration that I find meaning in my study and I feel deeply honored to continue my work with women’s health and fertility.

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LIST OF ABBREVIATIONS

AMH: anti-Müllerian hormone
ART: assisted reproductive technology
CTT: classic test theory
CFKS: Cardiff Fertility Knowledge Scale
CVI: content validity index
EFA: exploratory factor analysis
FABM: fertility awareness based method
FAQ: fertility awareness questionnaire
FAS: Fertility Awareness Survey
FKAS: fertility knowledge assessment scale
FSH: follicle stimulating hormone
FW: fertile window
KFS: Knowledge of Fertility Scale
KR20: Kuder-Richardson formula 20
ICC: item characteristic curve
IRT: item response theory
IVF: in vitro fertilization
LH: luteinizing hormone
LGBT: lesbian, gay, bisexual and transgender
NFP: natural family planning
RHA: Reproductive Health Awareness
RLP: reproductive life planning
STI: sexually transmitted infection

I. INTRODUCTION

Background and significance

A comprehensive definition of fertility knowledge refers to information that an individual acquires about his or her fertility throughout their life course. For women, this knowledge includes information regarding the menstrual cycle, pregnancy potential in each menstrual cycle and at different life stages, and risks of infertility (Mu, 2016). Fertility knowledge is important in determining a woman's ability to perform fertility self-care, which can directly impact both her sexual and reproductive behaviors and health outcomes (Barron, 2013; Institute for Reproductive Health [IRH], 2013; Rodriguez, 2013; Witt, McEvers, & Kelly, 2013).

Young female adults can be defined as women between the ages of 18 to 24 (Jekielek & Brown, 2005). This population experiences high sexual and reproductive health risks during their current life stage, as well as potential risks for infertility in the future. A graph of the reported rates of chlamydia and gonorrhea infections from 2010 to 2014 shows that young female adults between the ages of 20 and 24 had the highest infection rates compared to young women between the ages of 15-19 and the ages of 25-29 (See Figure 1).

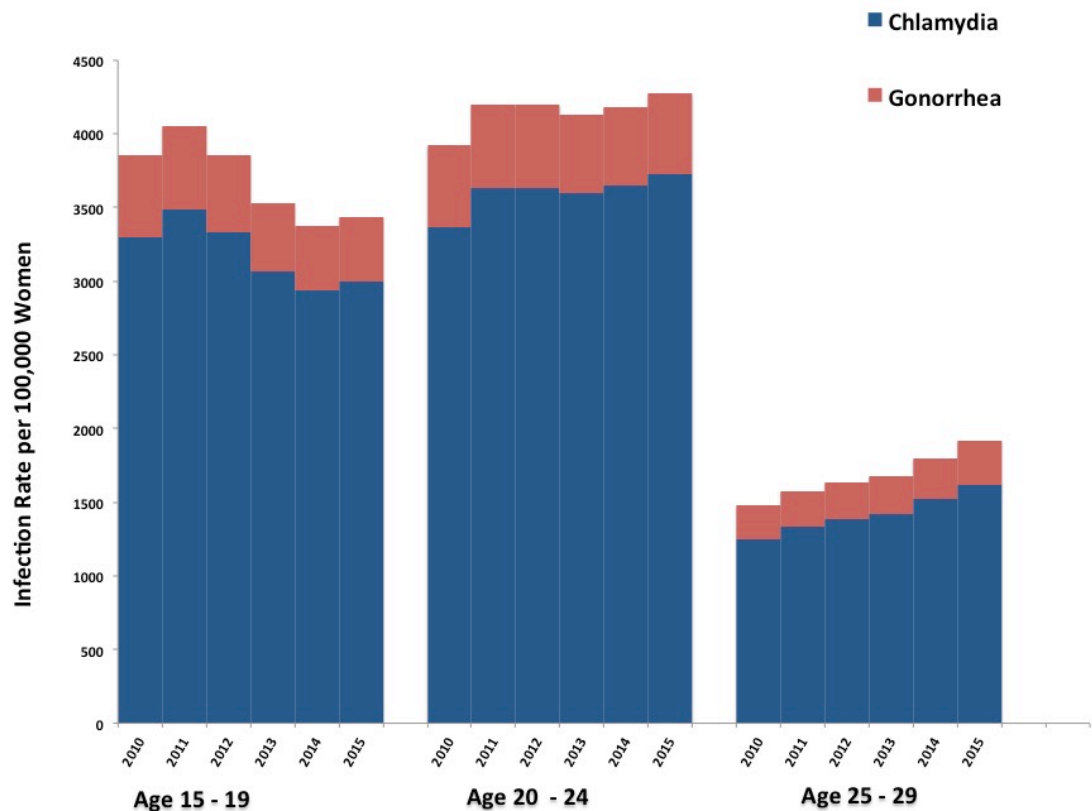


Figure 1. Reported Gonorrhea and Chlamydia Infection Rates for Different Age Groups of U.S. Women from 2010 - 2015.

Source: Data was adapted from the 2014 Sexually Transmitted Disease Surveillance (Centers for Disease Control and Prevention [CDC], 2015a; CDC, 2015b).

At the same time, demographic trends indicate that U. S. women are delaying childbearing, and the pregnancy rates for women aged 30 and older have been increasing since 1990, among which women over 40 have the highest increase (CDC, 2010). One potential reproductive threat of this delay is that female fertility naturally declines with a woman's biological age and there is an increased risk of age-related infertility. A combined graph of pregnancy rates among different age groups from 1990 to 2010 and

the decline of female fertility illustrate the historic fertility trend and female fertility changes during the life span (See Figure 2).

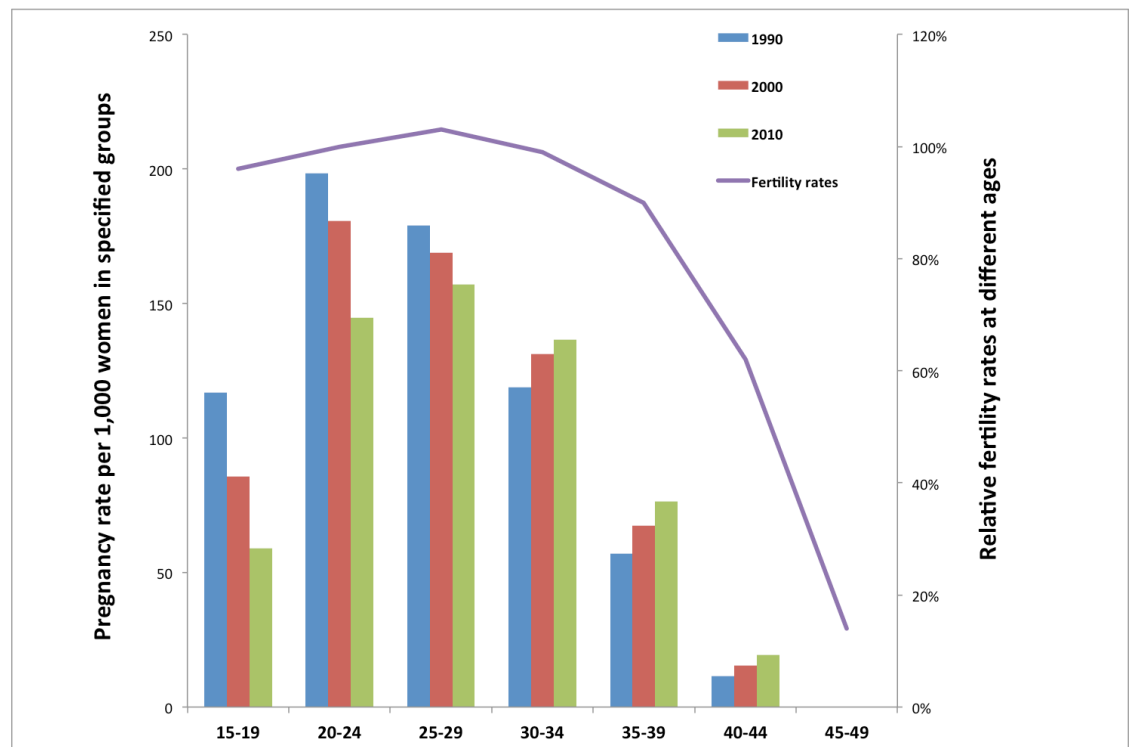


Figure 2. Trend of pregnancy rates and relative fertility rates in specified age groups

Source: Trend of pregnancy rate was adapted from the National Center for Health Statistics (CDC, 2015c) and relative fertility rates were adapted from Menken, Trussell, and Larsen (1986).

Although studies indicate that young female adults view motherhood as highly important for themselves in the future (Goundry, Finlay, & Llewellyn, 2013; Quach, & Librach, 2008; Trent, Millstein, & Ellen, 2006), some of them may unknowingly jeopardize their fertility health through unhealthy lifestyles and risky sexual behaviors in their current life stage. Each year, 24,000 women become infertile due to undiagnosed

sexually transmitted infections (STIs) (CDC, 2012). Infertility is a serious medical condition that affects a significant portion of individuals and couples in the United States (CDC, 2014a). The condition of infertility can have tremendous health, psychological, and economic impact on the individual and the overall society. According to the CDC (2012), the cost of diagnosing and treating infertility exceeds \$5 billion per year. Several national strategies have been proposed to decrease the incidence of infertility and promote reproductive health. The CDC (2014a) developed the National Action Plan to detect, prevent, and manage infertility. The American Society for Reproductive Medicine (ASRM) produced several national campaigns to highlight the critical connections between many modifiable lifestyle factors and infertility, and to educate the public about fertility health. Among all these national strategies for infertility prevention, young female adults are one of the target populations due to their high risks of STIs and unhealthy lifestyles.

For young women, the main focus of reproductive health education has been safe sex, and prevention of unplanned pregnancy and STIs /HIV (Brady, 2003; Everywoman, 2013; Littleton, 2012). Fertility health and infertility prevention have not been directly addressed since the majority of young women may not actively plan childbearing at this life stage. Nevertheless, current national data indicate that U. S. women between the ages of 18 to 24 experience a disproportionately high number of negative sexual and fertility health outcomes including the highest unintended pregnancy rate and STI infection rates compared to any other age groups of women (CDC, 2015a; CDC, 2015b; Finer & Zolna, 2016). The CDC has called for reproductive health promotion through a life cycle perspective using tools such as reproductive life planning (RLP). The goal of RLP is to

help women to actively participate in their reproductive health care, to develop a set of personal reproductive goals regarding whether, when and how to have children, and to decide the appropriate actions in order to reach these short- and long-term reproductive goals (The American College of Obstetricians and Gynecologists [ACOG], 2016; CDC, 2014b).

Compared to sexual health education, fertility health education focuses on educating women on topics of female fertility changes within the menstrual cycle and throughout the life span, the impact of lifestyle factors on female fertility, and many preventable infertility risks (Barron, 2013; Hampton, Mazza, & Newton, 2013; Stern, Larsson, Kristiansson, & Tydén, 2013; Wojcieszek & Thompson, 2013). The addition of fertility health alongside sex education may help young female adults to appreciate their sexuality without jeopardizing their fertility health. Thus, young female adults may be better prepared to manage their current sexual and reproductive health needs as well as to preserve and protect their fertility for future family planning (Barron, 2004; Brady, 2003; CDC, 2014a; IRH, 2013). Therefore, fertility health education should be an integrated component of this comprehensive RLP for young female adults.

Statement of the Problem

Experts concur that a comprehensive approach to address young female adults' reproductive health needs is critically needed (ACOG, 2016; Barron, 2013; CDC, 2014b; Littleton, 2014; IRH, 2013; Rodriguez, 2013). Specifically, for young female adults, the challenges are how to concurrently protect young female adults against unintended pregnancy and STIs/HIV, as well as the safeguarding of their future fertility (Brady, 2003). Comprehensive reproductive health services need to address the link between

risky sexual behaviors and unhealthy life styles and many preventable sexual and reproductive health risks (CDC, 2014b).

Limitations of the current sex education. The current sex education has many limitations in promoting comprehensive reproductive health for young female adults. Although STIs are well-established factors contributing to female infertility, studies indicate that sexual health education programs rarely discuss associations between STIs and infertility (Phillips & Martinez, 2010; Littleton, 2014). Many young female adults are uninformed regarding how and why STIs or behaviors such as multiple sexual partners can cause infertility (Goundry et al., 2013; Quach & Librach, 2008; Sabarre, Khan, Whitten, Remes, & Phillips, 2013). Inadequate or incorrect knowledge about fertility and conception may lead young women to miscalculate or underestimate their pregnancy risk, which could contribute to inconsistent or no use of contraceptives (Kaye, Suellentrop, & Sloup, 2009; Nettleman, Chung, Brewer, Ayoola, & Reed, 2007; Polis & Zabin, 2012). For example, some young women may choose not to use contraceptives based on the erroneous assumption that they were infertile since they did not get pregnant with unprotected sex in the past (Reed, England, Littlejohn, & Bass, 2014).

Young female adults often have concerns and worries about fertility protection and fertility preservation. In a national survey of 1,010 women, 34% of the women believed that long-term use of hormonal contraceptives could cause infertility (EMD Serono, 2011). Similarly, young women in several qualitative studies voiced their concerns that contraceptives may cause damage to a woman's body and fertility (Clark, 2001; Wimberly, Kahn, Kollar, & Slap, 2003; O'Sullivan, Udell, Montrose, Antonello, & Hoffman, 2010), and believed that they should "take a break from the pill every few

years” (Kaye et al., 2009, p.8). It seems that addressing young women’s concerns regarding their fertility might clarify some of these erroneous fears related to contraception. Furthermore, current sex education provides minimal to no information regarding fertility health. Young female adults often are unaware that abnormal menstrual cycles (e.g., irregular cycles, anovulation, excessive bleeding or pain) may indicate potential fertility problems and other reproductive health problems, such as endometriosis and polycystic ovarian syndrome (Barron, 2013; Sabarre et al., 2013).

Applications of fertility knowledge in sexual and reproductive health care.

Fertility knowledge can be applied to help a woman in multiple aspects of her sexual and reproductive health care (Barron, 2004; Barron, 2013; IRH, 2013). Knowledge and concern of STIs and infertility may promote young women to seek / participate in regular preventive STI screening (Goundry et al., 2013; Quach & Librach, 2008; Trent et al., 2006). Accurate fertility knowledge could help young women to clarify their inaccurate assumptions of their infertility status and their risks of unplanned pregnancy, which may prompt young women to be more consistent with the use of contraceptives (Frohworth, Moore, & Maniaci, 2013; Polis & Zabin, 2012). Meanwhile, for young women who choose to use fertility awareness based methods (FABM) to avoid pregnancy, knowledge and awareness of the fertile window (FW) within each menstrual cycle could increase the effectiveness of the methods and help them to successfully avoid unplanned pregnancy (Berger, Manlove, Wildsmith, Peterson, Guzman, 2012; Guzman, Caal, Peterson, Ramos, & Hickman, 2013).

Fertility knowledge can also be used to promote positive RLP for young women (Witt et al., 2013). Stern et al. (2013) conducted a randomized controlled trial to provide

fertility and reproductive education to young women during their contraceptive counseling visits. Their findings showed that young women who received the education demonstrated increased fertility knowledge and greater intention to change their lifestyles compared to women in the control group. Furthermore, 90% of the young women who received fertility health education agreed it was a “very or rather positive” experience and RLP should be routinely discussed (Stern et al., 2013, p.2457). In two online fertility education studies, young women demonstrated significant improvement of fertility knowledge related to age-related fertility decline and preventable infertility risks (Daniluk & Koert, 2015; Wojcieszek & Thompson, 2013). However, much of the knowledge improvement did not sustain after six months of the education (Daniluk & Koert, 2015), which may suggest that fertility health education should be an ongoing process (i.e., RLP) not just an one-time education event.

Limitations of available fertility knowledge assessment instruments. A distinct challenge to improving or safeguarding women’s reproductive health includes accurately assessing young women’s current fertility knowledge. Accurate assessment of young female adults’ fertility knowledge is important because it can provide a foundation to develop effective educational interventions (Bunting, Tsibulsky, & Boivin, 2013). Several instruments have been developed to assess fertility knowledge for different female population groups. Hampton et al. (2013) utilized a fertility awareness questionnaire to evaluate infertile women’s knowledge of fertility during the menstrual cycle and used both multiple-choice questions and open-ended questions. Daniluk, Koert, and Cheung (2012) developed a Likert-scale fertility awareness scale to evaluate women’s knowledge of fertility changes throughout the life span and knowledge of

assisted human reproduction. Bunting et al. (2013) developed the Cardiff Fertility Knowledge Scale to evaluate infertile couples' fertility knowledge of both male and female fertility. A detailed description of these three fertility knowledge assessment instruments will be provided in the literature review section of chapter two. Overall, several limitations are noted among these current available fertility knowledge assessment instruments: (1) None of these instruments provide a comprehensive measurement of fertility knowledge, (2) The available instruments demonstrate a lack of validity and reliability in what they purport to measure, and (3) None of these instruments are developed or validated for young female adults.

The limitations observed in the above fertility knowledge assessment instruments significantly hinder health care providers' and health educators' ability to accurately assess young female adults' fertility knowledge. The development of a reliable and valid fertility assessment tool that addresses the comprehensive meaning of fertility knowledge is important in order to provide targeted fertility health education. This is the first study that intends to develop a FKAS for young female adults, which will contribute positively toward promoting reproductive health for young women (CDC, 2014b). Once the validity and reliability of the FKAS is established, this instrument could be utilized in providing individualized fertility health education in a variety of health service settings. This study will also explore the relationships among young female adults' individual and contextual factors, their self-perceived fertility knowledge, their actual fertility knowledge, and their fertility health risks. Once these relationships are identified, in future research interventions could be developed to help young female adults in their RLP. Ultimately, the study will serve as a foundation for the future development of

comprehensive reproductive health education programs to assist young female adults in developing the knowledge and ability to manage their sexual and reproductive health needs.

Brief descriptions of the theoretical frameworks. This study was guided by three theoretical frameworks, the Reproductive Health Awareness (RHA) model, classic test theory (CTT), and item response theory (IRT). The RHA provides a framework that helps to situate women's sexual and reproductive health in a lifecycle and provides a holistic view to understand women's fertility health needs at each life stage. Thus, the RHA model will guide the development of a comprehensive fertility knowledge assessment instrument for young female adults. The RHA also guided the research process to explore the relationships among young female adults' individual and contextual factors, their actual fertility knowledge, their self-perceived fertility knowledge, and their fertility health risks. Both CTT and IRT are measurement theories that guided the development and evaluation of the newly developed fertility knowledge assessment scale. A detailed discussion of the theoretical frameworks is presented in chapter two.

Key concepts in the dissertation study. The following concepts are important for the development of the proposed study. Therefore, a brief definition of each concept is provided to facilitate the understanding of the research project.

Fertility self-care: fertility self-care refers to a woman's ability in knowing about her own fertility and risk factors, and taking appropriate action in managing her fertility and seeking medical care if needed (Bunting & Boivin, 2008).

Fertility management: fertility management is an ongoing process for a woman. From menarche to menopause, a woman makes decision and takes action about her fertility (Hawkins, Fontenot, & Harris, 2008). Fertility management includes both avoiding and achieving pregnancy, which can be either a deliberate or unintentional process.

Fertility health education: fertility health education is health education focusing on topics of female fertility changes within the menstrual cycle and throughout the life span, the impact of lifestyle factors on female fertility, and many preventable infertility risks (Barron, 2013; Hampton et al., 2013; Stern et al., 2013; Wojcieszek & Thompson, 2013).

Individual factors: Individual factors refer to the socio-demographic characteristics of the women, such as age, ethnicity, and education level that may impact a woman's fertility behaviors (Hawkins et al., 2008).

Contextual factors: Contextual factors refer to the ecological and environmental factors that provide the backdrop in which a woman lives with her fertility. These factors include but not limited to interpersonal relationships, social, cultural, religious backgrounds (Hawkins et al., 2008).

Fertility knowledge: Fertility knowledge is a multidimensional and dynamic concept. For women, this knowledge includes information regarding the menstrual cycle, pregnancy potential in each menstrual cycle and at different life stages, and risks of infertility (Mu, Appendix A).

Actual fertility knowledge: actual fertility knowledge refers to the scientific facts related to female fertility (Chan, Chan, Peterson, Lampic, & Tam, 2015;

Lundsberg et al., 2014), which is an objective assessment of a woman's true fertility knowledge level.

Self-perceived fertility knowledge: contrary to actual fertility knowledge, self-perceived fertility knowledge measures how much fertility knowledge a woman believes she has (Daniluk et al., 2012; Peterson, Pirritano, Tucker, & Lampic, 2012). This is a subjective rating of a woman's fertility knowledge level by herself.

Fertility health risks: Fertility health risks refer to a number of potentially modifiable risk factors that could predispose a person to infertility (Kelly-Weeder & O'Connor, 2006; Kelly-Weeder & Cox, 2007).

Study Purpose

The primary purpose of this study was to develop and evaluate the psychometric properties of the MU-Fertility Knowledge Assessment Scale (MU-FKAS) for young female adults. The secondary purpose was to explore the relationships among young female adults' individual and contextual factors, their self-perceived fertility knowledge, their actual fertility knowledge, and their fertility health risks. A full description of the specific research aims and research questions is provided in Chapter Two.

Significance

Significance to nursing. The National Institute of Nursing Research (NINR, 2011) recognizes health promotion and disease prevention among the main focus areas for nursing research. This strategy calls for nursing researchers to study and understand behavioral, social, and economic factors that may impact and influence individuals to make healthy decisions to maintain, protect, and preserve their health (NINR, 2011).

Young female adults disproportionately suffer high rates of STIs and many short- and long-term reproductive complications stem from undiagnosed STIs (U.S. Department of Health and Human Services, 2016). Given the potential impact of fertility knowledge on these young women's current and future sexual and reproductive health outcomes, their lives, and its economic costs, it is imperative to assess young women's fertility knowledge (CDC, 2014a; IRH, 2013). This study will provide the critical information about the current level of young female adults' fertility knowledge and the relationships among their individual and contextual factors, their self-perceived fertility knowledge, their actual fertility knowledge, and their current fertility health risks. Thus, the results from this study can be the first step in developing targeted education/intervention programs to improve young female adults' reproductive health that includes preventing unintended pregnancy, STIs, cervical cancer, and infertility.

In addition, this study will contribute to the development of fertility knowledge among nursing students. Health promotion and disease prevention is one of the essential elements of baccalaureate nursing education (American Association Colleges of Nursing [AACN], 2008). Nurses are expected to serve both as advocates and educators in promoting healthy lifestyle changes across the lifespan at the individual level and population level (AACN, 2008). Among the youth population, nursing students play unique roles in sexual and reproductive health promotion and disease prevention. They not only need fertility knowledge for themselves, but will also educate patients as healthcare providers in their professional lives. Thus, nursing students are vital in promoting fertility health for the youth population. This study will contribute to the development of a comprehensive reproductive health curriculum for nursing education,

and the increased fertility knowledge will benefit nursing students themselves as well as the patient populations they serve.

Significance to vulnerable populations. The process of “living with one’s fertility” is an ongoing and ever-changing phenomenon (Rodriguez, 2013, p.182). The decisions that a woman makes regarding her fertility will have profound physical, educational, economic, and social consequences for the woman (Hawkins et al., 2008). One critical movement in women’s fertility management has been the development of modern contraceptives. In one way, many feminists, such as Margaret Sanger, have praised the availability of safe and effective contraception that has allowed women to gain control of their bodies and permit women to achieve their life goals (Hawkins et al., 2008). On the other hand, it has been argued that the advance of contraception has supported and promoted the separation of sexuality and fertility, which may contribute to the invisibility of fertility for some young women (Söderberg, Lundgren, Olsson, & Christensson, 2011). Despite the progress of reproductive medicine and technology, women still struggle with their fertility management and continue to suffer many negative fertility outcomes, such as unplanned pregnancy, abortion, and infertility (Hawkins et al., 2008).

It is also important to recognize that young women who belong to the marginalized groups (i.e. female sex worker, women with HIV, lesbian, gay, bisexual and transgender [LGBT] women) may experience increased vulnerability in their fertility management due to factors such as social isolation, stigma, discrimination, or limited access to health care (Schwartz & Baral, 2015). For example, female sex workers are exposed to higher risks of violence, STIs, HIV, and unintended pregnancy due to their

occupation (Duff et al., 2011; Schwartz & Baral, 2015). Women living with HIV may encounter different challenges in managing their fertility because of their infection status and drug regimen. Some of these issues include family planning, safe conception method, and the impact of antivirals on the effectiveness of hormonal contraceptives (Chadwick, Mantell, Moodley, Harries, Zweigenthal, & Cooper, 2011). Despite the limitation in data collection, current national statistics indicate that LGBT youth populations experience elevated sexual and reproductive health risks, such as younger age of sexual debut, having more male and female sexual partners, and higher abortion rates (Tornello, Riskind, & Patterson, 2014). Meanwhile, LGBT women may encounter different fertility challenges in their experiences of achieving pregnancy. For instance, lesbian women / couples need to make conscious decisions regarding their access of sperm and their methods of conception prior to their childbearing initiation (Schwartz & Baral, 2015)

Both fertility and infertility are value-laden concepts that are impacted by the socioeconomic, cultural, religious and ethnic background of the woman (Hawkins et al., 2008). For instance, a group of diverse young women in a qualitative study shared their perceived stigma related to infertility and infertile women within their unique cultures. Similarly, the young Arab, Algerian, Chinese, Ethiopian, and Iranian women in this study described that infertility is frequently viewed as stigma, and in many instances, the women bore the blame of infertility in their respective cultures. Meanwhile, several young Canadian women described infertility as a biomedical health condition that is not associated with stigmatization at all (Whitten, Remes, Sabarre, Khan, & Phillips, 2013). Despite the different cultural perspectives regarding the meaning of infertility, the

majority of these young women stated that potential personal infertility would have negative impact on their self-esteem and sense of femininity with emotional sadness (Whitten et al., 2013).

Undoubtedly, the discourse concerning female fertility and fertility management is diverse and complex. Nevertheless, fertility knowledge should be a basic component of these discussions. Hawkins et al. (2008) suggested that fertility knowledge, specifically knowledge related to signs and symptoms of fertility should be the “cornerstone of fertility regulation” (p. 323). Scholars have advocated providing fertility knowledge and information to women as a part of the RLP (Stern et al., 2013; Witt et al., 2013), and supporting women to make informed family and childbearing decisions within their life contexts (Craig et al., 2014; Boivin, Bunting, & Gameiro, 2013). Understanding and application of fertility knowledge are meaningful for a woman regardless of her gender identity and sexual orientation. For example, knowledge of the FW can help a woman with HIV to time her intercourse or manual self-insemination to achieve a desired pregnancy (Schwartz & Baral, 2015). This knowledge is also important for a lesbian woman who is planning pregnancy with her same sex partner. Fertility knowledge may help young women to appreciate the relationship between sexuality and fertility that could empower young women in their self-development as a whole person (Rodriguez, 2013). A valid and reliable fertility knowledge assessment instrument can be used to facilitate young women in learning about their fertility and provide better fertility self-care within their specific life situations.

Summary

This study will serve as a starting point to address the continuum of women's fertility health using a life course framework, the RHA. Assessing young female adults' fertility knowledge can provide the baseline for fertility health education and promotion for this population. The current study will make a substantive contribution to advance the science of reproductive health education and care for young female adults.

Comprehensive reproductive health services should incorporate both sexual health education and fertility health education for young female adults (Brady, 2003; Everywoman, 2013). It is imperative to help young women understand the critical connection among their lifestyle, their sexual behaviors, and their overall reproductive health throughout their lifespan. Through the development of a valid and reliable fertility knowledge assessment scale, nursing can bring fertility health education, the missing piece of reproductive health, into young female adults' health services.

II. REVIEW OF THE LITERATURE AND THEORETICAL FRAMEWORKS

Introduction

This chapter provides conceptual frameworks and empirical support to conduct the study. First, the chapter presents the conceptual frameworks for the study, the Reproductive Health Awareness (RHA) model, Classic Test Theory (CTT), and Item Response Theory (IRT). Next, philosophical underpinnings that guide the study are described. Then, a comprehensive literature review that is relevant to the development of the MU-Fertility Knowledge Assessment Scale (MU-FKAS) and its impact on young female adults' sexual and reproductive health is presented. This review includes a discussion of female fertility and its main components. A comprehensive integrative review provides a picture of the current studies related to young female adults' fertility knowledge. Lastly, an evaluation of the current existing fertility knowledge assessment instruments highlights the limitations of these scales and provides rationale for the development of a new fertility knowledge assessment instrument for young female adults.

In addition, this chapter discusses the primary investigator's assumptions related to female fertility and fertility health education. The chapter concludes with a restatement of the purposes and research questions based on the support from the presented theoretical and empirical evidence.

Conceptual Framework

As introduced in Chapter One, this study is guided by the RHA, the CTT, and the IRT. The RHA views women's reproductive health through a lifecycle approach and provides the support for the development of a holistic and comprehensive fertility knowledge assessment instrument for young female adults. The RHA model also offers

an ecological lens to examine young female adults' sexual and reproductive health within the overall social, cultural, and political environments and support the exploration of the relationships among young female adults' individual and contextual factors, their self-perceived fertility knowledge, their actual fertility knowledge, and their fertility health risks. Both the CTT and the IRT are measurement theories that are widely used to guide the development and psychometric analyses of an instrument, and were applied to develop a reliable, valid, and usable fertility knowledge assessment instrument for young female adults.

Reproductive Health Awareness Model. The RHA model was developed by the Institute of Reproductive Health at Georgetown University to guide reproductive health promotion and wellness development for women at every stage of life (Marshall, Jennings, & Cachan, 1997). The RHA model supports cohesive efforts throughout community, educational, and health organizations in helping women to develop knowledge and skills in order to make informed sexual and reproductive health decisions (Marshall & Aumack Yee, 2003). This wellness-centered framework focuses on promoting women's reproductive health throughout the life span and it enables the integration of sexuality and fertility in comprehensive reproductive health education and services. The RHA emphasizes empowering women in their own reproductive health management and being responsible for actively participating in their own health. The ultimate goals of the RHA are to increase knowledge, foster positive attitudes, and develop critical skills that will lead to positive sexual and reproductive health outcomes (Marshall & Aumack Yee, 2003). There are four core components forming the foundation of the RHA model and they are body awareness, gender awareness,

interpersonal communications, and integration of sexuality (Marshall et al., 1997; Marshall & Aumack Yee, 2003).

Body awareness. Body awareness refers to how an individual learns to care for and respect his / her own body (Marshall et al., 1997, Aumack Yee, 1997). The concept of body awareness is based on the physical and biological structures of the female body. Female body includes both the reproductive anatomy and the underlying reproductive hormonal systems, and knowledge and understanding regarding how female reproductive system functions have been evolving with the advance of science (Woods & Loranger, 2008).

However, the development of body awareness goes beyond learning about the reproductive anatomy and physiology (Aumack Yee, 1997). It requires the woman to apply the general scientific information and fully grasp its meaning at a personal level. Through the development of body awareness, a woman learns to observe her own body, understand her body's normal changes, and know what is healthy and typical for herself at each life stage (Marshall et al., 1997; Marshall & Aumack Yee, 2003). This process is crucial for a woman to truly appreciate her own fertility; thus, a woman can make informed decisions regarding her own fertility management.

Gender awareness. Gender awareness is a culturally and socially based concept and it provides the broad ecological context to view health (Kopp, 1997). Understanding and appreciation of gender awareness is a key foundation for the RHA model. Women comprise half of the U.S. population and display significant biological and social health differences compared to men (U.S. Department of Health and Human Services, 2013). As research and science advance, there is an increasing understanding regarding the

impact of gender and sex on disease and health patterns (Verdonk, Benschop, de Haes, & Lagro-Janssen, 2009). For each individual woman, a comprehensive management of health and disease needs to be based on both the biological and sociocultural components of her sex and gender identity (McGregor, 2015).

The concept of sex focuses on the biological structure of the individual while the concept of gender refers to the socially and culturally constructed characteristics of women and men. Gender awareness requires healthcare providers to consider the interaction of biological and sociocultural factors on a person's health behaviors, outcomes, and services (World Health Organization [WHO], 2015). It is important to recognize that both a woman's biologic sex and gender can impact her sexual and reproductive health. Female fertility is a multidimensional construct rooted within the anatomy and biology of the female body. At the same time, a woman's gender identity and sexual orientation will impact her sexual and reproductive behaviors (Schwartz & Baral, 2015).

One impact of gender on sexual and reproductive health stems from the gender inequities existing between men and women. These inequities are frequently displayed as the imbalanced power within a relationship and the double standard of sexual expectations and behaviors between men and women (Blanc, 2001). Women may not be able to exercise their ability to make sexual and contraceptive decisions (World Bank Group, 2014). The LGBT populations may experience increased challenges and difficulties in navigating sexual and reproductive options due to stigma and discrimination (Everett, McCabe, & Hughes, 2016).

Comprehensive reproductive health services should be gender-based and address the impact of gender inequity on women's ability to negotiate their sexual and reproductive choices. A key strategy to improve women's sexual and reproductive outcomes is the empowerment of women (Corroon et al., 2014). Teaching young women about their body and fertility is the first step toward promoting empowerment among young women, thus, young women can develop a strong voice and autonomy in managing their own fertility and sexuality (Brady, 2003; Marshall et al., 1997; Marshall & Aumack Yee, 2003; Rodriguez, 2013).

Integration of sexuality. According to the WHO, "sexuality is a central aspect of human being throughout life encompasses sex, gender identities and roles, sexual orientation, eroticism, pleasure, intimacy and reproduction" (2006, p.5). For each woman, the expression of sexuality is a complex and ongoing process and is influenced by ethnic, cultural, moral, and religious factors (Fogel, 2013; Higgins & Davis, 2011). How a woman expresses her sexuality has a direct impact on her sexual and reproductive behaviors and outcomes (WHO, 2006). For instance, a woman with multiple sexual partners is exposed to increased risks of STIs and potential future infertility (CDC, 2016a). Women who have experienced sexual abuse or intimate partner violence have reported greater coercive sexual encounters, higher unprotected sexual activities, and drug abuse (Decker et al., 2014). Meanwhile, a woman's sexuality may also impact her fertility decisions. A lesbian woman or a single woman may choose to use artificial insemination methods or assisted reproductive technology (ART) to achieve a pregnancy based on her sexuality preference or life choice (Blake, 2011; Schwartz & Baral, 2015).

On the other hand, a woman's fertility intention may influence her sexuality and women often change their sexual behaviors in relationship to their fertility goals. A woman/ couple may consciously plan intercourse around the time of ovulation in order to achieve a desired pregnancy (Mu & Fehring, 2014). In some cases, these practices can put performance pressure and stress on both partners, and influence their expression of sexuality and intimacy toward each other (Wilkinson, Roberts, & Mort, 2015). Infertility diagnosis and treatment may also negatively affect a woman's sense of self-image, her expression of sexuality, and her intimate relationship (Fogel & Woods, 2008; Tao, Coates, & Maycock, 2011). Different contraceptive methods may affect the expression and experience of sexuality for women (Higgins & Davis, 2011; Higgins & Smith, 2016). The impact of contraceptives on sexual pleasures (i.e., physical pleasure and comfort, spontaneity, closeness and intimacy) is a major factor in determining the type and practice of contraceptive for both men and women (Higgins & Hirsch, 2008).

Sexuality and fertility are two inter-related components of reproductive health and are continuously interacting with each other throughout a woman's life. Comprehensive reproductive health promotion needs to address the impact of sexuality on a woman's fertility and help young women to achieve their optimal fertility goals within their own life contexts.

Descriptions of the five study concepts. The RHA framework views reproductive health education as a continuum starting from birth to death and each developmental stage has its specific education / health foci (Marshall et al., 1997; Marshall & Aumack Yee, 2003). This life course framework supports the development of a holistic and comprehensive fertility knowledge assessment instrument to measure

young female adults' fertility knowledge and guide the development of fertility health education throughout a woman's life. Within the RHA model, reproductive health is viewed as a dynamic process not a static state and is influenced by multiple factors (Aumack-Yee, 1997). A woman's knowledge and understanding of fertility may influence her lifestyle choices and contribute to her fertility health risks (Kelly-Weeder & O'Connor, 2006; IRH, 2013; Rodriguez, 2013). At the same time, how knowledgeable a woman perceives herself to know about fertility will also influence her actions in fertility self-care (Bunting & Boivin, 2007). Despite the available literature in describing and assessing the concept of individual factors, contextual factors, actual fertility knowledge, self-perceived fertility knowledge, and fertility health risks for young women, currently, no studies have explored the relationship among these factors on a young woman's fertility knowledge and fertility health risks. This understanding will guide future research in providing individualized fertility health education and care. A detailed description of the five main study concepts is provided below.

Individual factors. Individual factors refer to the socio-demographic characteristics of a woman, which may impact her fertility decisions and behaviors (Hawkins et al., 2008). Several studies had assessed the relationship between women's socio-demographic factors and their fertility knowledge. Lundsberg et al. (2014) conducted an online survey with 1,000 U. S. women between the ages of 18 to 40 to assess their knowledge, attitudes, and practices related to fertility and conception. Their findings indicated that women between the ages of 18 to 24 had less knowledge of the impact of obesity and irregular menses on female fertility and they also had less accurate understanding regarding ovulation and the FW within the menstrual cycle compared to

either the age group of 25-34 or the age group of 35 to 40 (Lundsberg et al., 2014). Berger et al. (2012) analyzed data obtained from a national sample of 1,800 young people between the ages of 18 and 29 to evaluate their knowledge of the FW. Despite the overall low knowledge level among the whole group, the researchers found that women's fertility knowledge was positively associated with their age and education level, and both black and Hispanic young adults had less accurate knowledge compared to their white peers (Berger et al., 2012). However, Daniluk et al. (2012) carried out an online survey with 3,345 Canadian women between the ages of 20 to 50 to evaluate their fertility knowledge. They concluded that women in their study generally lacked comprehensive and coherent fertility knowledge, and women's age and their education levels were not correlated with their fertility knowledge. For this study, the selected individual factors (age, ethnicity, and education) were collected using a demographic questionnaire.

Contextual factors. Different from individual factors, contextual factors refer to the ecological /environmental factors that may impact how a woman lives with her fertility, these factors included but not limited to interpersonal relationships, social, cultural, and religious backgrounds (Bunting et al., 2013; Hawkins et al., 2008). Bunting et al. (2013) surveyed fertility knowledge of 10,045 international participants (8355 women and 1690 men) who had been trying to conceive. The researchers examined the relationships among selected contextual factors (residing country, fertility experience, fertility medical consultation, past pregnancy experience) and fertility knowledge. Their findings indicated that fertility knowledge was positively associated with the following factors, including residing in a high human development index country, having a paid job, living in an urban area, and having had fertility medical consultation. However,

fertility knowledge was not correlated with either infertility experience or past pregnancy experience (Bunting et al., 2013).

Berger et al. (2012) assessed the relationship between certain contextual factors (being sexually active or not, having received formal sex education, use of contraception methods, and past pregnancy experience) and their knowledge of the FW using a national sample of 1,800 young people. The only association was that young people who used natural family planning (NFP) or withdraw method had more accurate knowledge of the FW. Whether being sexually active, past pregnancy experience, use of condoms or hormonal contraceptive methods, or received formal sex education was not associated with higher knowledge of the FW (Berger et al., 2012). Similarly, Fehring, Schneider, and Raviele (2011) found that women who used an online-based NFP education and service program had a significant increase in their knowledge of fertility within the menstrual cycle. It seems that women who use fertility awareness based methods (i.e., FABM or NFP) may have higher fertility knowledge compared to women who have no direct experience of monitoring their fertility (IRH, 2013).

Lucas, Rosario, and Shelling (2015) examined the relationship between young people' fertility knowledge and their relationship status. Their findings indicated that participants who were either married or in relationships had more accurate knowledge of IVF success rates compared to participants who were single. For this study, the selected contextual factors (whether being sexually active, contraception methods, pregnancy experience, and relationship status) were measured using the same demographic questionnaire.

Actual fertility knowledge. Actual fertility knowledge is defined as the scientific facts related to female fertility (Chan et al., 2015; Lundsberg et al., 2014), which is an objective assessment of a woman's true fertility knowledge level. Many studies have described what young women know about female fertility. Yet, there are no studies that have attempted to assess the relationship between young women's fertility knowledge and their fertility health risks. As described in chapter one, there also lacks a valid, reliable, and comprehensive instrument to quantify fertility knowledge. Therefore, this study will attempt to develop such a valid and reliable instrument and will be used to measure young women's actual fertility knowledge.

Self-Perceived fertility knowledge. Self-perceived fertility knowledge refers to how much a woman believes she has fertility knowledge. This is a subjective self-assessment of an individual's fertility knowledge. Several studies have examined women's self-perceived fertility knowledge and women displayed a range of perceptions related to their fertility knowledge level (Chan, Chan, Peterson, Lampic, & Tam, 2015; Daniluk et al., 2012; Jukkala, Meneses, Azuero, Cho, & McNees, 2012; Peterson, Pirritano, Tucker, & Lampic, 2012). In most of the studies, self-perceived fertility knowledge was usually assessed using one or two global questions. For instance, Daniluk et al. (2012) used two four-point Likert scale questions to ask the participants to self-rate their overall knowledge regarding fertility and ART procedures and treatment options. Both Peterson et al. (2012) and Chan et al. (2015) used one five-point Likert scale question to evaluate young people's self-assessed fertility knowledge level. Jukkala et al. (2012) developed the Knowledge of Fertility Scale (KFS) for self-assessment of fertility knowledge. The KFS contains 21 items with a three-point rating scale that

evaluate women's self-perceived knowledge level regarding specific fertility component. The KFS had established validity and reliability with a sample of breast cancer survivors. Compared to the available approaches of assessing women's self-perceived fertility knowledge, the KFS has greater comprehensiveness and reliability. For this study, young women's self-perceived fertility knowledge will be assessed using the FKS (Jukkala et al., 2012).

Fertility health risks. Fertility health risks refer to a number of potentially modifiable risk factors that could predispose a person to infertility (Kelly-Weeder & O'Connor, 2006; Kelly-Weeder & Cox, 2007). Evidence regarding the impact of certain lifestyles on fertility has been growing rapidly in recent years. Hassan and Killick (2004) evaluated the association between women's lifestyle and their time to pregnancy among 2112 pregnant women. Their findings indicated certain lifestyle (i.e., smoking, alcohol, body mass index, coffee and tea consumption) could significantly prolong a woman's time to conceive, and these effects were cumulative and dose-dependent. Kelly-Weeder and Cox (2007) assessed the relationship of certain lifestyle factors and female infertility using a subpopulation (412 fertile women and 412 infertile women) of the 1995 National Survey of Family Growth. Their results revealed that the following factors, including increasing age, ectopic pregnancy history, obesity, and current smoking status, were significantly correlated to increased female infertility. Meanwhile, both histories of condom use and Pap smear in the last year were associated with decreased female infertility risk (Kelly-Weeder & Cox, 2007).

Tools have been developed to quantify fertility health risks. Bunting and Boivin (2010) developed and validated a fertility status awareness tool – FertiSTAT. This tool

allows a woman to assess her fertility risks based on her own life style and reproductive history. The FertiSTAT was developed using a Delphi method and demonstrated its validity (Bunting & Boivin, 2010). Hvidman et al. (2015) created a fertility risk evaluation tool to provide fertility assessment and fertility counseling for women of reproductive ages. This tool requires the assessment of serum anti-Müllerian hormone (AMH) and a transvaginal sonography in order to establish the current fertility status for the woman. While the evaluation of AMH and sonography is important for a woman who is experiencing fertility difficulties, such assessments may not be appropriate for a young and healthy woman who has no apparent fertility health issues. The cost and access of such clinical evaluation are also prohibitive for their broad applications. Compared to the fertility risk evaluation tool, the FertiSTAT provide a quick and simple fertility risk assessment for young a woman, which is non-invasive and requires no infertility expert consultation. Thus, young women’s fertility health risks will be assessed using FertiSTAT (Bunting & Boivin, 2010). A summary table including the RHA elements, the study variables, and the empirical measurement is provided below (See Table 1).

Table 1. Summary of the included RHA elements, study variables, and empirical measurements

RHA elements	Study variables	Empirical measurements
Individual factors	Age, ethnicity, education	Demographic questionnaire
Contextual factors	Sexual experience, Contraceptive methods, Pregnancy experience Relationship status	Demographic questionnaire

Fertility knowledge	Self-perceived fertility knowledge Actual fertility knowledge	Knowledge of Fertility Scale The newly developed MU-FKAS
Fertility health risks	Multiple factors that can predispose a woman to infertility or fertility-related health issues	FertiSTAT

Measurement Theory. Measurement is assigning numeric numbers to individuals in a systematic way to represent certain attributes of individuals (DeVellis, 2012). Measurement theory is a branch of applied statistics that focuses on the development and evaluation of measurements and can provide information about the usefulness, accuracy, and meaningfulness of the instrument (Allen & Yen, 2002). There are two main types of measurement theories, the CTT and the IRT. Each of these theories provides unique statistical methods to assess the psychometrics of an instrument both at the item and whole scale level.

Classic test theory. CTT has been the foundation for measurement theory for more than 80 years and has been widely used in the development and evaluation of many instruments (Allen & Yen, 2002). CTT is a true score theory that states a person's observed score consists of two components: true score and error score. The mathematic expression for CTT is $X = T + E$, in which X is the observed score, T represents the theoretical true score, and E is the error score or the error of measurement (Allen & Yen, 2002). Using CTT, an individual's observed total score on a scale is usually used to estimate the reliability and validity of the whole scale (De Ayala, 2009; DeVellis, 2012).

CTT can be used to evaluate an instrument's performance both at the item and the whole scale level. At the item level, item statistics, such as means and variance, item difficulty, and item discrimination can be calculated and assessed for each individual item. CTT also provides ways to assess the overall accuracy statistics (e.g., standard error of measurement, reliability coefficient) for the whole scale. Reliability refers to the proportion of variance that is due to the variance of the underlying latent variable and can be estimated for each instrument (DeVellis, 2012). The common methods to estimate reliability include test/retest, parallel forms, and internal consistency, and the selection of the estimate method is based on the characteristics of the instrument and its application (Allen & Yen, 2002; Streiner & Norman, 2008).

Validity of an instrument refers to how accurately an instrument measures what it purports to measure (Waltz, Strickland, & Lenz, 2010). There are three main types of validity, which are content validity, construct validity, and criterion-related validity (Streiner & Norman, 2008). Content validity of an instrument refers to the completeness of the items sampling the full range of the content and content validity index (CVI) is the preferred evaluation method (DeVon et al., 2007). There are many ways to assess the construct validity of an instrument, such as contrasted groups, hypothesis testing, factor analysis, and the multitrait-multimethod (DeVon et al., 2007). Among these approaches, factor analysis is frequently used to derive factors that assess the theoretical structure of the instrument, thus, provide support for the construct validity of the instrument (Allen & Yen, 2002). Using contrasted group approach, two groups with known difference in the construct are sampled to validate the instrument (Devon et al., 2007; Streiner & Norman, 2008). Criterion validity is the evidence of the hypothesized relationship between the

attributes being measured and another purposefully selected variable (the criterion).

Ideally, the criterion should be a “gold standard” that is well established and recognized in the field (Streiner & Norman, 2008).

Although CTT based psychometric analyses are easy to carry out and are widely used for instrument development, several limitations are noted. First, since all item level statistics are based on the individual and their reference group’s performance on the same item, these statistics are sample dependent, which means as the sample changes, the estimation of the item statistics will change (Fan, 1998; Hambleton & Jones, 1993). Likewise, the reliability of the scale is also sample dependent and varies with each application. For example, the estimate of reliability of the same scale will be lower from a homogeneous sample than from heterogeneous sample, which makes it impossible to interpret the reliability of the scale without the sample context (Hambleton, Swaminathan, & Rogers, 1991). Furthermore, the estimate of reliability for instruments with binary responses may not be accurate due to the limited variance in each item, which often leads to the lower-bound estimate of reliability (DeVellis, 2012).

Item response theory. IRT is an alternative to CTT, which has been increasingly used in instrument development and evaluation in recent years. As a measurement framework, IRT provides a way to link the actual item responses with the underlying latent trait that is assessed by a test or scale (Drasgow & Hulin, 1990). This underlying latent trait represents a hypothetical and unobservable characteristic, attribute, or trait that impacts the subjects’ response toward a set of questions, and is usually denoted as theta (θ). IRT purports that an examinee’s performance can be explained or predicted based on the underlying attribute and individuals with higher value of the attribute should have

higher probabilities to obtain a positive or correct response than individuals with lower attributes (Drasgow & Hulin, 1990). Compared to CTT approach, IRT is a latent trait theory that focuses on the probabilistic distribution of examinees' success at the item level and uses a mathematical function to specify the relationship between the observable performance and the underlying latent trait (Fan, 1998). A group of models have been developed within the IRT framework. For scales with dichotomous format, three IRT models, one-, two-, and three-parameter IRT models are commonly used to assess both person and item statistics (Fan, 1998).

In contrast to the focus of the CTT on the whole scale, the focus of IRT is on the properties of the individual item, which leads to the different statistical analysis in assessing the reliability and validity of a scale (Fan, 1998; DeVellis, 2012). In CTT, the reliability of a scale is influenced by both the length of the scale and the inter-item correlation, and can be enhanced through redundancy - increasing the number of items in the scale. On the other hand, IRT approach focuses on identifying better items to improve the reliability of the scale. Furthermore, IRT can help differentiate the location of different items on the continuum of the latent trait. Consequently, the reliability of the whole scale can be improved through better items and more complete measurement of the underlying latent trait (Drasgow & Hulin, 1990). Another great advantage of IRT is its ability to present item and scale characteristics in visual forms (DeVellis, 2012). An item characteristic curve (ICC) can visually depict each item's difficulty, discrimination, and false positives and aids in the evaluation of each item's performance. The item information function curve indicates the contribution of each individual item to the assessment of the underlying trait at each ability level (Hambleton & Jones, 1993). At

the same time, the test information function is the sum of information in a test and provides estimates of the errors related to ability estimates, and a test information function curve highlights the precision of a scale in assessing the latent attribute at different levels of ability in a visual form (Hambleton & Jones, 1993). In all, the ICC, item information function curve, and the test information function curve can provide useful information when assessing the quality of the items and the overall scale in measuring the intended latent attribute.

The advantages of combining CTT and IRT in psychometrics evaluation.

Although CTT and IRT have been viewed as rivals, many researchers have noted there is no clear advantage with one framework over the other one (Fan, 1998; DeVellis, 2012). In contrary, the combination of selected CTT and IRT analyses can provide a comprehensive assessment of the quality of the measurement (DeVellis, 2012). For this study, the CTT was used to assess the reliability and validity of the newly developed MU-FKAS as a whole scale. Then, the IRT was used as a supplementary framework to provide visual illustration of the individual items on the MU-FKAS using the ICC and item information curve to provide more detailed information about the performance of each individual item in assessing the latent attribute, i.e., fertility knowledge. The application of both CTT and IRT provided a more comprehensive evaluation of the newly developed MU-FKAS, and will lead to further refinement of the scale both at the individual item and the whole scale level.

Philosophical Underpinnings of the Study

Paradigms are patterns of beliefs and practices that provide lenses, framework, and processes to guide nursing inquiry (Guba & Lincoln, 1994; Weaver & Olson, 2006).

Each paradigm provides guiding principles to address the ontological, epistemological, and methodological questions of nursing research (Guba, 1990; Guba & Lincoln, 1994). Thus, this section will discuss the scientific philosophy of post-positivism, which guides the selection of the design and methodology of this study.

Historically, scientific inquiry had heavily emphasized observation and quantification of the phenomenon being studied (Guba & Lincoln, 1994). Positivism had been the dominant philosophical paradigm since its principles support scientific approaches that are based on rigid rules of logic, precise measurement, and empirical testing (Weaver & Olson, 2006). Within the Positivism paradigm, researchers are detached from the “observable” and observations are stripped of contexts (Guba & Lincoln, 1994). These restrictions greatly limit nurse researchers since the main focus of nursing science is human beings and the impact of human behaviors on health, and human behaviors are complex phenomena that require contexts to understand (Im & Chee, 2003). In response to the limitations of Positivism, Post-positivism proposes there is no absolute truth and contextual factors are important in understanding relationships among variables (Monti & Tingen, 1999). Post-positivism continues to emphasize well-defined concepts and variables, and empirical testing for scientific inquiry while recognizing the importance of values and interpretation in scientific inquiry (Guba & Lincoln, 1994; Phillips, 1990).

In regards to ontology, Post-positivism considers that “critical realism” is the only and possible truth that human beings can apprehend (Guba & Lincoln, 1994). There is no theory-neutral reality and reality can only be comprehended and understood based on critical examinations (Weaver & Olson, 2006). For epistemology, Post-positivism

supports modified dualism in that the researcher cannot be totally detached from reality and interpretation is required to comprehend the knowable (Guba & Lincoln, 1994). For methodology, Post-positivism emphasizes a “modified experimental/manipulative” approach or design (Guba & Lincoln, 1994, p.110). The researcher aims to conduct research in natural settings, collect more situational information, and solicit emic viewpoints to understand the study phenomenon (Guba & Lincoln, 1994). Researchers are encouraged to use multiple sources of data to aid in the interpretation of the phenomenon (Kimchi, Polivka, & Stevenson, 1991).

The conceptualization and design of this study was closely aligned with the paradigm of post-positivism. First, the construct of fertility knowledge is not directly observable. A well-developed instrument can aid in the interpretation and understanding of the construct of fertility knowledge (Schumacher & Gortner, 1992). Also, the utilization of RHA will guide the exploration of the relationships among young female adults’ individual and contextual factors, their self-perceived fertility knowledge, their actual fertility knowledge, and their current fertility health risks. Second, this multi-phase study uses both fertility knowledge experts and young female adults to develop and evaluate the MU-FKAS, which provide multiple data sources to validate the newly developed instrument. Furthermore, the data was collected through Qualtrics, an online survey tool, in the subjects’ natural setting (Guba & Lincoln, 1994).

Review of the Related Literature

The following review of the literature will provide a comprehensive description of the current stage of fertility knowledge development for young female adults and its impact on their sexual and reproductive health outcomes. First, the review will describe

the multiple dimensions of female fertility. The impact of fertility knowledge on young female adults' sexual and reproductive health outcomes will also be reviewed. Next, an integrative review is conducted to summarize the current research related to young female adults' fertility knowledge. Finally, the review will provide an evaluation of the available fertility knowledge assessment instruments. Gaps in these previous studies will provide justification for the current study and the development of a valid and reliable fertility knowledge assessment instrument.

Female Fertility. Female fertility has been frequently defined as a biological term that is associated with reproduction and procreation (Friese, Becker, & Nachtigall, 2006; Brady, 2003; Vigil, Ceric, Cortes, & Klaus, 2006; Wimberly et al., 2003).

However, female fertility is a much broader term that encompasses both biological and psychosocial dimensions, and the four key attributes of female fertility are biological self, psychosexual self, power, and paradox (Rodriquez, 2013). The relationship between a woman's biological self and psychosexual self is dynamic and ongoing, which often reveals in the power and struggle during the process of fertility suppression, fertility preservation, or fertility realization (Friese et al., 2006; Keogh, 2006; Rodriguez, 2013; Söderberg et al., 2011).

Biological aspect of female fertility. A woman's biological fertility can be viewed both through the lens of her life stage and her monthly cycle. Female fertility is a changing phenomenon and has a beginning, peak, and ending point in a woman's life. Menarche is viewed as the start of a woman's fertility, and the menstrual cycle is regarded as a sign of female fertility (Friese et al., 2006; Littleton, 2012; Vigil et al., 2006). A consistent downward trend in the mean age of menarche have been observed

over the years and this decline is noticeable for all race/ethnicity groups, among which non-Hispanic black female has the largest decline (McDowell, Brody, & Hughes, 2007).

Female fertility changes within the life cycle. A woman's biological fertility is closely related to the quantity and quality of her oocytes, and her biological age is important in determining her fertility potential (Strauss & Williams, 2014; Friese et al., 2006). A woman has the maximum number of oocytes residing in her ovaries when she is a fetus at the 20 weeks of gestation (Peters, 1976). The number and quality of oocytes then progressively decrease from fetal life until menopause (Balasch & Gratacós, 2012; Strauss & Williams, 2014). It is well established that female fertility declines with the advance of biological age (Andersen, Wohlfahrt, Christens, Olsen, & Melbye, 2000; Dunson, Colombo, & Baird, 2002; Menken, Trussell, & Larsen, 1986; Laufer, Simon, Samueloff, Yaffe, Milwidsky, & Gielchinsky, 2004), and there is a sharp drop of fertility around the age of 35 (Mills & Lavender, 2011). The onset of perimenopause varies depending on multiple factors, and the median age at menopause ranges between the ages of 50 and 52 years for women in the industrialized countries (Gold, 2011). Menopause usually is viewed as the end point of natural female fertility that signals the loss of fertility and the completion of the fertile stage for the woman (Rodriguez, 2013).

Female fertility within the monthly cycle. At the same time, female fertility also ebbs and flows in a monthly cyclic fashion. A woman's menstrual cycle can be divided into two main phases: the ovulatory phase and the luteal phase, and ovulation is the central event of the monthly cycle (Moghissi, 1992). Ovulation is defined as the releasing of a mature ovum from the ovary and this process is the result of complex interactions among the brain, the pituitary, and the ovary (Yen, 1979). The two main

gonadotropins involved in the stimulation and maturation of ovarian follicles are follicle stimulating hormone (FSH) and luteinizing hormone (LH) (Moghissi, 1992). Both FSH and LH are released by the pituitary gland. The primary function of FSH is to stimulate follicular growth. The LH peak is closely related to the timing of ovulation and research indicates that ovulation usually occurs within 16 to 24 hours after the LH peak (Moghissi, 1992). Current evidence supports that a woman is only fertile for about six days and then she is infertile for the rest of the cycle (Wilcox, Weinberg, & Baird, 1995; Dunson et al., 2002). This cyclic change of female fertility has been applied to help women avoid or achieve pregnancy.

The impact of lifestyle and environmental factors on female fertility. Apart from the naturally changing characteristics of female fertility, a woman's biological fertility is also impacted by many environmental and lifestyle factors (ASRM, 2013; Chandra, Copen, Stephen, 2013; Kelly-Weeder & O'Connor, 2006; Macaluso et al., 2010). Considerable evidence has demonstrated that undiagnosed STIs, such as chlamydia and pelvic inflammatory disease, can cause infertility (Macaluso et al., 2010). Certain lifestyle factors, such as multiple sexual partners, tobacco smoking, moderate to large alcohol consumption, and obesity, also impair fertility (ASRM, 2013; Barron, 2013; Bunting & Boivin, 2008; Kelly-Weeder & O'Connor, 2006). Increased evidence indicates that certain environmental and work hazards can impact female fertility and lead to decreased fertility or abnormal birth outcomes (ASRM, 2013). Exposure to a number of exogenous estrogenic compounds in food and environment may have short /long-term impact on human fertility and health (Andersson & Skakkebaek, 1999; Fisch, Hyun, & Golden, 2000).

Psychosocial aspect of female fertility. A woman lives with her fertility from menarche until menopause. How a woman manages and fulfills her fertility needs has tremendous impacts on her physical wellbeing as well as her psychosocial wellbeing (Hawkins et al., 2008). The phenomenon of female fertility is often described as a paradox in women's life (Keogh, 2006; Rodriguez, 2013; Söderberg et al., 2011). This paradoxical view of fertility is reflected in how a young woman has to juggle the needs of both her fertile body and her sexual body within the context of her life. Keogh (2006) defined a woman is symbolically consisting of a fertile body and a sexual body, in which the fertile body represents the reproductive structure and capacity of a woman while the sexual body represents the woman's body to experience sexual activity. Young women often feel the incompatibility between the sexual body and the fertile body and need to make a choice between these two bodies (Keogh, 2006). Failure to balance the needs of both her fertile and sexual body can disrupt a woman's life, cause fear, worry, and struggles for the woman. For some young women, fertility is viewed simultaneously as both "a burden and a blessing" (Söderberg et al., 2011, p.402). As one young woman describes her feeling about fertility, "I feel like it's [fertility] my most precious and feared thing. Both my greatest ambition and my worst nightmare if you become pregnant, and has always been that" (Keogh, 2006, p.91).

The paradox of female fertility is also reflected in the dilemma that a woman may experience between her optimal biological age and the social age that she is ready to have children (Bachrach, 2006; Earle & Letherby, 2007; Everywoman, 2013; Littleton, 2012; Söderberg et al., 2011). Young women generally view pregnancy as a choice and decision that needs to happen at the 'right time' (Earle & Letherby, 2007; Söderberg et

al., 2011), and express a high sense of perceived self-control over their intention to delay childbearing (Williamson & Lawson, 2015). For some women, fertility may be assumed as a bodily function that will work when the woman is ready (Everywoman, 2013; Söderberg et al., 2011) and there is longevity of female fertility (Hashiloni-Dolev, Kaplan, & Shkedi-Rafid, 2011; Littleton, 2012; Williamson & Lawson, 2015). These assumptions of female fertility can have profound impact on women's reproductive decisions, which could lead to age-related infertility and involuntary childlessness (Dougall, Beyene, & Nachtigall, 2013; Everywoman, 2013).

Female fertility has been viewed as a vital component of their identity by some women (Brady, 2003; Rodriguez, 2013; Söderberg et al., 2011; Whitten et al., 2013). Researchers have found that young women often place high importance on motherhood and express strong hope to have their own children in the future (Tydén, Svanberg, Karlstrom, Lihoff, & Lampic, 2006; Bretherick, Fairbrother, Avila, Harbord, & Robinson, 2010; Peterson et al., 2012; Virtala, Vilska, Httunen, & Kunttu, 2011), and many of them associate infertility with emotional stress, negative gender identity, and lower self-esteem (Whitten et al., 2013). Clearly, the meaning of female fertility is far beyond biological reproduction as one young woman talks about her wish of becoming a mother one day: "It is a part of life too. I think it is very important for me to have children. I would not feel complete otherwise" (Söderberg et al., 2011, p. 406). This description again highlights the critical connection between the biological and psychosocial components of female fertility that complement the development of a woman as a whole person. It is imperative to help young women learn about the power

and paradox of female fertility and empower them to make informed reproductive health decisions (Rodriguez, 2013; Söderberg et al., 2011).

Female fertility within diverse contexts. A woman lives through different fertility stages throughout her life, and her perspectives and needs regarding fertility shift depending on her life situation and her life stage. Meanwhile, female fertility exists in multiple contexts, and a woman's sexuality, gender identity, culture, and religious background will impact how a woman views and manages her fertility (Hawkins et al., 2008). Fernández and Fogli (2006) studied the effect of culture and family influence on women's fertility with 1,145 women who were all born in the United States but had different ethnic backgrounds. Their findings indicated that both culture and family were significant factors in predicting women's fertility, a woman tended to have more children if she belonged to an ethnic group that usually had more children or if she was from a large family.

Religion is another salient factor that may influence a woman's fertility and family planning decisions and behaviors (Schenker, 2000). Hayford and Morgan (2008) evaluated the relationship between women's religiosity and fertility using the 2002 National Survey of Family Growth data. Their results suggested that women who viewed religion as "very important" had both earlier and higher intended fertility and actual fertility outcomes compared to women who considered religion as "somewhat important" or "not important" in their life (Hayford & Morgan, 2008). Specific religious teaching regarding fertility and family may also influence women's fertility behaviors (Schenker, 2000). For instance, orthodox Jewish usually have substantially more children compared to other Jewish women (Mott & Abma, 1992).

A woman's gender identity and sexuality may also affect a woman's fertility experience. Currently, very limited research has been done to explore the LGBT populations' fertility-related needs. Studies show that more lesbian women are choosing to become parents in their same sex relationship (McCann & Delmonte, 2005; Renaud, 2007; Schwartz & Baral, 2015). However, LGBT women who desire to have children may face unique challenges in deciding how to achieve their fertility and family goals, and have to make conscious decisions in choosing how to conceive and their access of sperm (Hayman, Wilkes, Halcomb, & Jackson, 2015; Renaud, 2007; Schwartz & Baral, 2015). Transgender individuals may choose to provide oocytes or become pregnant based on their preserved reproductive biology, which adds to the complexity of fertility decisions for this population (Schwartz & Baral, 2015).

The Impact of Contraception and ART on Female Fertility. The impact of contraception and ART on female fertility is undeniable. The development of modern contraceptives has provided women the possibility to manage their fertility safely and effectively (Hawkins et al., 2008). According to the Guttmacher Institute (2016), U. S. women on average spend three decades of their reproductive life trying to avoid unintended pregnancies. With the assistance of contraceptives, a woman can intentionally prevent or defer pregnancy in order to fit in her life (Keogh, 2006). Nevertheless, women display great variance in their decision, use, and consistency of contraception (Hawkins et al., 2008), and nonuse, inconsistent, or incorrect use of contraceptives accounts for 95% of all unintended pregnancy (Guttmacher Institute, 2016).

Since the success of the first test tube baby in 1978 ART has allowed some women to achieve their fertility goal beyond the natural limits of fertility (Edwards, 2002). In the United States, the use of ART has increased over the years and about 1.5% of infants were conceived with ART in 2012 (CDC, 2016b). Post-menopausal in vitro fertilization (IVF) with donor-oocytes further extends childbearing beyond the normal reproductive years for women (Friese et al., 2006). The removal of the experimental label on oocyte cryopreservation, the support of two prominent technology companies (i.e., Facebook and Apple) for their female employees to use this technology, and women's desire to delay childbearing have promoted the phenomenon of "social egg freezing" (Baldwin, Culley, Hudson, & Mitchell, 2014; Rebar, 2016). ART has expanded from a medically necessary procedure into an elective option for healthy women (Dondorp & De Wert, 2009). Nevertheless, ART carries its own risks and limitations, and the success rates vary significantly by women's age (Gnoth et al., 2011). A meta-analysis of 25 published ART articles has suggested that children who were born with ART had statistically higher risk of birth defects compared to natural conception (Hansen, Bower, Milne, de Klerk, & Kurinczuk, 2005). It is imperative for women to recognize that ART is not the 'silver bullet' to extend their natural fertility or solve infertility. Accurate knowledge regarding age-related fertility decline and ART could assist young women in making informed RLP and provide a more realistic understanding and appreciation of the ART on reproduction.

The Impact of Fertility Knowledge on Female Adults' Sexual and Reproductive Health

The Impact of Fertility Knowledge on Contraceptive Behaviors. A woman's fertility is closely linked and intertwined with her sexuality; knowledge and understanding of female fertility can impact a woman's sexual and reproductive behaviors, thus her sexual and reproductive outcomes (Brady, 2003, IRH, 2013). Studies indicate that a lack of fertility knowledge regarding the menstrual cycle and the FW may lead young women to utilize less reliable contraceptive methods or incorrectly interpret their body signs (Berger et al., 2012; Nettleman et al., 2007). Young women may erroneously believe that they are either subfertile or infertile based on the information that they did not become pregnant with unprotected sex (Frohworth et al., 2013; Moore, Singh, & Bankole, 2011). Thus, women may choose not to use contraceptives or inconsistently use contraceptives, which greatly increase their risks of unintended pregnancy (Nettleman et al., 2007; Gungor, Rathfisch, Beji, Yarar, & Karamanoglu, 2012; Witt et al., 2013). Furthermore, limited or inaccurate fertility knowledge may hinder young women's ability to avoid pregnancy effectively despite their strong intention to do so. Several studies show for young women who want to use FABM to avoid pregnancy, they were unable to correctly identify the FW during their menstrual cycle (Berger et al., 2012; Witt et al., 2013; Guzman, Caal, Peterson, Ramos, & Hickman, 2013).

Researchers have found that young women view the protection of their future fertility as very important and would like to have children in the future (Goundry et al.,

2013; Quach, & Librach, 2008; Trent et al., 2006; Stenhammar, Ehrsson, Akerud, Larsson, & Tydén, 2015). Yet, evidence indicates that many of them are not optimal in taking care of their fertility in their current life stage. Studies of female university students' sexual and contraceptive behaviors from 1989 to 2014 have shown that young females have increased numbers of sexual partners, increased riskier sexual behaviors, and higher rates of STIs (Larsson & Tydén, 2006; Stenhammar et al., 2015; Tydén, Bjorkelund, & Olsson, 1991; Tydén, Bjorkelund, Odling, & Olsson, 1996; Tydén, Olsson, & Haggstrom-Nordin, 2001; Tydén, Palmqvist, & Larsson, 2012). Meanwhile, several studies have suggested that young women may not know how and why risky sexual behaviors such as multiple sexual partners or STIs can cause infertility in the future (Goundry et al., 2013; Sabarre et al., 2013; Quach & Librach, 2008; Pitts, & Hanley, 2004), and that their behaviors and lifestyle could jeopardize their fertility (Bunting & Boivin, 2008).

The findings of some studies have suggested that a woman's fertility knowledge may influence their lifestyle choices and promote positive behavior changes (Fulford, Bunting, Tsibulsky, & Boivin, 2013; Hammiche et al., 2011; Nouri et al., 2014). Nouri et al., (2014) found that women with higher fertility knowledge were associated with a healthier lifestyle compared to women who had lower fertility knowledge among a group of university students ($N=340$). Fulford et al. (2013) found that women younger than 35 intended to make lifestyle changes in order to optimizing their fertility if they had higher fertility knowledge level and felt susceptible to infertility. Hammiche et al. (2011) provided tailored dietary and lifestyle counseling to 419 couples who were trying to

conceive, which resulted in significantly decreased alcohol use, more physical exercise and folic acid supplement in women and less alcohol use in men.

The Impact of Fertility Knowledge on Childbearing Behaviors and

Outcomes. Women's fertility knowledge can also impact their childbearing behaviors and outcomes. Knowledge of the FW can help a woman/couple to time their intercourse in order to achieve a desired pregnancy (Evans-Hoeker et al., 2013; Mu & Fehring, 2014; Robinson, Wakelin, & Ellis, 2007). Two studies found that many women have actively attempted to increase their fertility knowledge when they were trying to conceive (Hampton et al., 2013; Lundsberg et al., 2014). However, research thus far has suggested that women may not have accurate knowledge of their fertility during the menstrual cycle, which may lead to mistimed intercourse, delayed conception, or an unnecessary infertility consult (Blake, Smith, Bargiacchi, France, & Gudex, 1997, Hampton et al., 2013; Lundsberg et al., 2014; Robinson & Ellis, 2007; Zinaman, Johnson, Ellis, & Ledger, 2012).

Lack of knowledge of age-related fertility decline had been identified as a contributing factor leading to delayed childbearing and unexpected struggle with infertility for some women (Cooke, Mills, & Lavender, 2010; Cooke, Mills, & Lavender, 2012; Dougall, Beyene, & Nachtigall, 2012; Dougall et al., 2013; Friese et al., 2006). Both Bachrach (2006) and Everywoman (2013) shared their personal struggle with age-related infertility and their anger and resentment that they were not properly informed and educated on the decline of female fertility and the potential risks of age-related infertility. Women from several qualitative studies echoed these two women in their

opinions that women should be taught about their fertility, preferably at much younger ages (Dougall et al., 2012; Dougall et al., 2013; Friese et al., 2006).

Potential Contribution of Fertility Knowledge on RLP and Preconception.

Fertility knowledge plays an important role in young women's sexual and reproductive decisions and behaviors, and young women may make better decisions about sex and reproductive choices once they have basic fertility knowledge and feel empowered with their own body (Berger et al., 2012; Rodriguez, 2013). Research has shown that young women are interested in learning about their fertility and would like to increase their fertility knowledge (Ayoola & Zandee, 2013; Daniluk et al., 2012; Ekelin, Akesson, Angerud, & Kvist, 2012; García, Vassena, Trullenque, Rodríguez, & Vernaev, 2015). For instance, Ayoola and Zandee (2013) conducted a qualitative study with a group of low-income and ethnically diverse women ($N=41$), and these women identified "Knowing your body" as a main strategy to learn about the menstrual cycle, ovulation, and fertility changes in order to guide early identification of unintended pregnancy (Ayoola & Zandee, 2013). In Daniluk et al. (2012)'s study, women requested the correct answers of the fertility knowledge questionnaire and stated that they would like to learn more information about fertility. Meanwhile, women have demonstrated strong interest and engagement in learning about their body and fertility using an ovulation kit and a menstrual tracking record (Ayoola, Slager, Feenstra, & Zandee, 2015).

Fertility health is a continuum throughout a woman's life and a woman's current lifestyle may have long-term consequences on her future fertility (Macaluso et al., 2010). The key to help young women live healthily and positively with their fertility is to educate young women about their fertility health in an ongoing fashion throughout their

life instead of limiting this topic to the childbearing stage. At each life stage, sexual and reproductive health education and health promotion should build upon the woman's current knowledge and understanding of fertility and sexuality and her specific life situations (Marshall et al., 1997). In recent years, both RLP and preconception care have been increasingly recognized as critical components of health promotion and disease prevention for women of reproductive age (ACOG, 2005; ACOG, 2016; CDC, 2014b). The goals of RLP are to assist women make informed short and long-term reproductive life decisions while the focus of preconception care is to help women getting and staying healthy throughout their childbearing years (ACOG, 2005; CDC, 2014b). Fertility health education can contribute to both RLP and preconception care in many aspects (Cooke et al., 2010). For example, teaching young women about their fertility and clarifying their inaccurate information concerning contraceptives may promote them to consistently and effectively use contraceptives to avoid unplanned pregnancy (ACOG, 2016; Kaye et al., 2009; Reed et al., 2014). Awareness of the potential infertility risks due to unhealthy lifestyles may lead women to adopt healthy behavior changes, which can promote both fertility health and overall health of the women (Macaluso et al., 2010; ASRM, 2013). This can have profound influence on both the health of the mother and infant since approximately one half of the current pregnancies in the United States are unplanned (ACOG, 2016). Pregnancy planning can be a strong motivation for women to learn about fertility and make positive lifestyle changes to improve their health prior to the intended pregnancy (Barron, 2013). In a study conducted by Stephenson et al. (2014), 48% of smoker and 41% of drinkers reported either reduced or stopped smoking and drinking behaviors among the group of women who had planned their pregnancy. The discussion

and education of fertility and its impact on women's sexual and reproductive health can be integrated into each reproductive health counseling and service visit (Söderberg et al., 2011; Stern et al., 2013; Swift & Liu, 2014). The goal is to use every clinic encounter as a "teachable moment" to increase women's knowledge and ability to manage their fertility and be able to make informed RLP.

Fertility Knowledge among Young Female Adults

A woman's fertility knowledge has many impacts on her sexual and reproductive outcomes (Bunting & Bovin 2008). Accurate fertility knowledge is important for young women to make informed decisions regarding sexual behaviors, health monitoring, and family planning in their current life stage and their future (Barron, 2004; Ekelin et al., 2012; Goundry et al., 2013; Wojcieszek & Thompson, 2013). Young women who are equipped with better understanding of female fertility and menstrual cycle functions are in stronger positions to manage their reproductive and sexual health (Barron, 2004; Vigil et al. 2006, Rodriguez, 2013). On the other hand, lack of fertility knowledge among sexually active young women may lead to risky sexual behaviors or unintended pregnancy (Berger et al. 2012), and long-term consequences, such as infertility (Barron, 2004; CDC, 2014a). Thus, it is imperative to determine the state of science regarding fertility knowledge among young female adults. This knowledge and understanding can facilitate the development of research, education, and intervention in the area of fertility health for this population.

An integrative review was completed to evaluate the current state of the science regarding fertility knowledge studies among young female adults. Over the past 15 years, there have been a growing number of qualitative and quantitative research studies

conducted to assess young female adults' fertility knowledge and understanding. An integrative review is a goal-directed, systematic process that allows for the inclusion of literature with diverse methodologies and has the ability to synthesize experimental and non-experimental findings to answer specific questions, identify gaps in the literature, and gain a more complete understanding of a phenomenon of interest (Whittemore & Knafl, 2005). The guidelines developed by Whittemore and Knafl were employed in this integrative review to avoid bias and ensure the rigor of the review process, and there are five main steps involved in the review process, which include problem identification, literature search, data evaluation, data analysis, and presentation (Whittemore & Knafl, 2005).

The literature search stage is crucial to a high quality research review, and a comprehensive search is needed to identify the maximum relevant studies (Whittemore, 2005). A variety of search methods, such as electronic database search, ancestry search, and networking, were employed for the literature search and the search years were from 2000 to 2015. The search was limited to human subjects and articles written in English. The electronic databases included CINAHL, PsychINFO, Web of Science, and Google Scholar. The following search terms "fertility," "pregnancy," or "infertility," were combined with "knowledge," "aware*," "understand*," or "literate*". Search strategies such as truncation, tree structure, and wildcards were applied in the search process. The initial search results consisted of 5,670 articles. Then, additional search strategies were employed by combining the aforementioned results with the following terms "women, woman, college students, or university students". A total of 500 articles resulted from the search process, which were then screened for relevance by title. This screening resulted

in 145 articles. The abstracts of the 145 articles were obtained and evaluated for relevance to the study aim. In reviewing the abstracts of the 145 selected articles, the researcher noted that the majority of study samples included both young female and male adults and only four studies had young female adults alone as subjects. In order to reflect the comprehensiveness of the research, a decision was made to keep all the studies including both young female and male subjects with the mean ages of 18 to 24 and the results will be summarized by studies that include young female adults whenever possible. Based on this inclusion decision, the final sample consisted of 17 articles.

Quality appraisal of the included studies. One challenge associated with an integrative review is how to assess the quality of the primary sources due to the diversity of primary sources, and there is no one gold standard for all (Whittemore & Knalf, 2005). For this integrative review, the primary sources included both qualitative and quantitative descriptive studies. Therefore, the quality appraisal was based on the mythological characteristics of the original study, and included the following study constructs, sample, measurement, attrition, threats to validity, discussion, and intervention if applicable (Whittemore, 2005).

Appraisal of the sampling procedure and sample size. The integrative review included three qualitative descriptive studies and 14 quantitative descriptive studies. All of the 17 studies were published from 2006 to 2015, and were conducted in a variety of countries, including Sweden, Canada, Italy, Israel, England, the United States of American, Australia, China, Grenada, Spain, and Finland. Fourteen studies used university students as sample subjects; one study surveyed the oocytes donors (García et al., 2015), and one study interviewed young black and Hispanic women in the community

(Guzman et al., 2013). The majority of studies ($n=14$) used convenience samples except three studies used random selection procedures to obtain subjects (Lampic, Svanberg, Karlström, & Tydén, 2006; Peterson et al., 2012; Virtala et al., 2011). The sample size for females varied from 101 to 3,222 for the quantitative studies. The limitations that related to the sampling procedure included lack of power analysis to justify sample size and the use of convenience samples.

Appraisal of the instruments for quantitative data collection. For the 14 quantitative studies, questionnaires were used as the instruments to assess young female adults' fertility knowledge. Four of the studies (Chan, Chan, Peterson, Lampic, and Tan, 2015; Lampic et al., 2006; Tydén et al., 2006; Peterson et al., 2012) used the same questionnaire to assess young university students' fertility knowledge in three different cultures (Sweden, U.S.A, and Hong Kong, China). Two other studies (Hashiloni-Dolev et al., 2011; Lucas et al., 2015) used the same questionnaire to evaluate fertility knowledge for Israel and New Zealand university students. For the rest of the quantitative studies ($n=8$) the researchers developed their own questionnaire to collect the data. Among all of the questionnaires, a variety of question formats were used to assess fertility knowledge, including open response format, multiple-choices format, Yes / No / Don't know format, True / False format, and visual analog scale. In developing these questionnaires, the researchers often cited medical statistical data that vary from each other. These questionnaires were developed based on literature reviews and pilot testing prior to the application. However, there lacked reports of reliability and validity evaluation for these questionnaires. All these limitations regarding the quality and

consistency of these questionnaires made it harder to compare, contrast, and synthesize the findings from the included studies.

Appraisal of the quality of the qualitative studies. The three qualitative studies used either focus group (Goundry et al., 2013) or an individual semi-structured interview process to collect data (Guzman et al., 2013; Sabarre et al., 2013). All three qualitative studies provided description of fertility knowledge among the youth population (Sandelowski, 2000). The researchers applied a variety of qualitative data analysis techniques, i.e. framework analysis approach (Goundry et al., 2013), qualitative content analysis (Sabarre et al., 2013), and an ongoing, open, and iterative approach (Guzman et al., 2013) to explore and develop the themes. Limitations included the lack of steps (i.e. reflexivity, methods triangulation, or participant review of findings) to enhance trustworthiness of the data and to minimize bias (Beck, 2009).

Summary of the overall findings among the 17 studies. The included studies evaluated a variety of topics related to fertility knowledge. To summarize the research results in this integrative review, studies were organized according to the content of fertility knowledge each of the studies were focused on and were presented under the following categories: fertility knowledge related to menstrual cycle characteristics and ovulation, knowledge of fertility changes within the life cycle; knowledge of fertility risks related to modifiable lifestyle factors, knowledge of infertility and infertility treatments, self-perceived fertility knowledge level among young women, fertility myths, and young women's attitudes toward childbearing and fertility health education.

Fertility knowledge related to menstrual cycle characteristics and ovulation. A main component of the knowledge of female fertility is related to menstrual cycle

characteristics and ovulation. Menstrual cycle characteristics are often the early indicators of a woman's fertility health and overall health (Barron, 2013), and knowledge of the FW is important for women to avoid or achieve pregnancy (Hampton et al., 2013; Mu & Fehring, 2014). Among all these studies, only four included an assessment of young women's knowledge related to the menstrual cycle characteristics and ovulation (García et al., 2015; Guzman et al., 2013; Rouchou & Forde, 2015; Sabarre et al., 2013). Overall, the young women in these four studies demonstrated limited knowledge related to the menstrual cycle and ovulation. García et al. (2015) conducted structured interview with 229 oocytes donors and asked these women to identify the FW. Half of the women were able to identify the FW is located in the middle of the menstrual cycle. Yet, 7.4% of the women thought the probability of pregnancy was the same throughout the menstrual cycle. Similarly, only 44.7% out of 334 female university students knew that the FW is in the middle of a woman's menstrual cycle (Rouchou & Forde, 2015). Guzman et al. (2013) interviewed 58 women who used FABM and found that 64% of these young women had none to limited knowledge of the FW, which is crucial for these women to avoid an unplanned pregnancy. Sabarre et al. (2013) conducted individual semi-structured interviews with 23 female college students and noted that these female college students did not know that certain menstrual cycle variability and symptoms, such as irregular menstrual cycles, anovulation, and excessive pain or bleeding, might indicate fertility problems.

Knowledge of female fertility changes within the life cycle. Another important component of female fertility is the natural fertility changes throughout the lifecycle. Female fertility changes throughout a woman's life and is closely associated with a

woman's biological age and the quantity and quality of her oocytes (ASRM, 2013). It is vital for young women to be aware of age-related fertility changes, thus, they can make informed decisions related to childbearing and family planning. Fourteen of the included studies ($N=17$) focused on assessing young women's knowledge and understanding regarding three key points of female fertility change throughout the lifecycle, which are the most fertile age period, the age when female fertility starts to decline, and the age when female fertility drops sharply.

Overall, young women in these 14 studies lacked accurate and specific knowledge of age-related fertility change despite their general awareness of the impact of age on female fertility. Between 32 to 79% of young women in three studies overestimated the age period when female fertility is at its peak (Chan et al., 2015; García et al., 2015; Peterson et al., 2012). A consistent finding among the studies was that young women reported that female fertility started to decline at a much later age when compared to the current available medical literature (Ekelin et al., 2012; Lampic et al., 2006; Peterson et al., 2012; Virtala et al., 2011). Over one third of young women in these studies believed that female fertility started to decline only after the age of 40 (Bretherick et al. 2010; Chan et al., 2015; Ekelin et al., 2012; García et al., 2015; Peterson et al. 2012; Rovei et al., 2010) and about 30 to 53% of these young women even believed that female fertility declined markedly only after the age of 50 (Peterson et al., 2012; Rovei et al., 2010; Virtala et al. 2011). Meanwhile, young women viewed pregnancy as being easier than reality and overestimated the likelihood of natural conception at a variety of age ranges; the overestimation was especially inaccurate and inflated for women over the age of 40

(Bretherick et al. 2010; García et al., 2015; Hashiloni-Dolev et al., 2011; Lucas et al., 2015; Rovei et al., 2010).

Knowledge of fertility risks related to modifiable lifestyle factors. Knowledge and understanding of the impact of modifiable lifestyles on a woman's fertility health and her overall wellbeing are important for young women to make meaningful choices in safeguarding and protecting their fertility in their current life stage. The overall findings indicate that young women had adequate knowledge regarding the impact of the common negative lifestyle factors on fertility health (Bunting & Boivin, 2008; Ekelin et al., 2012; Nouri et al., 2014; Rouchou & Forde, 2015). For example, Bunting and Boivin (2008) surveyed 110 female undergraduate and graduate students and over 90% of these young women thought that obesity, low body weight, smoking, alcohol, drugs, and stress could adversely lower a woman's chance of getting pregnant (Bunting & Boivin, 2008). Nouri et al (2014) surveyed 340 undergraduate students (170 females) and noted that female medical students demonstrated the highest knowledge regarding the influences of caffeine, alcohol, smoking, exercise, weight, and diet on female fertility. Furthermore, these female medical students exhibited healthier lifestyle compared to the non-medical female undergraduate students (Nouri et al., 2014).

However, there is a clear knowledge gap existing for the influence of STIs on female fertility among young female adults. Several studies specifically evaluated young women's knowledge regarding STIs and their impact on female fertility (Ekelin et al., 2012; Goundry et al., 2013; Rouchou & Forde, 2015; Sabarre et al., 2013). Ekelin et al. (2012) surveyed 247 high school students (including 101 females) between the ages of 18 to 20 and found that about 64% of these young women did not think that gonorrhea

infection could create fertility risks. In two qualitative studies conducted with young female college students, the young women either did not identify STIs as risk factors for infertility (Sabarre et al., 2013) or were unaware of how and why STIs could lead to infertility and only one young woman had ever heard of pelvic inflammatory disease (Goundry et al., 2013).

Knowledge of infertility and infertility treatments. Infertility is a serious medical condition that impacts many men and women (CDC, 2015d). Knowledge and understanding regarding the etiology, diagnosis, and treatment of infertility may help young women to adopt proactive behaviors to preserve their fertility (Macaluso et al., 2010) or to prompt them to seek timely fertility care (Bunting & Boivin, 2007). Eleven of the studies have extensively evaluated young women's knowledge of infertility and infertility treatments (Bretherick et al., 2010; Ekelin et al., 2012; García et al., 2015; Hashiloni-Dolev et al. 2011; Lampic et al., 2006; Lucas et al., 2015; Peterson et al. 2012; Rovei et al., 2010; Sabarre et al., 2013; Svanberg, Lampic, Karlström, & Tydén, 2006, Tydén et al. 2006). The overall findings revealed that young women often possess general but very unsophisticated knowledge related to infertility and its treatments.

Sabarre et al. (2013) conducted individual semi-structured interviews with 39 undergraduate students (23 females) to inquire about these young people's knowledge and perceptions of infertility. Their findings indicated that these young women had basic understanding regarding what infertility is, yet they were unclear about the underlying causes or the specific diagnostic tests related to female infertility. Over half of the interviewed women were able to name several infertility treatments and frequently cited IVF. Rovei et al. (2010) surveyed 958 university students (607 females) and 91% of

these women either did not know or did not believe there were increased risks associated with ART for both the women and the fetus.

Five quantitative studies evaluated young women's knowledge regarding the success rates of IVF treatment and young women in these studies consistently had overly optimal views regarding IVF and overestimate the success rates of IVF (Svanberg et al. 2006, Tydén et al. 2006; Hashiloni-Dolev et al. 2011, Lucas et al., 2015; Peterson et al. 2012). The findings from two studies indicated that these young women were unaware that female age was a main factor that could impact the outcomes of IVF and did not know that late age pregnancy were made possible only with young egg donation or egg freezing (Bretherick et al., 2010; Hashiloni-Dolev et al. 2011). About 3% of the young oocyte donors ($N=229$) even believed that IVF had no age limits in helping women to get pregnant (García et al., 2015).

Self-perceived fertility knowledge level among young women. Three out the 17 studies also assessed young women's self-perceived fertility knowledge level. Despite the generally low to moderate actual fertility knowledge level demonstrated by these young women in the three studies, young women displayed a range of different perceptions related to their self-perceived fertility knowledge level. Ekelin et al. (2012) surveyed 247 high school students (101 females) and asked the participants to rate their fertility knowledge level on a visual analogue scale. These young women gave a mean score of 4.3 (± 2.4) out of 10, which indicated that they felt that they had less than optimal fertility knowledge. Peterson et al. (2012) surveyed 246 undergraduate students (138 females) and used a 5-point Likert scale (i.e., 'not at all educated' to 'very educated') to assess how knowledgeable these young people believed themselves about fertility issues.

Nearly half of the young people believed that they were either 'educated' or 'very educated' regarding fertility issues despite their low and inaccurate actual fertility knowledge. Similarly, 38% of 367 Chinese students considered themselves 'educated' and 6% of the students believed they were 'highly educated' about fertility topics (Chan et al., 2015). The discrepancy between these young women's actual fertility knowledge level and their perceived fertility knowledge level is important to explore in order to understand its impact on young women's fertility decision making and fertility outcomes.

Fertility myths. Along with fertility knowledge, the assessment of fertility myths among young women also provided an important component to understand young women's view and beliefs related to female fertility, which often reflected the influence of their individual culture. These fertility myths usually surrounded the topic of infertility and the possible solutions in dealing with infertility. For instance, Rouchou and Forde (2015) surveyed 334 young women who enrolled at the St. George's University in Grenada and noted that 75.8% of the young women held the belief that infertility is due to God's will and could be treated with prayer despite receiving higher education. In a questionnaire study conducted with 683 students (453 female) from the University of Auckland, New Zealand, 21 of them thought that certain alternative therapies like acupuncture, yoga, natural remedies and supplements, and Pacific Island massage could prolong female fertility (Lucas et al., 2015). Bunting and Boivin (2008) assessed fertility knowledge and fertility myths among 149 university students (110 female) and found that certain behaviors, such as living in the countryside, eating five portions of fruit and vegetables, or adoption, were believed to increase a woman's chance of getting pregnant. Similarly, Hashiloni-Dolev et al. (2011) found that young Israeli

female college students in their study believed that healthier lifestyle, exercises, and longevity could preserve female fertility and allow women in their late 40s to late 60s to achieve pregnancy.

Young women's attitudes toward childbearing and fertility health education.

Thirteen out of the 17 studies inquired young women about their intention and plan for childbearing (Bretherick et al., 2010; Chan et al., 2015; Ekelin et al., 2012; García et al., 2015; Hashiloni – Dolev et al., 2011; Lampic et al., 2006; Lucas et al., 2015; Nouri et al., 2014; Peterson et al., 2012; Rovei et al., 2010; Sabarre et al., 2013; Tydén et al., 2006; Virtala et al., 2011). An average of 89% (range 65% -100%) of these young women ($N=6,253$) wanted to be mothers and planned to have children in the future.

The topic of fertility and infertility was viewed as relevant for this life stage. Goundry et al. (2013) conducted a qualitative study to explore young people's knowledge and understanding regarding the links between STIs and infertility. Most of the 60 participants expressed comments to support the discussion and education of infertility, especially in relationship to STIs at their current age as one participant stated, "definitely relevant now but it should have been started earlier" (Goundry et al., 2013, p.4). In another study conducted by Ekelin et al. (2012), young people thought they could take better care of their fertility; however, they needed more knowledge of the factors that could impact their fertility. In the study with 229 young oocyte donors, one third of these young women actually asked healthcare providers for more information after their study and expressed a strong wish to learn more about their fertility (García et al., 2015).

Discussion. This integrative review provides a comprehensive summary regarding the current state of fertility knowledge among young female adults. Given the

various limitations and inconsistencies among the studies in the assessment of fertility knowledge, cautions are needed to interpret the available evidence about young female adults' fertility knowledge.

In all, this integrative review highlighted several critical needs in the development of research, education, and intervention for young female adults' fertility health. First, it is important to reach a consensus regarding what fertility knowledge includes. A variety of fertility knowledge topics have been assessed among these 17 studies. However, there was a lack of agreement in what is essential and meaningful for young women to know about female fertility. Secondly, a valid and reliable instrument is needed to measure young female adults' fertility knowledge. Among the 14 quantitative studies, 10 different questionnaires were developed to evaluate young women's fertility knowledge. Minimal reliability and validity have been evaluated and established with these questionnaires. The inconsistency and variability of the question format within the 10 questionnaires also created difficulties in summarizing the overall study findings and comparing differences among the studies. This limitation highlights the importance of developing a reliable and valid instrument to assess young women's fertility knowledge. In developing such an instrument, careful consideration should be given to the scope, detail, and format of the scale. Third, the integrative review has provided evidence that there is a clear knowledge gap existing among young women regarding female fertility and young women are interested in learning more about this topic. Further research is needed to provide evidence as to determine how and when fertility health education should be provided and incorporated into young women's reproductive health care services.

An Evaluation of the Available Fertility Knowledge Assessment Instruments

Fertility knowledge is a key concept in determining a woman's fertility self-care ability whether in the context of avoiding or achieving pregnancy (IRH, 2013). For young women, limited fertility knowledge can have a negative impact on their current and future sexual and reproductive health outcomes. Young women may experience increased risks of unintended pregnancy, STIs and HIV due to inadequate knowledge and misperceptions about their fertility and unsafe sexual behaviors in their current life stage (Brady, 2003). These risks not only impact young women's current lives, but also have long-term effects on their future fertility. Thus, accurate fertility knowledge is critical for these women in order to make informed reproductive and sexual health decisions (Barron, 2013; Ekelin et al., 2012; Wojcieszek & Thompson, 2013).

The challenges lie in how to accurately measure young female adults' fertility knowledge. A comprehensive definition of fertility knowledge refers to information about fertility throughout the life course. This knowledge includes information regarding menstrual cycle, pregnancy potential in each menstrual cycle and at different life stages, and risks of infertility (Mu, 2016). Through an extensive literature review and email communications with the experts in this field, three fertility knowledge assessment instruments were located. The three instruments are the fertility awareness questionnaire (FAQ), the Fertility Awareness Survey (FAS), and the Cardiff Fertility Knowledge Scale (CFKS).

The Fertility Awareness Questionnaire. Blake et al. (1997) designed the FAQ to determine women's level of knowledge about their fertile time and the use of the fertile time in their conception attempts. The FAQ contained 16 questions. Thirteen of

the questions were multiple-choice and three were open-ended questions that asked the women to describe their fertility symptoms and their understanding related to the symptoms. There were three categories in the FAQ: 1) Fertility symptom awareness, 2) The understanding related to the fertility symptoms, 3) Use of the information to enhance conception. The score for each of the three categories ranged from zero to two and the maximal total score was six. A score of four or greater was predetermined as having adequate fertility knowledge and understanding of the fertile time during the menstrual cycle (Blake et al., 1997).

The original FAQ was given to 90 women who were going through infertility investigation and 10 of the women were excluded from the analysis due to anovulation. Two independent natural family planning teachers scored the questionnaire. Twenty-six percent of the women had adequate fertility knowledge according to the predetermined cut-off score of four or greater. On the other hand, 46% of the women were considered as having no knowledge or understanding of what fertility symptoms meant or what they were. These findings highlighted the significant knowledge deficiency among a group of women who were seeking infertility consultation and many of them attempted to time their intercourse during their perceived fertile time. There were no validity or reliability evaluations reported for the original FAQ or the inter-rater agreement rate regarding the two independent scorers.

Hampton et al. (2013) refined and expanded the original FAQ to measure fertility knowledge, attitudes, and practices of infertile women who were seeking fertility assistance. The updated FAQ aimed to measure detailed knowledge and practice of the rhythm, temperature, and mucus fertility monitoring methods to determine the fertile time

during the menstrual cycle. The researchers based the refinements of the FAQ with the available research evidence and piloted the refined FAQ with six women. The refined FAQ has three sections with a total of 17 items. Section one collects social-demographic characteristics of the subjects. Section two determines knowledge and practice of the three fertility-awareness methods (rhythm, temperature, and mucus) and the use of the FW for conception. Section three measures subjects' attitude and actions to improve their fertility knowledge.

The refined FAQ was distributed to 390 women who were seeking infertility assistance and the response rate was 72.3%. Two clinicians assessed responses on each questionnaire to determine the fertility-awareness level of each participant, and the Kappa measure of agreement showed an inter-rater agreement of .82 (Hampton et al., 2013). The participants were classified as having none, poor, moderate, or high fertility knowledge by the two clinicians. The results indicate that only 12.7% of the women had high fertility knowledge related to the identification of the FW, meanwhile, 52.2% displayed poor fertility knowledge in that aspect. Women's previous exposure to fertility information was a significant predictor of their fertility knowledge level and there was no association between women's socio-economic status and their fertility knowledge level.

In summary, the FAQ assesses women's fertility knowledge related to the FW in the menstrual cycle, which is only one component of the concept of fertility knowledge. Even though the researchers had attempted to establish content validity through literature review and pilot testing, there were minimal reliability or validity tests done to evaluate the FAQ. One main reason is the structure of the FAQ, which included both open-ended questions and multiple-choice questions and the requirement of specially trained persons

to grade the responses. The FAQ's item format could add expense in training the scoring person and also create difficulty in the standardization of the scoring process (Allen & Yen, 2002).

The Fertility Awareness Survey. Daniluk et al. (2012) developed the FAS to evaluate childless women's knowledge of fertility and assisted human reproduction (AHR). The FAS was developed based on a thorough review of the available literature and previous questionnaire surveys and was piloted with childless women of various ages and educational background. The FAS consisted of social-demographic information, two self-rating scales, and the fertility knowledge assessment scale. The fertility knowledge assessment scale contained 16 fertility-related and AHR knowledge questions on a 5-point Likert scale (definitely not, probably not, uncertain, probably, and definitely), and was treated dichotomous as either correct or incorrect in scoring.

A total of 3,345 women aged 20 to 50 completed the online FAS. The results showed that only about one third of the women answered six questions correctly out of the 16 questions. Many of the women were unsure about knowledge of age-related fertility change and AHR as their responses to these questions were clustering around the choice of "uncertain." Furthermore, 95.4% of the women perceived themselves to be more knowledgeable than their actual fertility knowledge level. This finding may have impact on how these women make reproductive decisions in their life situations. Women in the study expressed a strong interest and desire to learn more about fertility and AHR related information and the urge to discuss childbearing with their partners after completing the survey (Daniluk et al., 2012).

Cronbach's alpha was utilized to determine the internal consistency of the fertility knowledge scale and oblique factor analysis was used to assess the internal structure of the 16-item knowledge scale. The knowledge scale showed a very low internal consistency ($\alpha = 0.519$) and the factor analysis failed to produce a pattern matrix after 25 iterations (Daniluk et al., 2012).

In their following study, Daniluk and Koert (2013) added four new items to the fertility knowledge scale of the FAS. The four newly added items were specific to male fertility. A total of 599 men between 20 to 50 years old filled out the modified FAS. Similar to women, the majority of men perceived themselves to be knowledgeable or fairly knowledgeable about fertility and ART. Yet, these men displayed even less actual fertility knowledge compared to the women in their previous study (Daniluk et al., 2012). Cronbach's alpha and oblique factor analysis were used to assess the reliability and internal consistency of the modified fertility knowledge scale. The Cronbach's alpha improved to 0.74 and the factor analysis again failed to produce a pattern matrix as in the previous study.

In conclusion, the FAS was designed to assess childless women and men's knowledge of age-related fertility change, AHR, and male fertility. However, the FAS left out a main component of fertility knowledge, fertility related to menses and the FW. Overall, the FAS displayed minimally acceptable internal consistency of 0.743 for a new scale (DeVellis, 2012). There appeared no coherent internal structure for the fertility knowledge assessment scale based on the results of the factor analysis. Furthermore, it is cumbersome to use a five point Likert scale and then convert the answers to a

dichotomous correct/incorrect scoring system. This approach could lead to loss of information and mistakes in calculating the total and average scores (Pallant, 2010).

The Cardiff fertility knowledge scale. Bunting et al. (2013) developed the CFKS to assess both men and women's fertility knowledge in an international study. The CFKS consists of three categories, the indicators for reduced fertility, misconceptions about fertility, and the basic facts about infertility. There are 13 items in the CFKS and these items were selected based on their known association to the fertility decision-making process. Each question has a three-point answer scale of "true," "false," or "don't know." A "correct answer" is assigned one point while an "incorrect" or "don't know answer" is assigned zero points. The total fertility score is the percentage of correct answers that range from zero to 100% (Bunting et al., 2013).

The CFKS was translated into 12 languages and was administered to a group of 10,045 people (8355 women and 1690 men) who are trying to conceive from a total of 79 countries. Results indicated the average correct score for the fertility knowledge was 56.9% with a range from 17% to 79%, and the variables of female gender, university education, employment, and prior infertility medical consultation were significantly related to higher fertility knowledge. The researchers were able to perform an exploratory factor analysis and internal consistency analysis with the CFKS. The exploratory factor analysis showed that all of the 13 items loaded more than 0.30 on one factor and explained about 30% of the variance, which was a very modest loading (Waltz et al., 2010). The Cronbach's alpha coefficient was 0.79 for their study that is acceptable for a new scale (DeVellis, 2012).

Overall, the CFKS displayed better validity and reliability compared to the FAQ and the FAS. The 3- category response (“true,” “false,” and “don’t know” is appropriate to assess knowledge, and is easy to use and score. However, the CFKS did not assess fertility knowledge related to menstrual cycle and the FW, which is a key component of fertility knowledge especially for women / couples trying to conceive. Furthermore, the CFKS was simultaneously tested in 12 languages and 79 countries that can confound the findings of validity and reliability due to the influence of culture and language.

Discussion. Altogether, the three fertility knowledge assessment scales have attempted to measure fertility knowledge among women at different life-stages and cross many countries and cultures. It is important to understand the impact of fertility knowledge on women’s reproductive health decisions and behaviors, and these studies indicate that inaccurate fertility knowledge may hinder a woman’s chance of getting pregnant (Blake et al., 1997; Hampton et al., 2013). On the other hand, women with higher fertility knowledge were more willing to seek medical help and change their life styles in order to optimize their fertility (Fulford et al., 2013). Thus, the concept of fertility knowledge is an important concept related to women’s reproductive health behaviors and outcomes, and is meaningful to evaluate each woman’s fertility knowledge and understanding in order to provide personalized sexual and reproductive health education and care.

However, the three fertility knowledge assessment instruments lack a clear theoretical framework to guide the selection and inclusion of the question items. A comprehensive definition of fertility knowledge refers to information related to fertility throughout the life course which includes fertility knowledge related to menstrual cycle

characteristics, pregnancy potential in each menstrual cycle and at different life stages, and risks of infertility (Mu, 2016). Therefore, a fertility knowledge assessment instrument needs to include items addressing each component of fertility knowledge in order to provide an accurate and comprehensive evaluation of a woman's fertility knowledge level. However, the three available instruments focus only on one or two components of fertility knowledge. For example, the FAQ is the only instrument trying to assess women's fertility knowledge related to the menstrual cycle and the FW. The FAS focuses on fertility changes at different life stages and AHR knowledge while the CFKS included items to assess women's fertility knowledge related to life style factors.

Furthermore, the three fertility knowledge instruments display great variability in their response format, despite all of the three instruments being designed to measure fertility knowledge. For instance, the FAQ employs both open-ended questions and multiple-choice questions to assess women's fertility knowledge related to menstrual cycles and two trained scorers need to grade the answer and to determine the knowledge level. The FAS uses a five-point Likert scale of "definitely not," "probably not," "uncertain," "probably," and "definitely" to "reflect the strength of knowledge" (Daniluk et al., 2012, p.422). For scoring, the researchers convert the five-point Likert scale into a three - category response by combining "definitely not" and "probably not" into "No" response, "probably" and "definitely" are considered "Yes" response, and "uncertain" is interpreted as "don't know." The CFKS uses a three - category response ("true," "false," and "don't know") for each of the question items and the correct answers are reported in percentage. In developing an instrument, it is important to consider the specific item formatting based on the purpose of the scale, the characteristics of the measure, and the

setting where the measurement occurs (Waltz et al., 2010). For a fertility knowledge assessment instrument in a clinical setting, the format of “True,” “False,” and “Don’t know” is easy to use and easy to score compared to the style of multiple choice or Likert scale.

Reliability and validity are vital characteristics of sound measurement instruments (Waltz et al., 2010). Overall, the three fertility knowledge assessment scales demonstrated limited evidence of validity and reliability evaluation in their development process. The FAQ had no formal reliability evaluations except the Kappa measure of agreement of 0.82. Both the CFKS and the FAS reported Cronbach’s alpha coefficient, the CFKS had α of 0.79 and the FAS reported α of 0.74. Nevertheless, neither of the reported Cronbach’s alpha coefficients is optimal for these two instruments. The face validity was assessed in the three instruments through either expert review or lay people. However, face validity is the weakest form of validity since it only provides a subjective assessment of the instrument (DeVon et al., 2007). Construct validity assessments were minimal for all these instruments. Daniluk et al. (2012) conducted an exploratory factor analysis for the FAS in their two studies. They were unable to specify a coherent internal structure for the FAS. Bunting et al. (2013) performed an exploratory factor analysis for the CFKS with only moderate loading (> 0.30). No other validity evaluations have been done for the three fertility knowledge assessment instruments.

In all, a few challenges have been noted in choosing an appropriate instrument to measure fertility knowledge for the population of young female adults. The three available fertility knowledge assessment instruments displayed a lack of comprehensiveness in assessing fertility knowledge and also limited validity and

reliability. There is a critical need to develop an instrument that is representative of the comprehensive definition of fertility knowledge and can be applied to assess young female adults' fertility knowledge in a variety of educational and clinical settings.

Gaps in the Literature

To summarize, previous studies have demonstrated that fertility knowledge is a key concept, which plays a significant role in young female adults' sexual and reproductive decisions, behaviors, and outcomes. However, questions remain as to how the concept of fertility knowledge should be operationalized and measured for this population. The studies in the literature review indicate that young female adults place high importance on motherhood and view the topic of fertility as relevant and meaningful in their current life stage. Yet, young females generally display low and inaccurate knowledge regarding female fertility. Current studies also lacked valid and reliable instruments to measure young women's fertility knowledge. While there are a few available fertility knowledge assessment instruments that have been developed for other populations, each of these instruments demonstrated limited validity and reliability in assessing fertility knowledge without measuring all of the components within fertility knowledge.

Research conducted to date has mainly been descriptive in nature, and focused on assessing young female adults' fertility knowledge. There is a lack of studies to explore the relationship between young women's fertility knowledge and their fertility health risks at their current life stage. While there is some evidence that young women's fertility knowledge is positively associated with their current life style (Nouri et al., 2014), the evidence is inadequate due to the lack of a sound instrument to operationalize

either variable. The understanding of how young female adults' fertility knowledge may influence their fertility health risks is necessary in order to develop individualized education and health care for young women.

This study addresses several gaps identified in the literature. A FKAS for young female adults was developed using the Delphi panel technique to address the limitations of the aforementioned fertility knowledge assessment instruments. The application of the Delphi panel technique is an innovative approach to use a group of content experts to establish consensus for the fertility knowledge content which has not been previously well defined (Keeney, Hasson, & McKenna, 2011). The developed FKAS was validated with both young women who use FABM and young women who are not using FABM. The application of both CTT and IRT statistical analysis methods provided a comprehensive understanding regarding the psychometrics of the newly developed FKAS. Thus, the study produced a refined FKAS that can be utilized in research and clinical practice. This study also explored the relationships among young female adults' individual and contextual factors, their self-perceived fertility knowledge, their actual fertility knowledge, and their fertility health risks at their current life stage. The findings will help researchers and clinicians to understand the relationships among young women's background factors, perceptions, and knowledge in order to identify the significant factors for targeted intervention to decrease young female adults' fertility health risks.

Study Aims and Research Questions

The primary purpose of the study was to develop and evaluate the psychometric properties of the MU-FKAS for young female adults. The secondary purpose was to

explore the relationships among young female adults' individual and contextual factors, their self-perceived fertility knowledge, their actual fertility knowledge, and their fertility health risks. The following specific aims and research questions were addressed and a diagram was developed to illustrate the research questions among the study concepts (See Figure 3).

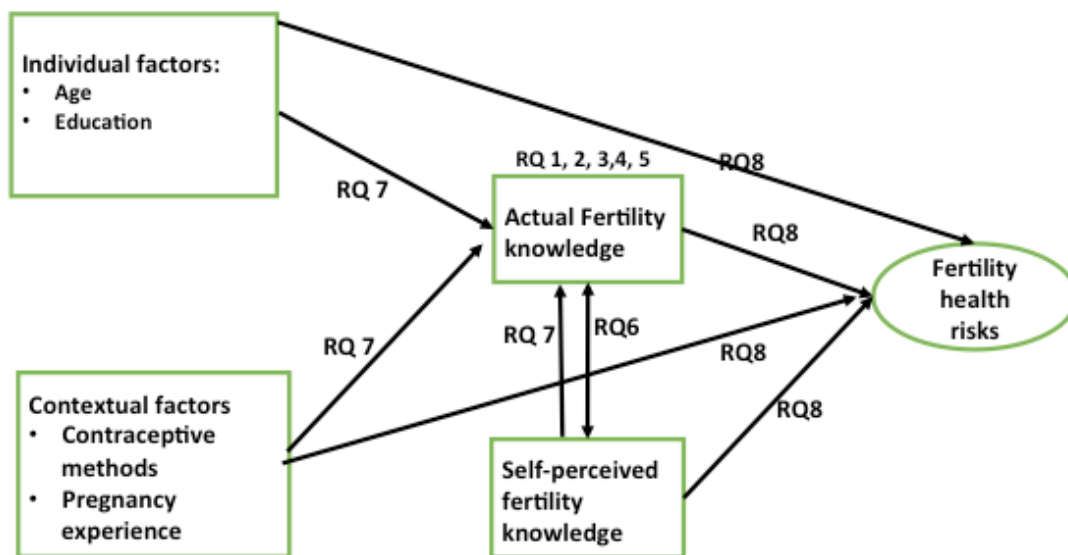


Figure 3. Research questions among the five study concepts.

Specific aims and research questions. The following specific aims and research questions were addressed by this study:

Aim1: To determine the psychometrics of the developed MU-FKAS both at the item and the scale level

RQ1: What is the inter-rater agreement on each of the items and the entire scale among a panel of content experts?

RQ2: What is the internal consistency (reliability) of the MU-FKAS?

RQ3: What is the construct validity of the MU-FKAS as indicated by known groups of FABM user vs. non-FABM user?

RQ4: What is the construct validity of the MU-FKAS as demonstrated by exploratory factor analysis?

RQ5: What is the quality of the items on the MU-FKAS?

Aim2: To explore the relationships among young female adults' individual and contextual factors, their self-perceived fertility knowledge, their actual fertility knowledge, and their fertility health risks.

RQ6: What is the relationship between young female adults' self-perceived fertility knowledge and their actual fertility knowledge?

RQ7: What are the relationships among young female adults' individual and contextual factors, their self-perceived fertility knowledge, and their actual fertility knowledge?

RQ8: What are the relationships among young female adults' individual and contextual factors, their self-perceived fertility knowledge, their actual fertility knowledge, and their fertility health risks?

Assumptions of the Study

It is important to acknowledge the assumptions that underlie the development and design of the study. The following assumptions provide support for the selection of the theoretical framework and the specific approach to conduct this study:

1. Female fertility is a continuously evolving phenomenon throughout a woman's life. Therefore, it is appropriate to consider fertility health in a lifecycle framework.
2. Gender, sexual identity and orientation, sexual relationships, religion, culture, and reproductive technology impact the meaning of fertility
3. Fertility health education and promotion is a main component of reproductive health promotion.
4. Fertility health education has the potential to affect young female adults' knowledge, perceptions, and behaviors related to their fertility.
5. Most young female adults highly value motherhood. Knowledge and understanding of their fertility will promote and motivate young women to protect and preserve their fertility.
6. Fertility knowledge is a key concept that can impact young female adults' current and long-term sexual and reproductive health outcomes.

Summary

Female fertility is a continuously changing phenomenon throughout women's life with beginning, peak, and ending points. Fertility health education should be a core component of comprehensive reproductive health promotion for young female adults. Fertility health education is of paramount importance to teach these young women to learn about their body and their fertility, which may contribute to increased competency

in fertility self-care and fertility management (Bunting & Boivin, 2007; Hawkins et al., 2008). A reliable and valid fertility knowledge assessment scale can provide the baseline information for these women and will lead to individualized teaching and discussion about their fertility health in an ongoing fashion. It is through first accurately assessing these young women's fertility knowledge that future interventions may be implemented to improve the lack of knowledge and misconceptions about fertility. Thus, young female adults may avoid many negative sexual and reproductive health consequences of mismanaged fertility in their current and future life stages.

III. RESEARCH DESIGN AND METHODS

Introduction

This study used a multi-step, multi-method design to develop and assess the psychometric properties of the MU-Fertility Knowledge Assessment Scale (MU-FKAS). The data obtained from the cross-sectional survey were also used to explore the relationships among young women's individual and contextual factors, their perceived fertility knowledge, their actual fertility knowledge, and their current fertility health risks. The advantages of the study design are to provide multiple processes to establish the validity and reliability of the MU-FKAS (Streiner & Norman, 2008).

Research Design

There were three main steps involved in the study and a visual diagram illustrated the flow of the study (see Figure 4).

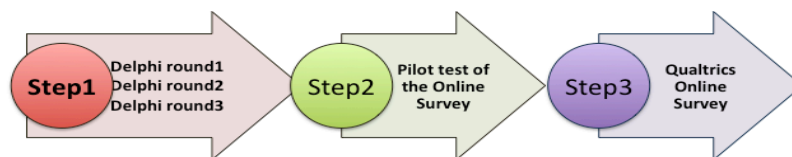


Figure 4. Diagram of the study process

Step one. A Delphi technique was used to evaluate and refine the items of the MU-FKAS. The Delphi technique is a survey method that uses a group of experts to establish consensus for the content (Waltz et al., 2010), and it is suitable to achieve agreement on content or issues that are not previously well defined (Keeney et al., 2011). Despite the increasing attention and usage of the concept of fertility knowledge in research and daily life, fertility knowledge presents a new and evolving concept that has not been well defined in the literature. The application of the Delphi technique has the potential to evaluate the MU-FKAS in its comprehensiveness and representativeness of the concept and reveal potential omission of any critical component of fertility knowledge, thus, increasing the rigor of the developed instrument (Lynn, 1986). The advantages of using a Delphi technique lie in the anonymity, rounds of iteration with feedback, statistical group responses and expert input (Goodman, 1987). Many types of Delphi technique are available depending on the purpose of the study and the possible resources available for the study (Keeney et al., 2011). Due to the diverse location and time availability of the experts, online survey technology (i.e., Qualtrics) was used for the gathering of the data (Dillman, Smyth, & Christian, 2009). The Delphi technique usually employs 2 to 4 rounds to achieve a consensus among a group of experts and each new round is built upon the results obtained from the previous discussion (Keeney et al., 2011). The primary investigator (PI) conducted three rounds of the Delphi survey to evaluate and refine the items of the MU-FKAS.

Step two. The online survey including the developed MU-FKAS was pilot tested with 10 young women. A pilot test is an essential step in evaluating how a newly

designed survey will work in real practice (Dillman et al., 2009). The purpose of the pilot testing is to identify issues related to the administration procedure, understanding of the questions, visual presentation of the questionnaire, and data coding, all of which will enhance the internal validity of the final study (Polit & Beck, 2012). Ten young women were recruited from the campus through flyer and word of mouth. The PI conducted cognitive interview with each of them and further revisions were made based on the feedback from these young women.

Step three. The finalized online survey was administered to a large sample of young female adults. Survey methods have evolved along with multiple cultural and technological changes over the years, and the Internet survey administration has gained much popularity due to its convenience, low cost, and wide availability (Dillman et al., 2009). An internet survey is particularly suitable for certain populations, i.e. college students, or young people who are familiar with web technology and use Internet widely in their daily life.

Sample and Setting

Step one. A small group of fertility knowledge content experts was invited to participate in the online Delphi panel discussion. Sample size recommendation for content validity evaluation is to recruit at least three but no more than 10 experts (Lynn, 1986). The recruiting goal was to obtain a group of 5 to 10 content experts for this study. The selection criteria for the panelists include the following: researchers with significant publications in women's reproductive and fertility health, and clinicians who work with women throughout their reproductive years.

Step two. For the purpose of assessing the wording, formatting, and clarity of the survey, a sample size of 10 or less is sufficient (Dillman et al., 2009; Hertzog, 2008). Therefore, the PI recruited a convenience sample of 10 young women between the ages of 18 to 24 from the university campus to pilot test the MU-FKAS.

Step three. Careful consideration has been given to the selection of sample population and sample size in order to address the proposed research questions. For Step Three, the major consideration for the estimate of sample size is factor analysis, which requires the largest sample size compared to the rest of the proposed statistical analyses. For factor analysis, it is important to consider both the relative number of subjects per variable and the absolute number of subjects in total (DeVellis, 2012). Tabachnick and Fidell (2007) recommended a minimum of five per variable. Tinsley and Tinsley (1987) suggested a ratio of 5 to 10 subjects per variable up to a sample size of 300. Comrey (1988) strongly advocated a sample size of 200 or more is optimal for factor analysis. Based on these sample size recommendations, the goal was to recruit a minimum of 300 study participants for the online survey.

The inclusion criteria are young women between the ages of 18 to 24, who read English and have access to the Internet. Women who are not within the ages of 18 to 24, do not read English, or do not have Internet access were excluded from the study. Two sample groups were recruited for the online survey, which are young women who use FABM and young women who do not use FABM. The purpose of recruiting these two different sample groups is to evaluate the construct validity of the MU-FKAS using known group validation (Hattie & Cooksey, 1984). Previous studies have shown that women who use FABM may have higher fertility knowledge due to their experience of

monitoring their fertility (Berger et al., 2012; Barron, 2004; Vigil et al., 2006). The recruiting goal was to obtain a minimum of 150 participants for each sample group.

Setting. All the steps of the study were conducted sequentially using Qualtrics, an online survey platform. Qualtrics is a web-based software that allows the researcher to set up the survey online and collect data electronically from study participants. Qualtrics has many features that enable the researcher to conduct a well-designed Internet survey. For example, the function of quotas provides the researcher with the ability to track the number of responses from different sample groups according to certain criteria and make sure the correct sample size will be met for each sample group. The combination of survey flow function and the skip logic will permit the researcher to set up screener questions at the beginning of the survey in order to filter out ineligible individuals, i.e., female not within the ages of 18 to 24 or male. The researcher can also send out individual thank-you and reminder emails to the correct group of people based on their survey completion history. All these functions will help the PI to minimize the overall survey error, to decrease nonresponse rates, and to increase the rigor of the online survey (Dillman et al., 2009).

Instruments

Young female adults completed an online survey through Qualtrics. The online survey includes four instruments, which are a demographic questionnaire, the MU-FKAS, the Knowledge of Fertility Scale (KFS), and the FertiSTAT. The demographic questionnaire collected the individual and contextual factors of the women. The MU-FKAS was used to measure young female adults' actual fertility knowledge level. The KFS measured young female adults' self-perceived fertility knowledge level. The

FertiSTAT assessed young female adults' current fertility health risk factors. A detailed description of these instruments is provided in the following section.

Demographic questionnaire. Demographic information of the study participants was collected using a demographic questionnaire (See Appendix A). The development and inclusion of the items on the demographic questionnaire was based on previous fertility knowledge studies (Lampic et al., 2006; Lundsberg et al., 2014; Peterson et al., 2012). Individual factors such as the participant's age, ethnicity, education, and number of children, and contextual factors such as the participants' relationship status, contraceptive methods, and their pregnancy experience were collected.

MU-Fertility Knowledge Assessment Scale. The MU-FKAS is intended to measure what a young female adult knows or does not know about the content of fertility knowledge. Therefore, a dichotomous scale was used. An initial set of 30 items has been developed through an extensive literature review and based on the conceptual framework of RHA. Sample questions include "A woman is born with all the eggs she will ever have" and "Ovulation occurs on the fourteenth day of each menstrual cycle." All items were rated on a 3-point scale of "true," "false," or "don't know." A correct answer was awarded with one point while an incorrect answer is assigned zero points. The "do not know" is also coded as incorrect. Points were summed, divided by the total number of questions and multiplied by 100 to produce a percentage of correct fertility knowledge score, which can range from 0 to 100%. Higher scores indicate greater fertility knowledge.

Knowledge of Fertility Scale. The KFS measures women's self-perceived knowledge level related to reproductive cycle, health factors related to fertility health, infertility treatment, alternative parenting options, and the effect of cancer treatment on fertility (Jukkala et al., 2012). The KFS consists of 21 items and the answer choices for each of the questions are "a little," "some," and "a lot," in which "a little" is assigned one point, "some" is two points, and "a lot" is three points. A total score is obtained by averaging the scores from all the items. A higher score indicates that the woman has a higher self-perceived fertility knowledge level.

The KFS assesses women's self-perceived fertility knowledge level as compared to their actual fertility knowledge level. Reliability of the KFS has been established with a sample of breast cancer survivors. The estimated Cronbach's alpha for the whole scale was 0.91 and Cronbach's alpha estimate for the five subscales were 0.85 (normal reproductive function), 0.73 (general information about fertility), 0.80 (infertility information), 0.78 (alternative parenting options), and 0.80 (cancer treatment affecting fertility). An exploratory factor analysis of the KFS retained the five factors that explained 95% of common variance (Jukkala et al., 2012). Criterion validity was assessed with three hypotheses tests and the findings supported the predicted associations and directions of the relationships between women's treatment status, whether women had consulted with a fertility specialist or not, and women's education level and their self-perceived fertility knowledge level (Jukkala et al., 2012). The KFS is a copyrighted instrument and permission has been obtained from the instrument developer to modify and use the scale for the study.

FertiSTAT. The FertiSTAT is a self-administered, multifactorial tool to measure a woman's risk factors related to her fertility (Bunting & Boivin, 2010). It was developed through an extensive literature review and its content validity was evaluated with a Delphi evaluation of 20 content experts. The FertiSTAT contains a total of 22 fertility risk factors (20 female-related and 2 male-related), and the 22 fertility risk factors are color coded into four risk zones (blue, yellow, orange, and red) with each color suggesting the appropriate steps that the women should take to monitor and protect her fertility (See Appendix B).

In the initial validation study, the FertiSTAT was given to a sample of 1073 women between the ages of 18 to 44. Both univariate and multivariate analyses were used to determine the association between the women's risk factors and their current fertility status. The univariate analysis showed that the majority of these 20 risk indicators were significantly associated with the women's current infertility status. The FertiSTAT tool also demonstrated acceptable discriminating ability between women who were currently pregnant and women who are infertile based on their indicated female fertility risk factors (the two male fertility factors were not included in the analyses). The tool correctly classified 91.0% ($n=243/267$) for the pregnant subgroup and 73.5% ($n=83/113$) of the infertile group (Bunting & Boivin, 2010). For the proposed study, the two male fertility health indicators were not included in the study since the study participants only contain young female adults. A total number of risk factors was reported for each woman.

Procedure

Step one. Data collection for this step lasted from September to November 2016. The PI compiled a list of 14 content experts through literature review and personal contacts. The PI first sent an individual invitation email to the 14 selected content experts. The invitation email explained the purpose of the study, the timeline and the proposed procedure for the Delphi discussion. Nine experts agreed to participate in the three rounds of Delphi study and one expert agreed to join only the first round of the Delphi discussion due to her time conflict.

One challenge in conducting an ongoing survey is the potentially high attrition rate (Dillman et al., 2009; Keeney et al., 2011). Many steps were taken to engage the experts in the three-rounds of Delphi discussion. For Round 1, the panelists were provided with the definition of fertility knowledge and its main components and the experts were asked to provide their input and opinions regarding the definition and content for fertility knowledge using two open-ended questions. The 10 experts had two weeks to respond to the first round of the discussion. A reminder email was sent to the experts at the end of the first week, and a thank-you email was sent after the first round of the discussion. All 10 experts completed the first round by the end of two weeks. The feedback obtained from the first round of the discussion was summarized and incorporated into the second round of the discussion.

For Round 2, the PI presented the summary of data obtained from the first round to the nine experts. The experts were also provided the original 30 items of the fertility knowledge questions. In this round, the experts were asked to rate the level of relevance of each item on a 4-point rating scale: (1) not relevant; (2) unable to assess relevance

without item revision; (3) relevant but needs minor alteration; or (4) very relevant (Lynn, 1986). The experts had two weeks to complete the final round of discussion. A reminder email was sent to the experts at the end of the first week. The nine experts completed the second round in two weeks. Out of the 30 items, 18 items achieved over 89% of agreement in their relevance among the nine content experts and were kept for the MU-FKAS. The PI deleted three items that were rated as “not relevant” by the whole group. Eight items received less than 89% of agreement in their relevance and were revised. The content experts also suggested six new items to assess young women’s fertility knowledge.

For Round 3, the PI summarized the findings from the second round to the nine experts. In this round, the experts were asked to rate the level of relevance on the eight revised items and the six new items proposed by the group of experts using the same relevance scale. The experts had two weeks to complete the final round of discussion. A reminder email was sent to the experts at the end of the first week. The nine experts again completed the third round in two weeks. A final thank-you email was sent to the experts at the completion of the three rounds of the Delphi discussion. Out of the 14 items, eight items achieved over 89% of agreement of relevance among the whole group and were kept. The majority of the group (eight out of nine) considered six items as “not relevant” and the PI deleted them. The final version of the MU-FKAS had a total of 26 question items that were incorporated into the online survey.

Step two. Data collection for this step occurred in two consecutive weeks in the beginning of December 2016. A convenience sample of 10 young women was recruited to pilot test the online survey using cognitive interview process (Dillman et al., 2009).

The PI recruited the 10 participants from a variety of places / organizations on the university campus. The PI set up an individual meeting with each of the participants on a campus location. At the meeting, the PI explained the process of cognitive interview and gave the young woman a paper copy of the online survey to write down her comments/observation. She was instructed to complete the online survey using her own electronic device. The PI then interviewed the young woman about her experience of completing the survey (Dillman et al., 2009; Waltz et al., 2010). The PI used a list of questions to obtain their feedback regarding the content and presentation of the survey and the process of the administration (Dillman et al., 2009). Notes were taken at the interview to keep track of the feedback from the young woman. Each woman received a \$15 Starbucks gift card at the end of the interview.

Step three. Data collection for this step lasted from the mid of January 2016 to the mid of February 2017. The PI recruited young women both from a Midwest private university and online. After obtaining approval from the University's Institutional Review Board (IRB) and Online Survey Review Group, the PI received a random email list of university students and staff (n = 600) from the Chair of the Online Survey Review Group. The PI sent out an invitation email with the anonymous survey link to all the email addresses on the email list. Simultaneously, the PI also attempted to recruit young women online. The original plan was to recruit young women who use FABM from a NFP website. The PI posted the study information and the survey link at the NFP website's forum and only three young women responded to the survey in one week. The PI decided to expand the recruiting efforts using the backup plan –recruiting from a

FABM group on Facebook. The PI was allowed to post the study information and the survey link on the group site.

Each participant had to complete the online consent and answer the two-screener questions before she could access the survey. The survey took 10 to 15 minutes to complete. The PI set up a thank-you message at the end of the online survey that is separated from the survey. In that thank-you message, the participants were asked to email the PI in order to receive their \$10 Starbucks E-gift card. A reminder email was sent to all participants a week after the initial email invitation (Dillman et al., 2009). Within three consecutive weeks, a total of 422 (159 out the email distribution and 263 participants from the Facebook) accessed the online survey and 342 (81%) met the study criteria. The PI decided to close the survey distribution and allowed the participants who had started the survey one more week to complete their survey before the whole survey was closed. The online survey site was closed on February 16, 2017.

Strategies to address methodological rigor. The development of a high quality survey study requires the researcher to address four types of survey error, which are coverage, sampling, nonresponse, and measurement (Dillman et al., 2009). Several strategies were put in place to enhance the rigor of the study. For a survey study including young adult population, the Internet is considered a useful and meaningful mode to reach a high coverage of the sample population (Dillman et al., 2009). The best way to recruit young women who use FABM from a wide range of geographic locations is through the Internet, which these women already are using in their daily life to monitor and chart their fertility online. Similarly, the majority of college students use Internet and

email in their daily communication. Therefore, the decision to use a Qualtrics survey provided the best coverage to reach the sample population.

Survey response rate is a major factor that can influence the accuracy of the data and the interpretation of the study results (Dillman et al., 2009). Several measures were put into place to engage the study participants and minimize nonresponse rates. For instance, a study logo was created and was consistently used for the study flyer, the recruiting email, and the online survey in order to establish the credibility of the study and provide the potential participants with a context and background of the study. Sending multiple contacts to the potential survey participants has been considered the most effective way to increase response rates (Cook, Health, & Thompson, 2000). An initial invitational email was sent out to all the potential participants and a follow-up email was sent after one week of the initial contact to remind the participants to complete the survey. The study participants also received a thank you email with a \$10 Starbucks's E-gift card at the completion of the survey.

Measurement errors are types of error related to inaccurate or imprecise answers from the respondents and are caused by unclear question wording, poor survey design, and confusing survey layout and display (Dillman et al., 2009). Both content and survey experts, and young women evaluated the online survey prior to its full implementation. The online survey was tested under a variety of possible combinations of operational system (i.e., platform, browsers, and user-controlled settings) in order to assure the quality and consistency of the online survey (Dillman et al., 2009). The pilot test also assessed the process of admission procedure, data coding, and downloading. All these

strategies helped the PI to minimize potential survey errors due to coverage, sampling, nonresponse, and measurement and carry out a high quality survey study.

Data management and analysis

All data obtained from the study were stored on an encrypted and password-protected laptop. Prior to the analyses, the electronic data were downloaded from Qualtrics into an Excel spreadsheet. The Excel spreadsheet had cell-parameters set to help alert the PI with any out-of-range data. The PI evaluated numbers that were outside of the parameter set and checked them against the original data on the survey site. SPSS statistical software, version 21 (IBM Corp., 2012) was used to assess internal reliability, classic item difficulty, classic item discrimination of the MU-FKAS, Person's r and multiple regression analysis. R Multidimensional Item Response Theory (mirt) statistical package (Version 1.24) was used to conduct the factor analysis and estimate item parameters, model fit, and to produce the item characteristic curve and item information curve for each of the items on the MU-FKAS. Descriptive statistics (means and standard deviations) were calculated for the sample characteristics including age, number of children, MU-FKAS scores, KFS scores and numbers of fertility health risks obtained from the FertiSTAT. Frequencies were reported for ethnicity, educational background, relationship status, fertility monitoring experience, and pregnancy experience. A detailed description of the specific statistical analyses that were conducted to assess each study aim was provided.

RQ1: What is the inter-rater agreement on each of the items and the entire scale among a panel of content experts?

This question was answered by calculating the content validity index (CVI) based on the experts' rating obtained from Step One (i.e., the Delphi panel discussion). Both CVIs at the item level and at the scale level are important to evaluate the content validity of the scale (Lynn, 1986; Polit & Beck, 2006; Rubio, Berg-Weger, Tebb, Lee, & Rauch, 2003). For each item, the Item-CVI is calculated as the number of experts giving a rating of either 3 or 4 divided by the total number of experts. The Scale-CVI was obtained by summing all the Item-CVIs and then divided by the total item number (Polit & Beck, 2006). The CVI depends on the number of experts who agree for the items and the entire scale. For a group of 6 to 10 experts, a minimum Item-CVI of 0.83 is needed in order for the instrument to be judged as having excellent content validity (Lynn, 1986; Polit & Beck, 2006).

RQ2: What is the internal consistency (reliability) of the MU-FKAS?

Research question Two was answered by calculating coefficient alpha using the data obtained from Step Three. Kuder-Richardson formula 20 (KR20) was calculated for the MU-FKAS. A coefficient alpha of 0.70 or above is considered as acceptable for new instrument development (DeVellis, 2012).

RQ3: What is the construct validity of the MU-FKAS as indicated by known groups of FABM user vs. non-FABM user?

Research question Three assessed the construct validity of the MU-FKAS using known group contrast method. An independent sample *t* test was used to test the difference of fertility knowledge level between FABM user and non-FABM user. The independent variable is the two groups of young women (FABM user and non-FABM

user). The dependent variable is their actual fertility knowledge level (i.e., MU-FKAS score). The significance level was set to be $p < 0.05$.

RQ4: What is the construct validity of the FKAS as demonstrated by exploratory factor analysis?

Research question Four was answered using EFA with the data obtained from Step Three. An EFA for dichotomous data was conducted using the R Multidimensional Item Response Theory (mirt) Package (Version 1.24). Maximum-likelihood methods were used for the factor extraction and oblique rotation was applied to factor rotation. The decision regarding the number of factors that were retained and interpreted was based on both empirical consideration and relevance to the definition and component of fertility knowledge.

RQ5: What is the quality of the items on the FKAS?

Research question Five was answered using the R mirt package with the data obtained from Step Three. The application of IRT models requires strong assumptions (Drasgow & Hulin, 1990). One of the main assumptions for IRT is unidimensionality (Hambleton et al., 1991). The EFA analysis provided information about the dimensionality of the MU-FKAS. Goodness of fit statistics will provide guidance in selecting the appropriate IRT model. Then, the selected IRT model was used to produce the item characteristic curve and item information curve for each of the items on the MU-FKAS. The item analyses from both CTT and IRT were compared and contrasted. Items that contributed minimally to the whole scale were either revised or eliminated due to their low quality and utility (DeVellis, 2012).

RQ6: What is the relationship between young female adults' self-perceived fertility knowledge and their actual fertility knowledge level?

Research question Six was analyzed using Pearson's correlation coefficient to examine the relationship between the woman's self-perceived fertility knowledge (KFS) score and her actual fertility knowledge (MU-FKAS) score. The data was assessed for normality, linearity, and homoscedasticity prior to the analysis. The significance level was set to be $p < .05$.

RQ7: What are the relationships between young female adults' individual and context factors, their fertility monitoring experience, their self-perceived fertility knowledge with their actual fertility knowledge level?

Research question Seven was analyzed using standard multiple linear regression. The independent variables include the young women's age, their educational level, FABM user or not, their pregnancy experience, and their self-perceived fertility knowledge. The dependent variable is the total fertility knowledge score measured by the MU-FKAS. The data were assessed for normality, linearity, homoscedasticity of residual, and multicollinearity prior to the regression analysis. Standard multiple regression was used to explore the unique variance that each of the independent variables explains the dependent variable (Pallant, 2010). The significance level was set to be $p < 0.05$.

RQ8: What are the relationships among young female adults' individual and contextual factors, their self-perceived fertility knowledge, and their actual fertility knowledge on these young female adults' current fertility health risks?

Research question Eight was analyzed using standard multiple linear regression. The independent variables include the young women's age, the educational background, their pregnancy experience, FABM user or not, the MU-FKAS scores, and the KFS scores. The dependent variable was the number of fertility health risk factors obtained from the FertiSTAT. The data were assessed for normality, linearity, homoscedasticity of residual, and multicollinearity prior to the regression analysis. Standard multiple regression was used to explore the unique variance that each of the independent variables explains the dependent variable (Pallant, 2010). The significance level was set to be $p < 0.05$.

Provisions for the protection of human rights

IRB approval was obtained from Marquette University prior to the initiation of the study. Approval from the Online Survey Review Group was obtained in order to recruit participants from Marquette University prior to Step Three. The Online Survey Review Group reviewed and approved the finalized online survey, email invitations, and email reminders used for Step Three.

This study posed minimal risk to participants. Much effort has been put in place to protect the participants' privacy and confidentiality. The PI's contact information was provided at each contact point with the potential study participants, i.e., information flyer, recruiting email, and the online questionnaire site for inquiry and questions related to the study. The study participants had to consent prior to access the online questionnaire and they were notified that they could withdraw from the study at any time during the survey.

One potential risk of taking part in this study was the use of study participants' email account to send the anonymous survey link. The PI took several strategies to

protect this information and keep it safe. The PI stored the email list in an encrypted Excel document in an encrypted folder on a password – protected laptop and the list was destroyed after sending the initial invitation email. The participants were asked to email the PI to receive their Starbucks E-gift card at the completion of the survey and their email addresses were used for sending the E-gift card. These email addresses were also stored in an encrypted excel document and were deleted at the completion of the study.

Limitations

Many efforts were made to ensure the internal and external validity of the study. However, there are still several limitations noted with the current study. One limitation is related to the selection of the sample population. First, the PI has to use a convenience sampling to select the sample population for the FABM user. The PI posted the study information at a Facebook site which women who are using FABM could access the study. Second, the random email list ($n=600$) that the PI obtained from the MU Online Survey Group included both males and females at a variety of ages. The PI had to set up screener questions at the beginning of the online survey to filter out participants who did not meet the study criteria.

Another limitation to the study is the instrument used for data collection. The FertiSTAT tool has demonstrated content validity and criterion validity through its development and initial validation process. The FertiSTAT has also been validated for its predictability to assess women's fertility health risks (Bunting & Boivin, 2010). However, this tool is still quite new and has not been widely used in research and clinical application, which makes it harder to compare the study results. Similarly, the FKS has been initially developed and used for the population of women with breast cancer.

Although the FKS has shown excellent reliability ($\alpha = 0.91$) for the sample of breast cancer women (Jukkala et al., 2012), currently, the FKS has not yet been applied in other women populations. It is important to take into consideration the impact of the reliability and validity of these instruments on the conclusions of the study (Streiner & Norman, 2008). However, research related to fertility health, especially for the young female adult population is still quite early in its development. Both the FertiSTAT tool and the FKS are two promising instruments existing in the current literature to measure key concepts related to women's fertility health. It is important to continue to test these instruments in order to assess and evaluate the application and usefulness of these instruments for women's fertility health education, research, and care.

Summary

This chapter describes the design and method for the completed study. A multi-step, multi-method design was used for the study, and a detailed explanation of the method, including sample, data collection procedure, data management, and data analyses were provided. Multiple strategies have been developed in order to enhance the rigor of the study. The chapter concludes with discussion of limitations of the study, as well as provisions for human subject protection.

**IV. MANUSCRIPT I: DEVELOPMENT AND PSYCHOMETRIC EVALUATION
OF THE MU-FERTILITY KNOWLEDGE ASSESSMENT SCALE**

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Abstract

Aims: To develop and evaluate the psychometric properties of the MU-Fertility Knowledge Assessment Scale (MU-FKAS) for young female adults.

Background: Young women between the ages of 18 to 24 experience disproportionately high rates of adverse sexual and reproductive health outcomes. Inadequate and inaccurate fertility knowledge can hinder a young woman's self-care abilities in managing her sexual and reproductive health. There is no validated instrument to assess young women's fertility knowledge.

Design: A three-step, multi-method approach was used for the development and evaluation of the MU-FKAS.

Methods: Three rounds of Delphi discussions were used to evaluate and refine the MU-FKAS. Cognitive interviews were conducted with 10 young women to evaluate the online survey. A convenience sample of 342 young women completed the final survey. Psychometric analyses included Kuder-Richardson 20 (KR20) coefficient, known group comparison, exploratory factor analysis, and item analysis.

Results: The MU-FKAS had acceptable internal consistency for a newly developed instrument (KR20 = .74). A known group comparison between young women who used fertility awareness based methods (FABM) vs. non-user showed a significant difference in their fertility knowledge level supporting the construct validity of the MU-FKAS. Exploratory factor analysis revealed a two-factor structure. Item analysis provided evidence for refinement of individual items on the MU-FKAS.

Conclusion: The MU-FKAS is a valid and reliable instrument to assess young women's fertility knowledge and can guide clinicians in providing individualized fertility health

education. Future studies are needed to evaluate its application in research and clinical practice.

Key words: Fertility knowledge, instrument development, psychometric testing, full information item factor analysis, Item response theory

Introduction

In recent years, fertility knowledge has been recognized as a key concept in determining a woman's fertility self-care ability (Barron, 2013; Bunting & Boivin, 2007; Fulford, Bunting, Tsibulsky, & Boivin, 2013; Institute for Reproductive Health, 2013). For young women, limited and inaccurate fertility knowledge can have negative impacts on their current and future sexual and reproductive health outcomes. For example, research indicates that young women may choose not to use or inconsistently use contraception due to their misconception about their fertility changes and conception possibilities within the menstrual cycle (Gungor, Rathfisch, Beji, Yarar, & Karamanoglu, 2012; Reed, England, Littlejohn, Bass, & Caudillo, 2014). Many young women do not know that risky sexual behaviors or sexually transmitted infections are significant risk factors for infertility (Goundry, Finlay, & Llewellyn, 2013; Quach & Librach, 2008; Sabarre, Khan, Whitten, Remes, & Phillips, 2013). Studies also indicate that young women may unintentionally plan to delay their childbearing due to their inaccurate knowledge of the impact of age on female fertility and conception (Chan, Chan, Peterson, Lampic, & Tam, 2015; Peterson, Pirritano, Tucker, & Lampic, 2012; Virtala, Vilksa, Huttunen, & Kunttu, 2011). Overall, these studies highlight the importance of providing fertility knowledge assessment and education in preconception care and reproductive life planning (RLP) for young women (Stern, Larsson, Kristiansson, & Tydén, 2013).

Background

The challenges lie in how to accurately assess young women's fertility knowledge. A comprehensive definition of fertility knowledge refers to information about fertility throughout the life course. For women, this knowledge includes

information regarding the menstrual cycle, pregnancy potential in each menstrual cycle and at different life stages, and risks of infertility (Mu, 2016). Previous research has used a variety of questionnaires to evaluate young women's fertility knowledge (Chan et al., 2015; García, Vassena, Trullenque, Rodríguez, & Vernaeva, 2015; Peterson et al., 2012; Virtala et al., 2011). Their findings provided valuable information regarding young women's fertility knowledge in different cultures and countries. However, these questionnaires often are designed for one-time use and are difficult to be applied in broad populations and clinical practice settings. It is important to develop an instrument that is representative of the comprehensive definition of fertility knowledge and can be applied to assess young women's fertility knowledge in a variety of educational and clinical settings.

Instrument development and evaluation is an iterative process. Despite the increasing attention and usage of the concept of fertility knowledge in research and daily life, fertility knowledge presents a new and evolving concept that has not been well defined in the literature. In developing the MU-FKAS, it was necessary to implement multiple processes to establish the validity and reliability of the instrument (Streiner & Norman, 2008). In developing an instrument, it is critical to consider the specific item formatting based on the purpose of the scale, the characteristics of the measure, and the setting where the measurement applies (Waltz, Strickland, & Lenz, 2010). The researchers intended to develop an instrument that is easy for clinicians to apply in their practice or young women who want to test their own fertility knowledge level. Based on these purposes, the format of "True," "False," and "Don't know" was chosen due to its easiness to use and score compared to the style of multiple choice or Likert scale.

Measurement theory is a branch of applied statistics that focuses on the development and evaluation of measurements and can provide information about the usefulness, accuracy, and meaningfulness of the instrument (Allen & Yen, 2002). There are two main types of measurement theories, classic test theory (CTT) and item response theory (IRT). Each of these theories provides unique statistical methods to assess the psychometrics of an instrument. CTT can be used to evaluate an instrument's performance both at the item and the whole scale level. At the item level, item statistics, such as means and variance, item difficulty, and item discrimination can be calculated and assessed for each individual item. CTT also provides ways to assess the overall accuracy statistics (e.g., standard error of measurement, reliability coefficient) for the whole scale. Nevertheless, CTT exhibits limitation in evaluating the dimensionality of categorical instruments due to its underline assumption of normal distribution and linearity of the data (Wirth & Edwards, 2007). In recent years, factor analysis using IRT has been applied in psychometrical analysis. One advantage of using IRT for dimensional analysis is directly using the full information from examinee response data instead of correlation matrices (Lane & Stone, 2006). Furthermore, IRT models may provide better illustration of the relationship between item performance and θ , the underlying latent ability (Hattie, 1985). Therefore, a combination of both CTT and IRT statistical analyses may compliment each other and provide a more comprehensive evaluation of the newly developed instrument.

Aim

The purposes of this study were to develop the MU-Fertility Knowledge Assessment Scale (MU-FKAS) for young women and to evaluate its psychometric

properties. Specifically, this study aimed to answer the following research questions: 1) what is the inter-rater agreement on each of the MU-FKAS items among a panel of content experts? 2) What is the internal consistency (reliability) of the MU-FKAS? 3) What is the construct validity of the MU-FKAS as indicated by known group comparison of fertility awareness based method (FABM) user vs. non-FABM user? 4) What is the construct validity of the MU-FKAS as demonstrated by exploratory factor analysis? And 5) what is the quality of the items on the MU-FKAS?

Design

This study used a multi-step, multi-method design to develop the MU-FKAS and to assess its psychometric properties. There were three main steps involved in the study: (1) development of the MU-FKAS; (2) Testing of the online survey; and (3) cross-sectional survey. The cross-sectional survey comprised of demographic information, self-perceived fertility knowledge, actual fertility knowledge (MU-FKAS), and fertility health risk factors. This paper focuses on describing the development and psychometric evaluation of the MU-FKAS.

Ethical considerations

The researchers obtained both approvals from the institutional review board and Online Survey Review Group of the university prior to the data collection. The cross-sectional survey was anonymous due to the sensitivity in collecting young women's sexual orientation, sexual behaviors, and life style factors.

Step one

A Delphi technique was used to evaluate and refine the items of the MU-FKAS during Step one. The Delphi technique is a survey method that uses a group of experts to

establish consensus for the content, and it is suitable to achieve agreement on content or issues that are not previously well defined (Keeney, Hasson, & McKenna, 2011; Waltz et al., 2010). The researchers first developed a definition of fertility knowledge and generated 30 question items through a comprehensive literature review. The definition and the 30 items were then used to facilitate the Delphi discussions. Three rounds of Delphi discussion were carried out and responses from each round were aggregated and fed back to the whole group for the next round of discussion.

Participants. Sample size recommendation for content validity evaluation is to recruit at least three but no more than 10 experts (Lynn, 1986). The recruiting goal was to obtain a group of 5 to 10 content experts for the Delphi discussion. The selection criteria for the panelists included the following: researchers with significant publications in women's reproductive and fertility health, and clinicians who work with women throughout their reproductive years. The researchers compiled a list of 14 content experts through literature review and personal contacts. An individual invitation email was sent to the selected experts. Nine experts agreed to participate in the three rounds of the Delphi discussions and one expert agreed to join only the first round due to her time constraints. Among the 10 content experts, five were from the US, two were from Australia, two from Canada, and one from Spain. These experts were from a variety of academic fields, including nursing ($n=5$), psychology ($n=2$), medicine ($n=2$), and pharmacy ($n=1$), and all had either a master and/or a PhD degree.

Data collection and analyses. Data collection for the three rounds of Delphi discussions lasted from September to November 2016. Qualtrics, an online survey environment, was used for the data collection and each of the rounds took two weeks to

complete. The researchers sent out the survey link to the content expert's email account. A reminder email was sent after one week. A thank-you email was sent at the completion of each round.

In the first round, two open-ended questions were used to obtain the content experts' opinions regarding the proposed definition of fertility knowledge and its main components. The content experts considered the topic of fertility knowledge as either "very important" or "extremely important" for young women. They unanimously agreed with the proposed definition of fertility knowledge and its main components. The content experts also suggested new content to expand the concept. The researchers summarized the collected ideas and feedback to the whole group at the second round.

In the second round, the researchers presented the 30 items that were developed through the literature review. The content experts were asked to rate the relevance of each item in assessing young women's fertility knowledge on a 4-point rating scale: (1) not relevant; (2) unable to assess relevance without item revision; (3) relevant but needs minor alteration; or (4) very relevant (Lynn, 1986). For each item, the content validity index is calculated as the number of experts giving a rating of either 3 or 4 divided by the total number of experts. To establish the content validity at the .05 level, a minimum of 83% of the experts need to rate each item with a "3" or "4" for a group of six or more experts (Lynn, 1986). Spaces were also provided for the experts to suggest new items or provide feedback. Out of the 30 items, 18 items achieved 89% agreement of relevance among the nine content experts, which means eight out of the nine experts had endorsed the item with either a "3" or "4." These 18 items were kept for the MU-FKAS. Three items were deleted due to their very low relevance rating by the whole group. Eight

items had less than 89% of agreement of relevance and were revised. The group of content experts also suggested six new items to assess young women's fertility knowledge.

For the third round, the researchers presented the eight revised items and six new items to the group. The content experts were asked to assess the relevance of the 14 items using the same procedure as in the second round. Out of the 14 items, eight items achieved 89% agreement of relevance among the whole group and were kept. Six items were deleted due to very low relevance rating. The final version of the MU-FKAS included 26 question items and was then incorporated into the online survey.

Step two

The researchers piloted the online survey with a small sample of young women to evaluate its performance (Dillman, Smyth, & Christian, 2009). The goal was to identify issues related to the administration procedure, to evaluate the visual presentation of the survey, to determine understanding of the questions, and to assess the data processing procedures, all of which enhance the internal validity of the instrument (Polit & Beck, 2012). The researchers conducted cognitive interviews with 10 young women to evaluate the online survey.

Participants. The researcher intended to recruit a diverse group of young women between the ages of 18 to 24 to pilot test the online survey. A purposeful sample of 10 young women was recruited from a private university campus through flyer and word of mouth. They were between the ages of 18 to 23 ($M=19.80$, $SD=1.75$) and from a variety of ethnic groups, including non-Hispanic white, Hispanic, African American, Indian, Chinese, and Iranian.

Data collection and analyses. Data collection for this step lasted two weeks in the beginning of December 2016. An individual time and place was scheduled with each young woman. The primary investigator (PI) conducted the 10 cognitive interviews. The PI explained the procedure and process of cognitive interview at the beginning of the interview. The young woman was given a paper copy of the online survey to write down their comments/observations. She was instructed to complete the online survey using her own electronic device. The PI then interviewed the young woman about her experience of completing the survey. The PI used a list of questions to obtain their feedback regarding the content and presentation of the survey and the process of the administration (Dillman et al., 2009). Each woman received a \$15 Starbucks gift card at the end of the interview.

The 10 young women completed the online survey on a variety of electronic devices and reported no technical difficulties in accessing and completing the survey. The presentation of the survey was consistent on all the tested devices. On average, it took the young women 8 to 26 minutes ($M=14.50$, $SD = 6.54$) to complete the survey. Overall, young women liked the color and image used for the survey and had no difficulties in reading and understanding the question items. A few minor revisions were suggested for some of the survey items. For example, they suggested providing the full spelling of medical terms besides the abbreviation. They also asked for examples of different contraceptive methods. They recommended using a numeric format for the numbers in the survey items. All these suggestions were discussed among the research team and were adapted for the final survey. Furthermore, the data contributed by the 10

young women were used to evaluate the data coding and processing procedure and no issues were identified.

Step three

The purpose of this step was to recruit a large sample of young women to test the psychometrics of the refined MU-FKAS. The data obtained from this step were used to answer research questions 2-5.

Participants. For Step Three, sample estimation was based on factor analysis. For factor analysis, it is important to consider both the relative number of subjects per variable and the absolute number of subjects in total (DeVellis, 2012). Tabachnick and Fidell (2007) recommended a minimum of five per variable. Tinsley and Tinsley (1987) suggested a ratio of 5 to 10 subjects per variable up to a sample size of 300. Comrey (1988) strongly advocated a sample size of 200 or more is optimal for factor analysis. Based on these sample size recommendations, the researchers planned to recruit a minimum of 300 young women to complete the online survey. Two sample groups, young women who use FABM and young women who do not use FABM, were recruited to evaluate the construct validity of the MU-FKAS using known group comparison (Hattie & Cooksey, 1984). Previous studies have suggested that women who use FABM may have higher fertility knowledge due to their experience of monitoring their fertility compared to women who do not use a FABM (Berger, Manlove, Wildsmith, Peterson, & Guzman, 2012; Vigil, Ceric, Cortes, & Klaus, 2006).

Data collection. Data collection for this step lasted from the mid of January to the mid of February 2017. The researchers recruited young women both from a private university campus and online. For the campus recruiting, the researchers obtained a list

of randomly selected email addresses from the university and sent out an email invitation with the survey link attached ($n=600$). In order to recruit young women who use FABM, the researchers posted the study information and the survey link on a FABM Group Facebook site. Within three consecutive weeks, a total of 422 (159 out of the email distribution and 263 participants from the Facebook) accessed the online survey and 342 (81%) met the study criteria. Among which, 165 young women (48.2%) had used a FABM while 177 young women (51.8%) had never used a FABM in their life. The participants were asked to email the PI at the completion of the survey to claim their \$10 Starbucks e-gift card in order to ensure the anonymity of their answers.

Data analysis.

R (Version 1.0.136) and R Multidimensional Item Response Theory (mirt) statistical package (Version 1.24) were used for data analyses. A total of 342 (81%) completed the online survey. Nine out of the 342 subjects had missing data for the MU-FKAS and were excluded from the psychometric analysis. Item responses were dichotomized into two categories, correct and incorrect. Response of “Don’t know” was also considered as incorrect.

An independent-sample t -test was done between young women who had used FABM and young women who never used FABM for the known group comparison. Maximum likelihood method was used for exploratory factor analysis. Model fit was evaluated using the Root Mean Square Error of Approximation (RMSEA), Tucker-Lewis Index (TLI), Comparative Fit Index (CFI), and Standard Root Mean Square Residual (SRMSR). Both CTT estimate of difficulty and discrimination and IRT difficulty and

discrimination parameters were calculated for each item in order to identify items that had a range of difficulty level and high discrimination.

Results

Participants

Three hundred and forty two young women ($M= 21.87$; $SD =1.88$) completed the online questionnaire. The sample consisted mainly of young women who were White (83.3%), Catholic (74%), and heterosexual (93.6%). Most of the women (95.6%) had either some college education or a college degree. Over half of these women had no pregnancy while 32.2% had experienced at least one pregnancy. Young women reported a wide range of contraceptive methods, ranging from zero to five different types. Over half of these young women (62.0 %) reported using one or two contraceptive methods in their lifetime. A comparison between young women who had used a FABM vs. non-users showed some differences between these two groups. Young women who used a FABM were significantly older in age, living in a stable relationship, and experienced a pregnancy compared to the non-users. Meanwhile, non-users were more diverse in their ethnicity background and religious affiliations compared to the FABM users.

Psychometrics of the MU-Fertility Knowledge Assessment Scale

Description of the MU-FKAS. The final MU-FKAS contains 26 items and assesses young women's knowledge of female fertility changes within the menstrual cycle and throughout the lifecycle, the impact of lifestyle factors on female fertility and conception, and the risks of infertility associated with age. The answer choices are true, false, or don't know. A correct answer receives one point and an incorrect or don't know is zero points. A total score is calculated by summing all the points, which then is

divided by the total number of questions and multiplied by 100. A possible score can range from 0 to 100. Young women demonstrated a wide range of scores from 27 to 100 ($M=78.04$, $SD= 14.36$).

Internal reliability of the MU-FKAS. KR20 was calculated to evaluate the internal consistency of the MU-FKAS. It was .74 for this sample population, which is considered satisfactory for a new instrument (DeVellis, 2012).

Construct validity with known group comparison. An independent-sample *t*-test was conducted to compare fertility knowledge for young women who used FABM and young women who never used FABM. There were significant differences in the score of fertility knowledge for young women who used FABM ($M = 83.08$, $SD = 11.47$) and young women who never used FABM ($M = 73.34$, $SD = 15.20$; $t(342) = 6.72$, $p < 0.0001$). Cohen's *d* of 0.72 shows the magnitude of the differences in the means (mean difference = 9.74, 95% *CI*: 6.89 to 12.59) is close to what is considered a large difference (Cohen, 1988). Young women who used FABM had significantly higher fertility knowledge compared to non-FABM users, which supports the construct validity of the MU-FKAS.

Exploratory factor analysis. Dimensionality was assessed using exploratory factor analysis. A one- through four-factor solution was evaluated using the R multidimensional item response theory (mirt) package (Chalmers, 2012). The decision of how many factors to retain was based on both the goodness of fit indices and factor interpretability. The researchers evaluated and compared the fit indices of the four factor models to select the better fitting model. A good fitting model should have a RMSEA less than .06, a CFI and TLI over 0.90, and a SRMR less than 0.80 (Hu & Bentler, 1999).

Compared to a one-factor model, the two-, three, and four factor models all had an acceptable model fit to the data (Table 1).

Meanwhile, the statistical information was weighed against the factor loading and interpretability among the four models. Compared to the one-, three-, or four-factor model, the two-factor model exhibited both parsimony and meaningfulness in its item grouping and factor loading (DeVellis, 2012). Twenty- one out of the 26 items had $>.40$ loading on either factor one or factor two (Table 2) (Tabachnick & Fidell, 2007). All the items that loaded strongly on Factor One were related to ovulation and conception while the items loading heavily on Factor Two concerned infertility risk factors (Table 2). Therefore, the two-factor structure made both conceptual and statistical sense for the MU-FKAS. Factor one accounted for 37.43% of the total variance and factor two explained another 34.94% of the remaining variance.

Item analysis with individual items. Both CTT and IRT were used to evaluate the quality of the individual items on the MU-FKAS. CTT item parameters included item difficulty (p) and discrimination (D) parameters, in which p is calculated as the percentage of test takers who correctly answered the question and D is the difference of the p level between the top 27% and the lowest 27% test takers (Popham, 1999). The 2-parameter modeling was used to assess IRT difficulty (b) and discrimination (a) parameters based on its flexibility and comprehensiveness in modeling response probability without considering the guessing potential (De Ayala, 2009). Since the exploratory factor analysis supported the two-factor structure, item analyses were conducted separately for Factor one (Ovulation and conception) and Factor two (Infertility risk factors).

Item parameters for the 12 items that were loaded on Factor One (Ovulation and conception) were presented in Table 3 and the 14 items that were loaded on Factor Two (Infertility risk factors) were described in Table 4. The CTT difficulty parameter ranged from 0.42 to 0.96, indicating that some items were assessing very basic knowledge (Item 1, Item 15) while a few items were more challenging for the young women (Item 22, Item 23). For the CTT discrimination parameter, 24 out the 26 items had a discrimination parameter estimate greater than 0.30, which is considered to be good (Popham, 1999).

The IRT difficulty parameter was between -2.92 and 0.43; Item 15 was the easiest and Item 22 was the most difficult on the instrument. Twenty-five out of the 26 items had a difficulty parameter estimate below zero. This suggests that the MU-FKAS items are relatively easy and therefore are most useful in differentiating young women who have low fertility knowledge level. The IRT discrimination parameter ranged from 0.46 to 3.46. Twenty-one out the 26 items had a discrimination parameter estimate of 0.80 or above, which is considered to have effective discriminatory power (De Ayala, 2009).

The IRT also provided information regarding the contribution of each item in assessing the latent construct (Hambleton & Jones, 1993). This information can be visually displayed as an item information curve and it is important to evaluate the item information curve for each item. Figure 1 illustrated a few selected item information curves. Item 1 showed a good information curve that measures fertility knowledge best around the θ level of -2.62. Compared to Item 1, Item 2, 13, 21, and Item 25 had a very flat information curve with very low value, which indicates these items contribute minimally toward assessing the construct of fertility knowledge. These three items will need to be evaluated further for revision or deletion.

Discussion

This study applied multiple methods and steps to develop and evaluate the MU-FKAS. The findings provided evidence for the validity and reliability of the instrument. The development of the MU-FKAS is based on a clearly defined construct and a comprehensive literature review. The application of the three rounds of Delphi discussion further validated the MU-FKAS in its comprehensiveness and representativeness of the concept, thus, increasing the rigor of the developed instrument (Lynn, 1986). Both known group comparison and exploratory factor analysis supported the construct validity of the instrument. However, caution is needed to interpret the finding of the known group comparison as other factors between the two groups may contribute to the significant difference of their fertility knowledge level (Hattie & Cooksey, 1984). Future studies could compare multiple groups of young women who may have different levels of fertility knowledge with the MU-FKAS in order to assess its construct validity.

The goal of instrument development is to construct a valid and reliable instrument with desired quality that can achieve the intended purpose (DeVellis, 2012). This study applied CTT and IRT statistical methods to evaluate the psychometrics of the MU-FKAS. Both CTT and IRT provided comparable difficulty and discrimination parameters. IRT also provided visual graphs to illustrate the function of each item at different level of the ability, which is important in assessing the performance of the scale at the item level (Hambleton & Jones, 1993). For example, Item 1 has a CTT difficulty parameter of 0.96 and discrimination parameter of 0.11 that may be considered as less optimal due to its easiness and lack of discrimination among women with high fertility knowledge.

However, examining the ICC and item information curve shows that Item 1 is actually highly discriminating around the θ level of -2, which means it is a very good item at assessing young women with low fertility knowledge (Figure 2). Similarly, Item 17 and Item 20 have very similar CTT difficulty and discrimination parameters. However, the differences between these two items became apparent when examining the graphs of the combined ICC and item information curve (Figure 3). Item 20 is a more discriminative question that provides a better estimate of the women's fertility knowledge compared to Item 17. Clearly, analyses of both the ICC and the item information curve provided by the IRT can help the selection of proper items for the MU-FKAS.

One question that needed to be addressed by the psychometric analyses was whether the instrument measures what it purports to measure. The researchers intended to develop an instrument that can be applied as a quick assessment tool in clinical and daily situations. The item analysis of the MU-FKAS shows that a majority of these items are relatively easy and have high discrimination parameter estimates at the lower level of the latent trait. Therefore, the MU-FKAS is useful in differentiating young women who have low fertility knowledge level, which fits the purpose of this instrument. Stern et al. (2013, 2015) noted that both young women and midwives view fertility and RLP discussion as positive and meaningful during contraceptive counseling. The MU-FKAS can provide a quick baseline assessment of the young woman's fertility knowledge level that could lead to a more focused and structured discussion in the limited amount of appointment time.

However, the MU-FKAS may not be an appropriate tool to use in certain clinical situation since it lacks items that could discriminate women with high fertility knowledge

level and also in certain specialty fertility topics, such as infertility treatments. More items with higher difficulty level that covers more specialty fertility topics should be added for future expansion of this instrument in a variety of clinical situations beyond preconception care and RLP consultation.

Limitations

This study used a non-probability convenience sample of young women. One possible bias from this sample is that many of the participants had either some college education or a college degree. It will be important to continue evaluating the validity and reliability of the MU-FKAS using different samples of young women. Also, the study was based on one sample from one country. It is necessary to test this instrument with young women from different countries, which may require translation and adaption to different cultures.

Conclusion

This study provided preliminary evidence of the psychometrical properties of the MU-FKAS. It showed that the MU-FKAS is a short test with acceptable reliability and validity that can be easily used in practice. Future studies are needed to evaluate its application in assessing young women's fertility knowledge and providing individualized fertility education and consultation in clinical settings.

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Tables and Figures

Table 1

Model fit indices with exploratory factor analysis of 1, 2, 3, and 4 factors

Model Fit Statistics	1-Factor Model	2-Factors Model	3-Factors Model	4-Factors Model
RMSEA	0.06	0.04	0.03	0.03
CFI	0.78	0.91	0.94	0.96
TLI	0.76	0.88	0.93	0.94
SRMSR	0.08	0.06	0.05	0.05

Table 2

Factor loadings for two-factor structure with exploratory factor analysis with oblique rotation

Items	Factor Loading		h^2
	1	2	
1. An ovulation is the releasing of an egg from the ovary.	0.58	0.11	0.40
2. There are about 6 days in each menstrual cycle when a woman is able to get pregnant.	0.37	0.01	0.13
3. The egg that a woman releases from her ovary lives for 12 to 24 hours if it is not fertilized.	0.63	0.08	0.44
4. The length of a menstrual cycle refers to the first day of the period until the day before the next period.	0.59	0.23	0.31
5. Normal menstrual cycle length ranges between 21 to 35 days.	0.43	0.07	0.21
6. Sperm from a man can live up to 5 days in a woman's body with good cervical mucus.	0.56	0.11	0.36
7. Ovulation always occurs on the 14 th day of each menstrual cycle.	0.80	0.00	0.63
8. A woman is born with all the eggs she will ever have in her life.	0.62	0.02	0.40
9. A woman's age is one of the strongest risk factors for infertility	0.38	0.52	0.27
10. Female fertility remains stable from puberty until menopause.	0.48	0.15	0.30

11. Sexually transmitted infections increase the risk of infertility.	0.04	0.67	0.44
12. The quality and quantity of a woman's egg decline as she gets older.	0.20	0.70	0.43
13. Women remain fertile even after menopause.	0.35	0.09	0.15
14. A woman's body weight may affect her chances of getting pregnant.	0.19	0.81	0.80
15. The likelihood of conceiving varies with a woman's age.	0.01	0.51	0.26
16. The risk of having a baby with Down syndrome increases with a woman's age.	0.19	0.55	0.41
17. Aging may increase a woman's chance of miscarriage.	0.12	0.61	0.44
18. A woman is most fertile in her 30s.	0.33	0.38	0.34
19. Smoking decreases a woman's fertility.	0.13	0.75	0.51
20. Being overweight may decrease a woman's chance of getting pregnant.	0.12	0.83	0.78
21. Being underweight may increase a woman's chance of getting pregnant.	0.11	0.22	0.08
22. Regular use of marijuana has no impact on a woman's ability to get pregnant.	0.04	0.50	0.23
23. Drinking more than 7 cups of caffeinated beverages a day lowers a woman's chance of getting pregnant.	0.08	0.47	0.25
24. The timing of ovulation may vary in each menstrual cycle.	0.67	0.02	0.47
25. A woman over 35 years old should seek medical help if she cannot get pregnant after 6	0.11	0.26	0.10

months of trying to get pregnant.

26. Cervical mucus is an indicator of changes in female fertility during the menstrual cycle.	0.70	0.07	0.53
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Note. Factor loadings greater than .40 are in boldface.

Table 3

CTT and IRT item parameters for Items loaded on factor One (Ovaluation and Conception)

Item Number	CTT Difficulty (p)	CTT Discrimination (D)	IRT Difficulty (b)	IRT Discrimination (a)
1	0.96	0.11	-2.57	1.61
2	0.64	0.60	-0.93	0.67
3	0.71	0.67	-0.85	1.44
4	0.83	0.37	-1.86	1.01
5	0.85	0.31	-2.27	0.87
6	0.79	0.51	-1.30	1.34
7	0.70	0.56	-1.10	2.07
8	0.89	0.33	-1.93	1.42
10	0.82	0.43	-1.75	1.06
13	0.85	0.37	-2.85	0.66
24	0.88	0.33	-1.75	1.54
26	0.86	0.40	-1.50	1.81

Note. CTT difficulty is calculated as % correct. CTT Discrimination is the difference of difficulty level between the top 27% and the lowest 27% scorers. IRT Difficulty and Discrimination parameters are determined by 2-paramter model.

Table 4

CTT and IRT item parameters for Items loaded on factor Two (Infertility Risk Factors)

Item Number	CTT Difficulty (p)	CTT Discrimination (D)	IRT Difficulty (b)	IRT Discrimination (a)
9	0.66	0.43	-1.15	0.62
11	0.82	0.44	-1.50	1.43
12	0.88	0.31	-1.95	1.25
14	0.89	0.33	-1.34	3.46
15	0.92	0.19	-2.92	0.97
16	0.86	0.37	-1.72	1.35
17	0.87	0.38	-1.78	1.43
18	0.63	0.63	-0.64	0.97
19	0.83	0.43	-1.37	1.67
20	0.87	0.41	-1.27	3.55
21	0.61	0.42	-1.06	0.46
22	0.42	0.64	0.43	0.91
23	0.51	0.64	-0.11	0.96

25	0.68	0.46	-1.41	0.59
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Note. CTT difficulty is calculated as % correct. CTT Discrimination is the difference of difficulty index between the top 27% and the lowest 27% scorers. IRT Difficulty and Discrimination parameters are determined by 2-parameter model.

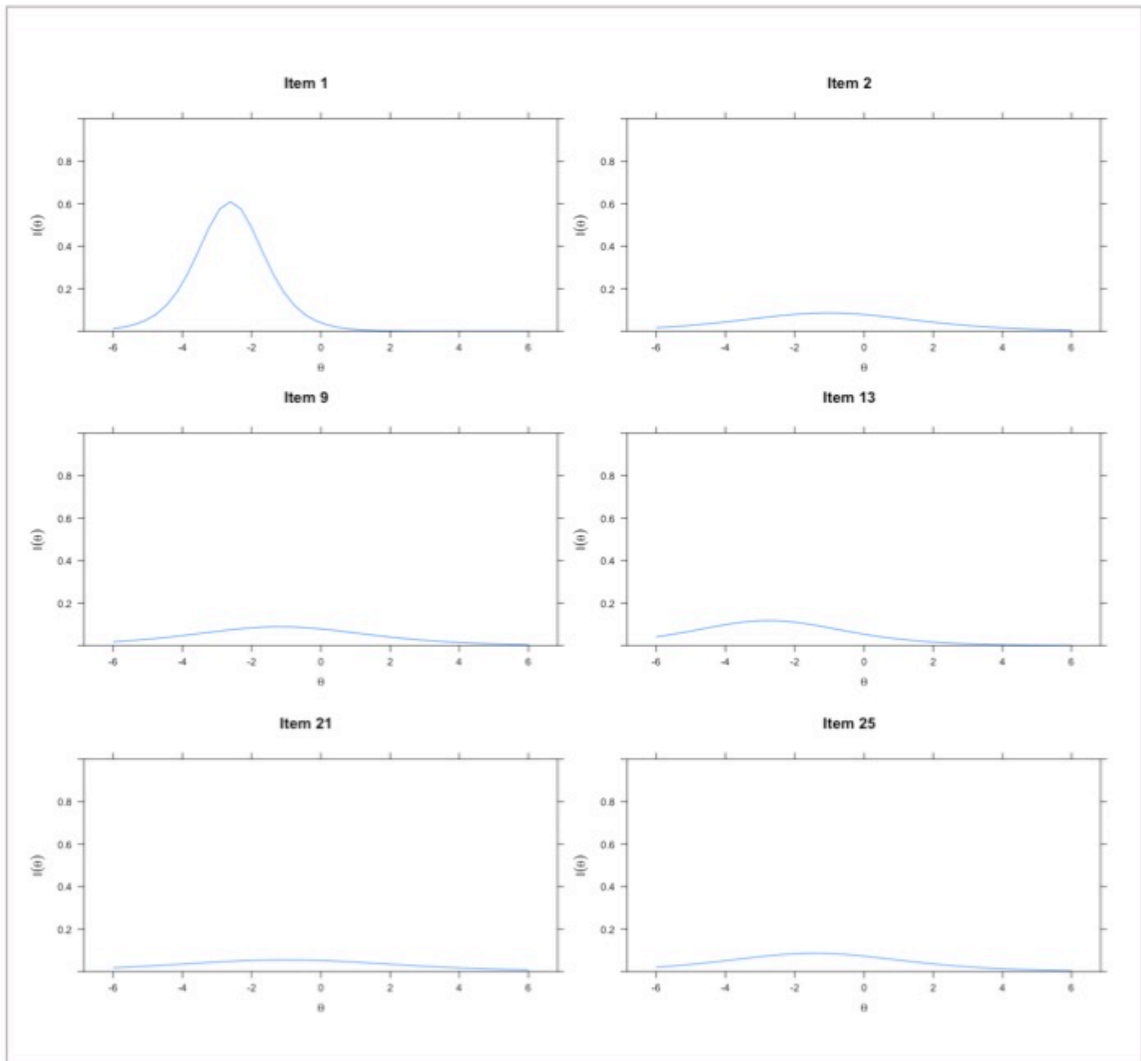


Figure 1. Item information curve for Item 1, 2, 9,13, 21, and 25

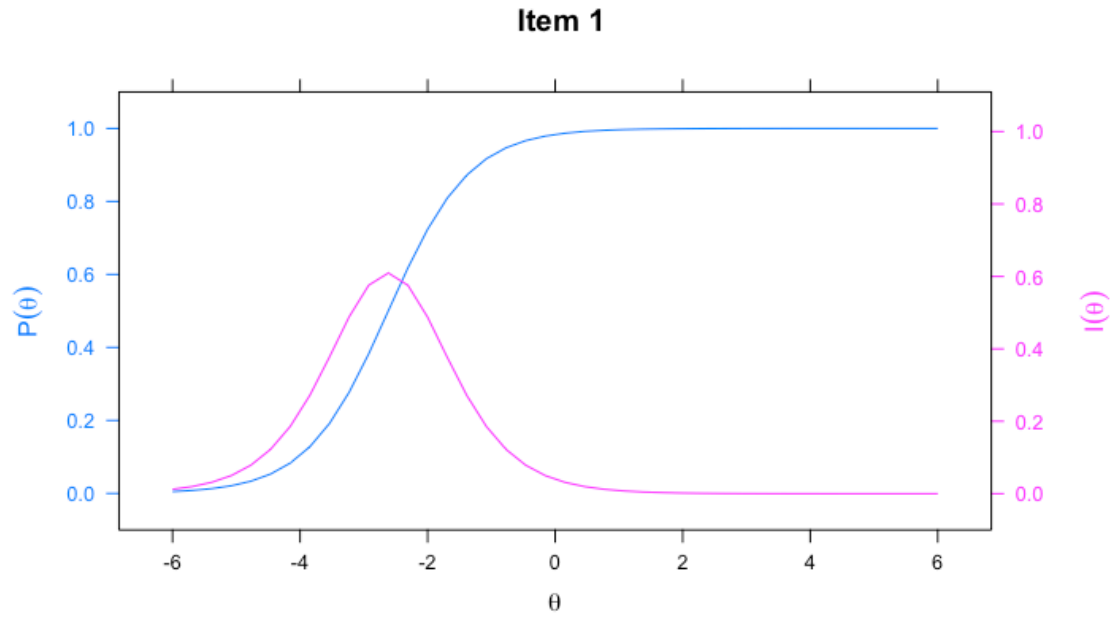


Figure 2. Item characteristic curve and item information curve of Item 1

*Note: Blue line represents the item characteristic curve and Pink line represents the item information curve

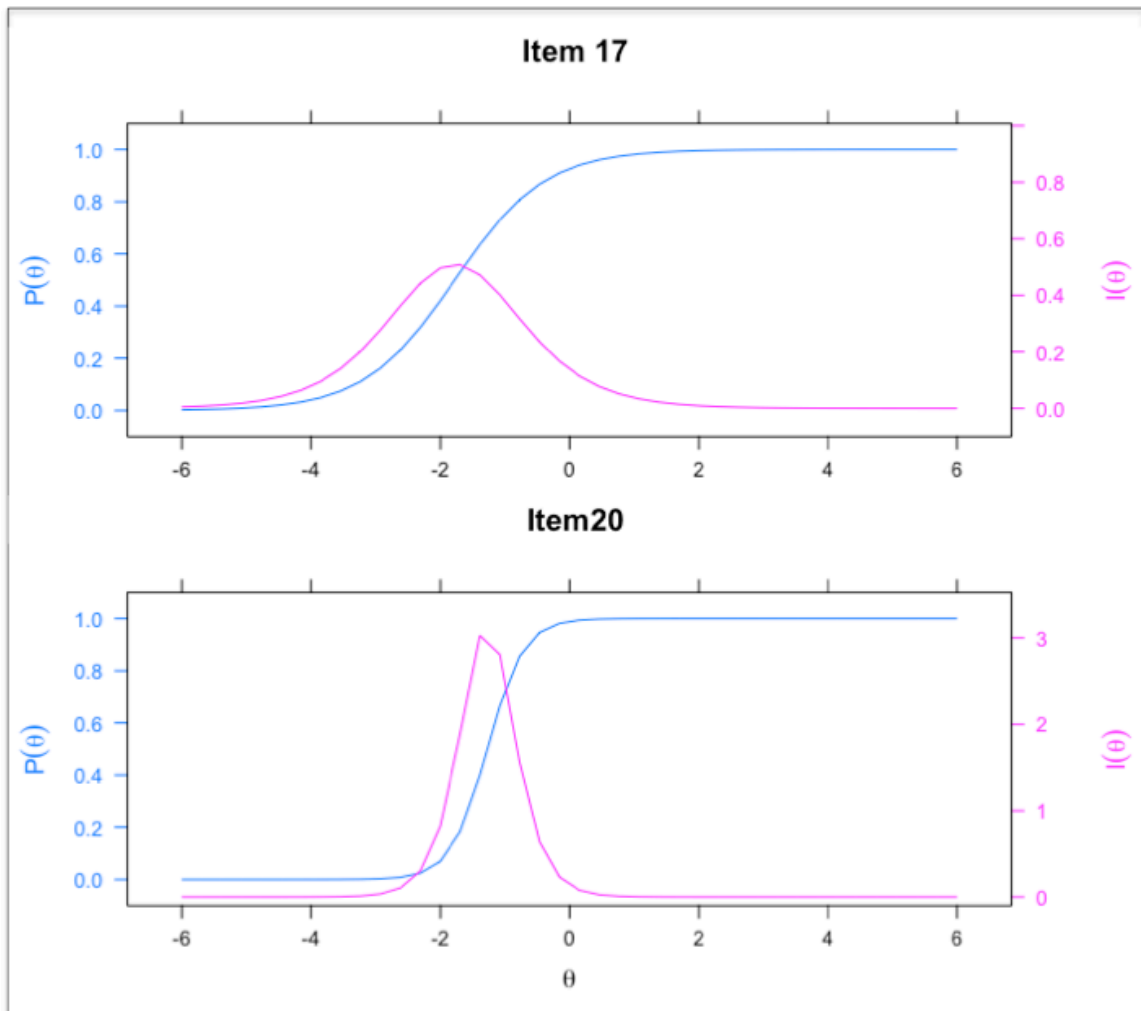


Figure 3. Item characteristic curve and item information curve of Item 17 and Item 20

*Note: Blue line represents the item characteristic curve and Pink line represents the item information curve

**V. MANUSCRIPT II: THE RELATIONSHIP BETWEEN YOUNG WOMEN'S
SELF-PERCEIVED AND ACTUAL FERTILITY KNOWLEDGE WITH THEIR
FERTILITY HEALTH RISKS**

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Abstract

Objective: To explore the relationships among young women's demographic factors, self-perceived fertility knowledge, and actual fertility knowledge, with their fertility health risks.

Design: A quantitative and cross-sectional study

Setting: An online survey

Subject: 342 young women between the ages of 18 to 24.

Main outcome measures: Self-perceived fertility knowledge level, actual fertility knowledge level, and number of fertility health risk factors.

Results: The majority of the participants were white and heterosexual. Participants had a wide range of actual fertility knowledge from as low as 27 to 100 ($M=78.04$, $SD=14.36$). Their self-reported fertility risk factors spanned from 0 to 12. A significant regression equation was found ($F(8,331)=6.053$, $p<.0001$) with an R^2 of .13. The experience of using fertility awareness based methods (FABM) ($beta = -.16$, $p < .02$); self-perceived fertility knowledge ($beta = .21$, $p < .0001$) and actual fertility knowledge ($beta = -.29$, $p < .0001$) were statistically significant in predicting participants' fertility health risks. Participants' age, education level, or pregnancy experience was not significant in predicting their fertility health risks.

Conclusion: This study provided evidence that fertility knowledge is important in young women's fertility self-care. Teaching young women about their own fertility may help them to avoid fertility health risks and protect their current and future fertility.

Key Words: Young women, Fertility knowledge, Fertility health risk

Introduction

Fertility is an evolving continuum throughout a woman's reproductive years. Many factors, such as lifestyle, age, and certain diseases, can affect one's fertility (Macaluso et al., 2010). Awareness of these factors may impact how people make certain life choices regarding their fertility and fertility-related outcomes. Young women between the ages of 18 to 24 face many potential fertility challenges in their current and future life stages. A young woman's fertility knowledge can directly impact both her sexual and reproductive behaviors and health outcomes (Barron, 2013; Institute for Reproductive Health [IRH], 2014; Witt, McEvers, & Kelly, 2013). Misconceptions regarding female fertility may lead some young women to inconsistently use contraception despite their intention to avoid pregnancy (Reed, England, Littlejohn, Bass, & Caudillo, 2014). Although young women value their fertility and motherhood, many of them do not know that risky sexual behaviors or sexually transmitted infections can cause infertility (Goundry, Finlay, & Llewellyn, 2013; Quach & Librach, 2008; Sabarre, Khan, Whitten, Remes, & Phillips, 2013). Young women often are unaware that abnormal menstrual cycles (e.g., irregular cycles, anovulation, excessive bleeding or pain) may indicate potential fertility problems and other reproductive health problems (Barron, 2013; Sabarre et al., 2013; Lundsberg et al., 2014).

Fertility knowledge is a dynamic concept that encompasses many components. For women, this knowledge includes information regarding menstrual cycle, pregnancy potential in each menstrual cycle and at different life stages, and risks of infertility (Mu, 2016). A number of studies have evaluated young women's fertility knowledge from a variety of angles. Researchers from Sweden, Finland, Italy, Israeli, New Zealand,

U.S.A., and Hong Kong assessed college women's knowledge of female fertility changes throughout the reproductive years and the success rates of assisted reproductive technology (ART) (Chan, Chan, Peterson, Lampic, & Tam, 2015; Hashiloni-Dolev, Kaplan, & Shkedi-Rafid, 2011; Lucas, Rosario, & Shelling, 2015; Peterson, Pirritano, Tucker, & Lampic, 2012; Rovei et al., 2010; Tydén, Svanberg, Karlström, Lihoff, & Lampic, 2006; Virtala, Vilska, Huttunen, & Kunttu, 2011). Their results indicate that college women overestimate the success rates of both natural conception and assisted reproductive technology at different ages. Guzman, Caal, Peterson, Ramos, and Hickman (2013) surveyed a group of young women who used a FABM about their knowledge of female fertility within each menstrual cycle. They found that many of these young women had low or inaccurate fertility knowledge that may affect the effectiveness of the method to avoid pregnancy. García, Vassena, Trullenque, Rodríguez, and Vernaev (2015) examined 229 oocyte donors' knowledge and awareness of female fertility changes within the menstrual cycle, age-related fertility decline, and ART. Almost half of these donors failed to identify correct ovulation time and the age range for optimal female fertility. Overall, young women from all walks of life have inadequate and inaccurate knowledge of female fertility changes throughout their reproductive years, the impact of lifestyle factors on their fertility, and the success rates of ART.

Previous research has focused on evaluating the impact of fertility knowledge on women's desired age for childbearing and conception planning in the future (Abiodun, Alausa, & Olasehinde, 2016; Daniluk & Koert, 2015; Stern, Larsson, Kristiansson, & Tydén, 2013; Wojcieszek & Thompson, 2013). However, there is less understanding regarding the relationship between young women's fertility knowledge and their fertility

health risks in their current life stage. One of the preconception goals is to improve women's knowledge, attitudes, and behaviors related to preconception health, thus, to achieve optimal birth outcomes (Johnson et al., 2006). The American College of Obstetricians and Gynecologists (2016) recommended that health providers should counsel each woman about her lifestyle at every health encounter in order to promote optimal preconception health. To understand the relationship between young women's fertility knowledge and health risks can help the health provider to provide individualized fertility and reproductive consultation. Therefore, our study aimed to explore the relationships among young women's demographic factors, self-perceived fertility knowledge, and actual fertility knowledge, with their fertility health risks.

Materials and methods

Recruitment

The study received approval from the Institutional Review Board of a Midwest private university in the United States. The recruitment occurred from December 2016 to January 2017. The researchers recruited young women from the university campus. The researcher also posted the survey link on a Facebook group site in order to recruit young women who use FABMs. The inclusion criteria were young women between the ages of 18 to 24 who understand English and have Internet access. The online questionnaire was delivered through an anonymous survey link using Qualtrics, an online survey environment.

Measures

The online questionnaire contained 80 items that collected data on participants' demographic factors, self-perceived fertility knowledge, actual fertility knowledge, and

fertility health risk factors. The initial questionnaire was evaluated by a group of content and survey design experts prior to its pretest. Cognitive interviews were done using 10 young women to evaluate the presentation, layout, flow, and comprehension of the entire questionnaire and each item (Dillman, Smyth, & Christian, 2009). Minor revisions were made based on both the feedback from the experts and young women.

Personal data (15 questions). Demographic items were developed based on previous fertility knowledge studies (Lundsberg et al., 2014; Peterson et al., 2012). The demographic questions collected information regarding young woman's age, ethnicity, education, relationship status, contraceptive methods, their pregnancy experience, and numbers of children.

Self-perceived fertility knowledge (21 items). The researchers adapted the knowledge of fertility scale (KFS) to assess young women's self-perceived fertility knowledge level (Jukkala, Meneses, Azuero, & McNees, 2012). This scale asks women to rate their knowledge level related to reproductive cycle, health factors related to fertility health, infertility treatment, alternative parenting options, and the effect of cancer treatment on fertility (Jukkala et al., 2012). The KFS consists of 21 items and the original answer choices for each of the questions are "a little," "some," and "a lot." During the cognitive interview, the sample of young women had expressed difficulty in selecting the right level when they felt they had no knowledge regarding certain fertility topics. Therefore, the option of "none" was added. In calculating participants' self-perceived fertility knowledge level, "none" was assigned one point, "a little" was two points, "moderate" was three points, and "a lot" was four points. A total score of self-perceived fertility knowledge was obtained by averaging the scores from the eight items

that specifically assessed participants' self-perception regarding the reproductive cycle, age, and health factors related to female fertility.

Actual Fertility knowledge (26 items). The researchers measured participants' actual fertility knowledge using the newly developed MU-Fertility Knowledge Assessment Scale (MU-FKAS). The development and psychometric analyses of the MU-FKAS were described in a different manuscript. The initial items of the MU-FKAS were developed through a comprehensive literature review. It was then evaluated and refined through three rounds of Delphi discussion among a group of 10 fertility knowledge content experts. The refined MU-FKAS had 26 items and displayed acceptable internal consistency with a Kuder-Richardson 20 coefficient of .74.

The MU-FKAS assesses young women's knowledge of female fertility changes within the menstrual cycle and throughout the lifecycle, the impact of lifestyle factors on female fertility and conception, and the risks of infertility associated with age. The answer choices are true, false, or don't know. A correct answer receives one point and an incorrect or don't know is zero points. A total score is calculated by adding all the points, divided by the total number of questions and multiplied by 100 yielding a possible score ranges from 0 to 100.

Fertility health risks (18 items). Participants' fertility health risk factors were assessed with the FertiSTAT. FertiSTAT is a validated self-assessment tool that evaluates women's reproductive history and lifestyle that may affect their fertility (Bunting & Boivin, 2010). The FertiSTAT contains a total of 22 fertility risk factors (2 age-related, 18 female-related, and 2 male-related), and the researchers only included the 18 female-related factors in the survey. The response scale was either "Yes" for the

presence of the factor or “No” for the absence of the factor. Participants could also choose “Not sure” if they were uncertain about certain risk factors. The total numbers of fertility health risk factors were summed for each woman.

Data Analysis

Statistical analyses were conducted using the Statistical Package for Social Science 22 (SPSS, Inc.). Descriptive statistics were calculated for participants’ demographic factors, and their scores on each of the scales. Pearson correlation was conducted to assess the relationship between participants’ self-perceived fertility knowledge and their actual fertility knowledge. Standard multiple linear regression was used to examine the relationship among participants’ demographic factors, their self-perceived fertility knowledge level, their actual fertility knowledge level, and their self-reported fertility health risk factors. Preliminary analyses were performed to ensure the data had no violation of the assumptions of normality, linearity, and homoscedasticity. The significance level was set to be $p < .05$.

Results

Participants

The descriptive statistics of the 342 participants ($M = 21.87$; $SD = 1.88$) who completed the online questionnaire are presented in Table 1. The sample consisted mainly of young women who were White (83.3%), Catholic (74%), and heterosexual (93.6%). Most of the women (95.6%) had either some college education or college degree. Over half of these women had no pregnancy yet, while 32.2% had experienced at least one pregnancy. Participants reported a wide range of contraceptive methods, ranging from zero to five different types. The majority of these young women (62.0%)

reported using one or two contraceptive methods in their lifetime. The top four frequently used contraceptive methods were hormonal contraceptives, barrier method, FABM, and withdrawal.

Self-perceived fertility knowledge

Participants' self-perceived fertility knowledge scores ranged from 8 to 32 ($M=20.86$, $SD= 4.88$). Twenty percent of the young women perceived themselves having “none” or “a little” fertility knowledge. Over half of the participants believed they had a “moderate” knowledge level while 28.7% considered themselves knowing “a lot” about female fertility.

Pearson correlation was used to assess the relationship between participants' self-perceived fertility knowledge level and their actual fertility knowledge level. The result showed there was a medium positive relationship ($r= 0.35$, $p= .0001$) between these two variables, with higher level of self-perceived fertility knowledge associated with higher actual fertility knowledge level.

Actual fertility knowledge

Participants demonstrated a wide range of actual fertility knowledge scores from 27 to 100 ($M=78.04$, $SD= 14.36$). Figure one showed the items and the percentage of participants' answers for each item. The participants' degree of knowledge varied greatly in depth and accuracy in different aspects of female fertility. Besides choosing the wrong answer, many participants also chose the option of “Don't know” to indicate their lack of knowledge for specific fertility topics. For example, although the majority of the participants (95.9%) knew the definition of ovulation, 79.47% of them believed that ovulation always occurs on the 14th day of each cycle and 8.80% of them did not know

when ovulation occurs in the cycle. Similarly, despite the fact that these participants knew that conception varies with women's age, 62.57% of them believed that a woman is most fertile in her 30s and about 27% of the participants did not know when a woman is most fertile. Furthermore, 82.11% of the participants thought that female fertility remains stable from puberty until menopause and 82.11% believed that women remain fertile even after menopause. The participants were generally aware that negative lifestyle factors, such as overweight, smoking, alcohol, impact female fertility and conception. However, 15% of them did not know that sexually transmitted infections increase the risk of infertility.

Standard multiple linear regression was conducted to examine the relationship among participants' demographic factors and their self-perceived fertility knowledge level, with their actual fertility knowledge level. A significant regression equation was found ($F(7, 334) = 12.25, p < .0001$) with an R^2 of .20 (Table 2). As it can be seen from Table Three, participants' education level, experience of using a FABM and self-perceived fertility knowledge level were significant in predicting their actual fertility knowledge level. All these three factors carried a significant positive regression weight, indicating that participants who used a FABM, or who had more than high school education, or who had higher self-perceived fertility knowledge level were associated with a higher actual fertility knowledge level. However, due to the small number of participants who had an education of high school or less, cautions are needed to interpret the impact of education on these participants' fertility knowledge level. As Table 2 indicated, participants' age and pregnancy experience were not significant predictors of their actual fertility knowledge level.

Fertility health risks

Young women evaluated their fertility health risks using the FertiSTAT. Overall, their self-reported fertility health risk factors ranged from 0 to 12 ($M = 1.74$; $SD = 1.87$). Among the reported fertility risk factors, the most frequently ones were related to a women's menstrual cycle. Almost half of these young women (42.2%) selected "Yes" for the description "I suffer from severe period pains" and 32.2% of them chose "Yes" for "My menstrual cycle is unpredictable. My period often comes more than five days earlier or later than expected (when I am not using contraceptives)." Nineteen percent of these young women also selected overweight as one of their fertility health risk factors. However, over 10% of these women were not sure about their menstrual cycle characteristics at all as they indicated that they do not know the length or characteristics of their menstrual cycle.

Standard multiple linear regression was used to examine the relationship among participants' demographic factors (age, education level, pregnancy experience, and using a FABM), self-perceived fertility knowledge, and actual fertility knowledge with their fertility health risks. A significant regression equation was found ($F(8,331) = 6.053$, $p < .0001$) with an R^2 of .13 (Table 3). The experience of using a FABM, self-perceived fertility knowledge, and actual fertility knowledge were statistically significant in predicting participants' fertility health risks. Participants' experience of using a FABM and their actual fertility knowledge level had significant negative regression weight, indicating participants who used a FABM or those who had higher actual fertility knowledge reported significantly less fertility health risk factors. Participants' self-perceived fertility knowledge level has a significant positive weight, indicating that

participants with higher self-perceived fertility knowledge reported higher fertility health risk factors. The participants' age, education level, or pregnancy experience was not significant in predicting their fertility health risks.

Discussion

Compared to previous studies with an older women population (Daniluk & Koert, 2012; EMD Serono, 2011; Lundsberg et al., 2014), this study focused on participants between the ages of 18 to 24 and provided valuable information regarding how much young women know and appreciate their fertility. Young women do value their fertility and place high importance regarding their own fertility. In our study, 87.3% of these participants considered fertility as "very important" or "extremely important" for themselves. After completing the online questionnaire, 35% of the study participants emailed us and requested the correct answers to the MU-FKAS items and online fertility resources. Many of them said that taking this survey motivated them to learn more about fertility and their own fertility health. This interest in learning about fertility has also been reported in several other studies that involved older reproductive aged women (García et al., 2015; Daniluk, Koert, & Cheung, 2012). It seems exposure to the topic of fertility can stimulate women's interest in learning more about fertility.

Findings from this study were consistent with previous studies that women have limited and inaccurate fertility knowledge (Chan et al., 2015; Hashiloni-Dolev et al., 2011; Lucas et al., 2015; Peterson et al., 2012; Rovei et al., 2010; Tydén et al., 2006; Virtala et al., 2011). This study utilized a newly developed fertility knowledge assessment instrument, the MU-FKAS, to measure participant's actual fertility knowledge. The 26 items provided valuable information both on the general level as well

as details in specific aspects of female fertility. Participants did have global knowledge regarding female fertility and conception. However, they lacked accurate understanding regarding the important details of different aspects of female fertility. For instance, the majority of these women were aware of the definition of ovulation. Yet, many of them had no true knowledge of the time of ovulation or the fertile window in menstrual cycle. Similarly, participants largely knew that age impacts female fertility. Nevertheless, many of them overestimate the age range for optimal fertility and the longevity of female fertility. Therefore, it is necessary to assess young women's knowledge on specific topics instead of asking broad fertility questions. The application of a simple and reliable fertility knowledge assessment scale could provide us with such information that could be used to guide individualized teaching.

This study further illustrated the relationship between young women's self-perceived fertility knowledge and their actual fertility knowledge. The moderately positive relationship between young women's self-perceived fertility knowledge and actual fertility knowledge indicates that young women do have a sense of their own general knowledge level. Compared to studies that use one global question to assess women's self-perception of their fertility knowledge (Chan et al., 2015; Daniluk et al., 2012; Peterson et al., 2012), this study provided more details in young women's perception regarding specific fertility topics. There are clear discrepancies between young women's self-perception and their actual fertility knowledge on certain fertility topics and the two main areas of misperceptions exist with ovulation and conception within the menstrual cycle, and age-related fertility decline. For instance, although over 70% of the participants believed they either knew "moderate" or "a lot" about the impact

of age on female fertility, a majority of them answered these questions wrong. This misconception may have been due to the popular coverage of advanced reproductive technology and successful stories of older pregnancies in the media. Participants also believed they were more knowledgeable in ovulation and conception than their actual knowledge. These findings highlight the importance to assess participants' actual fertility knowledge and clarify their specific misperceptions for female fertility.

This study was the first one to explore the relationship among participants' demographic factors, self-perceived fertility knowledge, and actual fertility knowledge, with their fertility health risks. Among the selected demographic factors, participants' experience of using a FABM was the only significant factor in predicting both their actual fertility knowledge and fertility health risks. Using a FABM requires a woman to pay attention to the characteristics of her menstrual cycle that can help her learn about her own fertility. Neither participants' age or their pregnancy experience were significant in predicting their actual fertility knowledge or fertility health risks. These results were similar to the findings from other studies (Daniluk et al., 2012; García et al., 2015). It is important to note that both participant's self-perceived fertility knowledge and actual fertility knowledge were significant in predicting their fertility health risks but in the opposite direction. Participant's self-perception was a positive predictor while their actual fertility knowledge was a negative predictor with their fertility health risks, which means that erroneous perception related to female fertility could lead young women to overlook certain fertility risk factors while higher actual fertility knowledge can help young women engage with better fertility self-care that minimizes their fertility health risks. Young women do have the opportunity to make lifestyle modifications, which can

optimize their fertility health and fertility-related outcomes now and in the future. However, their intention to change behavior is contingent on accurate and adequate fertility knowledge (Fulford et al., 2013).

Future Research Directions

Findings from this study may be limited due to the respondents being primarily Caucasian with higher education level, which hinders the generalizability of our results. Nevertheless, evidence from our study and previous research suggests that fertility knowledge can impact young women's sexual and reproductive planning, behaviors, and outcomes (IRH, 2014; Stern et al., 2013). It seems that young women also are interested in learning about their fertility and fertility knowledge, and often prefer to consult these issues with their health care providers (EMD Serono, 2011; Lundsberg et al., 2014; Stern et al., 2013). Future research needs to evaluate different methods of providing fertility knowledge assessment and education in clinical settings. However, past research indicates that one-time intervention does not produce sustainable long-term results (Daniluk & Koert, 2015; Wojcieszek & Thompson, 2013). Longitudinal studies are needed to evaluate the impact of ongoing fertility knowledge education on women's fertility health risks, and their sexual and reproductive behaviors and outcomes.

Conclusion

A young woman's fertility knowledge is important in her fertility self-care. The significant relationships between young women's fertility knowledge and their fertility health risks highlight the importance of assessing and teaching young women about their fertility and risk factors. It is essential to address both young women's misperceptions and their actual fertility knowledge in order to help them achieve optimal fertility health.

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Tables and Figures

Table 1
Demographic characteristics of the study participants

Characteristics	Total sample (n= 342) n (%)
Race/ethnicity	
White	285 (83.3)
Hispanic/Latina	32 (9.3)
Asian and Pacific islander	15 (4.4)
American Indian or Alaska Native	5 (1.5)
Black or African American	4 (1.2)
Religion	
Catholic	253 (74)
Protestant	53 (15.1)
Other religion	11 (3.3)
No religion	25 (7.6)
Education	
High school or less	15 (4.4)
Some college	170 (49.7)
College degree	116 (33.9)
Postgraduate	41 (12.0)
Sexual orientation	
Heterosexual or straight	320 (93.6)
Asexual	11 (3.2)
Bisexual	6 (1.8)
Other (Pansexual, Queer, Questioning)	5 (1.2)
Prefer not to answer	1 (.3)
Relationship status	
Single	102 (29.8)
In a relationship, not cohabitating	75 (21.9)
Not married, cohabiting	15 (4.4)
Married	143 (41.8)
Other	7 (2.1)
Pregnancy experience	
Yes	110 (32.2)
No	232 (67.8)



Figure 1. MU Fertility Knowledge Assessment items and percentage of respondents for each answer choice

Table 2
Young Women's actual fertility knowledge Regressed on Five Predictors (N = 340)

Predictor Variable	<i>b</i>	<i>SE</i>	β	<i>t</i>	<i>p</i>
Constant	43.57	12.05		3.62	.0001
Age	.34	.57	.04	.59	.55
High school vs. some college	8.17	3.62	.29	2.26	.03*
High school vs. college degree	8.89	3.78	.29	2.36	.02*
High school vs. postgraduate	9.25	4.29	.21	2.15	.03*
Pregnancy experience	-.91	.79	-.07	-1.15	.25
FABM user vs. Non-user	7.45	1.81	.26	4.11	.0001*
Self-perceived fertility knowledge	6.06	1.25	.26	4.86	.0001*

Note. Overall $R^2 = .20$, Adjusted $R^2 = .19$, $F(7, 334) = 12.25$, $P < .0001$

*Denotes significant predictors for young women's actual fertility knowledge

Table 3
 Young Women's Fertility Health Risks Regressed on Six Predictors (N = 342)

Predictor Variable	<i>b</i>	<i>SE</i>	β	<i>t</i>	<i>p</i>
Constant	1.38	1.67		.82	.43
Age	.08	.08	.08	1.03	.30
High school vs. some college	-.11	.50	.03	.23	.82
High school vs. college degree	-.22	.52	-.06	-.43	.67
High school vs. postgraduate	-.23	.59	-.04	-.39	.70
Pregnancy experience	.17	.11	.10	1.57	.19
FABM user vs. Non-user	-.58	.25	-.16	-2.29	.02*
Self-perceived fertility knowledge	.69	.18	.22	3.79	.0001*
Actual fertility knowledge	-.04	.01	-.29	-4.99	.0001*

Note. Overall $R^2 = .13$, Adjusted $R^2 = .11$, $F(8, 331) = 6.06$, $P < .0001$

*Denotes significant predictors for young women's fertility health risks

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Appendix A: Study Forms and Instruments

Recruiting Email for Step Three

Dear young women:

My name is Qiyang Mu, and I am a Ph.D. student at the College of Nursing, Marquette University. For my dissertation study, I developed an online survey to assess young women's fertility knowledge and their fertility health risks.

Currently, I am recruiting young women between the ages of 18 to 24 to take the online survey. It will take you about 10 to 15 minutes to complete the survey. At the completion of the survey, you will receive a \$10 Starbucks E-gift card.

Your participation in this survey is entirely voluntary, and all of your responses will be anonymous. If you are interested in participating in this research study, please click on the following link to access the survey:

[Women's Fertility Health Study-MU](#)

If you have any question about the study, please contact:

xxx-xxx-xxxx

***This study has been approved by the Institutional Review Board at Marquette University.**

Thank you for your kind consideration!
Sincerely,
Qiyang

Qiyang Mu, RN, BSN, Doctoral Student
College of Nursing
Marquette University

The Online Survey

Informed Consent Form

You have been invited to participate in this research study. Before you agree to participate, it is important that you read and understand the following information. Participation is completely voluntary. Please ask questions about anything you do not understand before deciding whether or not to participate.

PURPOSE:

The purpose of this research study is to assess young women's fertility knowledge and their fertility health risks. You will be one of approximately 300 participants in this research study.

PROCEDURES:

- The data will be collected using an online survey. You will receive the survey link through your email and you can proceed to the survey once you consent.
- The survey will collect information including your fertility knowledge and your fertility health risks. Specifically, the survey will ask questions regarding sexual behaviors and illegal drug use in order to estimate your fertility health risks.

DURATION:

- The online survey will take 10 to 15 minutes to complete.

RISKS:

- The risks associated with participation in this study are no greater than you would experience in everyday life.
- Collection of data and survey responses using the Internet involves the same risks that a person would encounter in everyday use of the Internet, such as hacking or information being unintentionally seen by others.

BENEFITS:

You may gain knowledge about fertility and fertilization through completion of the survey. This research may benefit society by helping the researcher to develop a fertility knowledge assessment instrument for young women like you.

CONFIDENTIALITY:

- Data collected in this study will be anonymous
- All your data will be assigned an arbitrary code number rather than using your name or other information that could identify you as an individual.
- Your email account will be stored in a separate and encrypted word file on a password-protected computer.
- Only raw response data without respondents' identification (email or IP address) will be downloaded from Qualtrics website and stored in an encrypted file on a password-protected computer.
- The research data will be reported in aggregate form in publication and presentation and you will not be identified by name.
- The data will be destroyed by shredding paper documents and deleting electronic files six months after the completion of the study. Although your responses will be deleted from the survey provider website at the completion of the study, your data may exist on backups or server logs beyond the time frame of this research project.

- Your research records may be inspected by the Marquette University Institutional Review Board or its designees, and (as allowable by law) state and federal agencies.

COMPENSATION:

- You will receive a \$10 Starbucks gift card at the completion of the survey. At the end of the survey, you will be asked to send an email to the researcher and then the researcher can send you the E-gift card. **This is to ensure that the data collection process is totally anonymous.**

VOLUNTARY NATURE OF PARTICIPATION:

- Participating in this study is completely voluntary and you may withdraw from the study and stop participating at any time while you are filling out the survey. However, once you click the submission button, the anonymous data will be used even if you withdraw from the study.
- You may skip any questions you do not wish to answer during the survey.

CONTACT INFORMATION:

- If you have any questions about this research project, you can contact Qiyang Mu at [REDACTED]
- If you have questions or concerns about your rights as a research participant, you can contact Marquette University's Office of Research Compliance at (414) 288-7570.

I have read, understood, and printed a copy of, the above consent form and desire of my own free will to participate in this study.

- Yes
- No

Are you female or male?

- Female
- Male
- Prefer not to answer

How old are you at the time of the survey?

Age in years

Section A: Demographics

What is your race / ethnicity? (Please select all that apply to you)

- American Indian or Alaska Native
- Asian and Pacific Islander
- Black or African American
- Hispanic or Latina
- White
- Other _____

What religion (if any) do you belong to or most closely identify with?

- Catholic
- Lutheran
- Methodist
- Baptist
- Jewish
- Other (please specify) _____
- No religion

What is your highest education level?

- High school or less
- Some college
- College degree
- Postgraduate school

Which best describes your sexual identity/sexual orientation?

- Asexual
- Bisexual
- Heterosexual or straight
- Lesbian
- Pansexual
- Queer
- Questioning
- A sexual identity/orientation not listed here (please specify)

- Prefer not to answer

What is your current relationship status?

- Single and not dating
- Single and dating
- In a relationship, not cohabitating
- Not married, cohabitating
- Married
- Other _____

What is your pregnancy history? (Please select all that apply to you)

- Have no pregnancy yet
- Currently pregnant
- Trying to get pregnant
- Have been pregnant before
- Other _____

How many times have you been pregnant (including miscarriages or abortions)?

Do you have any children?

- Yes
- No

How many children do you have?

Biological children
Adopted children
Step children

What type of birth control methods have you ever used? (You can select more than one answer)

- Abstinence
- Withdrawal or pull out
- Fertility awareness or natural family planning method
- Hormonal contraceptives (e.g., Pills)
- Barrier methods (e.g., condom)
- IUD or intrauterine device (e.g., Mirena)
- Tubal or female sterilization
- Other _____

How long have you been using the fertility awareness or natural family planning method?

What kind of hormonal contraceptives have you used? (You can select more than one answer)

- Oral contraceptives
- Injectable contraceptive
- Contraceptive patch (e. g., Ortho Evra)
- Vaginal ring or NuvaRing
- Emergency contraception or the 'morning after pill'

What kind of barrier methods have you used?

- Male condom
- Diaphragm, cervical cap, or female condom

How important do you consider fertility in your current and future life stage?

	Not at all important	Low importance	Moderately important	Very important	Extremely important
In your current life stage	•	•	•	•	•
In your future life stage	•	•	•	•	•

How often do you have concerns about your fertility?

- Never
- Rarely
- Sometimes
- Quite frequently
- Nearly always
- Always

Where do you currently receive information about fertility? Please select all the sources that you have used.

- Primary care physician
- Obstetrics/gynecology physician (OB/GYN)
- Nurse midwife/nurse practitioner
- Friends and family
- Online search
- Fertility App/period tracker
- Other _____

Where do you prefer to obtain fertility information? Please drag the choices according to your preference (1 means most preferred and 7 means least preferred).

- _____ Primary care physician
- _____ Obstetrics/gynecology physician (OB/GYN)
- _____ Nurse midwife/nurse practitioner
- _____ Family and friends
- _____ Online search
- _____ Fertility App/period tracker
- _____ Other

What is your height in feet and inches? For example, if you are 5 feet and 4 inches, write 5' 4".

Height in feet and inches

What is your current weight in pounds?

Weight in pounds

Section B: The following items ask your current knowledge about fertility and how fertility may be affected by certain conditions and breast cancer. Please read the items and select your choice.

How much do you feel that you know about the following topics

	None	A little	moderate	A lot
Female reproductive cycle	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Follicular phase	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ovulatory phase	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Luteal phase	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Age and fertility	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Obesity and fertility	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Smoking and fertility	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other health problems and fertility	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

How much do you feel that you know about the following topics

	None	A little	Moderate	A lot
Breast cancer	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Chemotherapy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Radiation therapy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Hormonal therapy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Assisted reproductive technology	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Egg, embryo, and sperm	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pregnancy and breast cancer	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Having children after cancer	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
An infertility workup	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

How much do you feel that you know about the following topics

	None	A little	Moderate	A lot
Psychosocial concerns after breast cancer	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Surrogacy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Adoption	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Child-free living	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Fertility online resources	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Section C: Knowledge of Female Fertility

Below are statements related to female fertility and fertilization. Please select the answer that you feel most confident to choose.

1. An ovulation is the releasing of an egg from the ovary.
 - True
 - False
 - Don't know

2. There are about 6 days in each menstrual cycle when a woman is able to get pregnant.
 - True
 - False
 - Don't know

3. The egg that a woman releases from her ovary lives for 12 to 24 hours if it is not fertilized.
 - True
 - False
 - Don't Know

4. The length of a menstrual cycle refers to the first day of the period until the day before the next period.
 - True
 - False
 - Don't know

5. Normal menstrual cycle length ranges between 21-35 days.
 - True
 - False
 - Don't know

6. Sperm from a man can live up to 5 days in a woman's body with good cervical mucus.
 - True
 - False
 - Don't know

7. Ovulation always occurs on the 14th day of each menstrual cycle.
 - True
 - False
 - Don't know

8. A woman is born with all the eggs she will ever have in her life.
 - True
 - False
 - Don't know

9. A woman's age is one of the strongest risk factors for infertility.
- True
 - False
 - Don't know
10. Female fertility remains stable from puberty until menopause.
- True
 - False
 - Don't know
11. Sexually transmitted infections increase the risk of infertility.
- True
 - False
 - Don't know
12. The quality and quantity of a woman's eggs decline as she gets older.
- True
 - False
 - Don't know
13. Women remain fertile even after menopause.
- True
 - False
 - Don't know
14. A woman's body weight may affect her chances of getting pregnant.
- True
 - False
 - Don't know
15. The likelihood of conceiving varies with a woman's age.
- True
 - False
 - Don't know
16. The risk of having a baby with Down syndrome increases with a woman's age.
- True
 - False
 - Don't know
17. Aging may increase a woman's chance of miscarriage.
- True
 - False
 - Don't know

18. A woman is most fertile in her 30s.
- True
 - False
 - Don't know
19. Smoking decreases a woman's fertility.
- True
 - False
 - Don't know
20. Being overweight may decrease a woman's chance of getting pregnant.
- True
 - False
 - Don't know
21. Being underweight may increase a woman's chance of getting pregnant.
- True
 - False
 - Don't know
22. Regular use of marijuana has no impact on a woman's ability to get pregnant.
- True
 - False
 - Don't know
23. Drinking more than 7 cups of caffeinated beverages a day lowers a woman's chance of getting pregnant.
- True
 - False
 - Don't know
24. The timing of ovulation may vary in each menstrual cycle.
- True
 - False
 - Don't know
25. A woman over 35 years old should seek medical help if she cannot get pregnant after 6 months of trying to get pregnant.
- True
 - False
 - Don't know

26. Cervical mucus is an indicator of changes in female fertility during the menstrual cycle.

- True
- False
- Don't know

Section D: Fertility health risk assessment

The following statements are related to facts that may impact a woman's fertility. Please tick all the boxes that apply to you.

Your reproductive history

	Yes	No	Not sure
I suffer from severe period pains	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I have had pelvic surgery	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
My menstrual cycle is unpredictable. My period often comes more than 5 days earlier or later than expected (When I am not using contraceptives)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
My menstrual cycle lasts less than 21 days (when I am not using contraceptives)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
My menstrual cycle lasts more than 35 days (when I am not using contraceptives)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I suffer from endometriosis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I have had pelvic inflammatory disease (PID)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I do not have a period (when I am not using contraceptives)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Your lifestyle:

	Yes	No	Not sure
I have unprotected sex with multiple partners	•	•	•
I smoke regularly (more than 10 cigarettes per day)	•	•	•
I cannot cope with the stress I am currently experiencing	•	•	•
I drink more than 14 units of alcohol per week (1 unit = a small glass of wine, 1/2 pint of beer, a single measure of a spirit)	•	•	•
I drink more than 7 units of caffeine per day (1 unit = a cup of coffee, 1/2 unit = a cup of tea or a can of soft drink such as cola)	•	•	•
I smoke marijuana frequently (more than four times a week)	•	•	•
I have had a sexually transmitted infection	•	•	•
I am more than 28 pounds overweight	•	•	•
I have used class A drugs in the past (e.g., heroin, cocaine, ecstasy)	•	•	•
I am currently taking anabolic steroids (for non-medical uses)	•	•	•