Women's Health Issues xxx-xx (2022) 1–13

ELSEVIER

WOMEN'S HEALTH ISSUES

www.whijournal.com

Original Article

U.S. Women's Knowledge of Reproductive Biology

Christina I. Fowler, PhD, MPH [a,*], Helen P. Koo, DrPH, MPH, MS [b], Alicia D. Richmond, MSW [c], Darryl Creel, MS [d], Kat Asman, MSPH [e]

[a] *RTI International, Research Triangle Park, North Carolina*
[b] *Independent Consultant, Durham, North Carolina*
[c] *Office of Population Affairs, U.S. Department of Health and Human Services, Washington, District of Columbia*
[d] *RTI International, Washington, District of Columbia*
[e] *RTI International, Atlanta, Georgia*

Article history: Received 3 November 2021; Received in revised form 19 May 2022; Accepted 31 May 2022

A B S T R A C T

Background: Having accurate knowledge of reproductive biology can help women to improve their general, sexual, and reproductive health and assert their sexual and reproductive rights.
Methods: This cross-sectional study examined knowledge of three topics (age-related fertility decline, egg supply, fertile period) among a national probability sample of 1,779 nonsterilized, English-speaking women (aged 18–29 years) in the U.S. general population. Using bivariate and multivariable regressions, we assessed associations between knowledge of these topics and individual characteristics.
Results: Most respondents were unmarried (63%), childless (78%), and intended to have children (65%); 51% did not know whether they would have difficulty conceiving, and 44% had discussed fertility-related topics with a health care provider. More respondents knew the age of marked fertility decline (62%) than the fertile period (59%) or that ovaries do not continuously produce new eggs (45%); 22% knew all three topics, and 13% knew none. In multivariable analysis, knowledge was positively associated ($p < .001$) with education, income, and having regular periods. Black and Asian respondents and those for whom religion was very important were less likely (all p values $< .01$) than White and nonreligious respondents to know all three topics. Knowledge was unrelated to relationship status, parity, childbearing intentions, receipt of fertility-related counseling or services, self-perceived infertility risk, or health status; the relationship with Hispanic ethnicity approached but did not reach significance ($p = .08$).
Conclusions: Young U.S. women have incomplete knowledge of aspects of their reproductive biology; these knowledge gaps could increase their risk of adverse health and reproductive outcomes. Policy-, provider-, and client-level interventions are warranted to address these knowledge gaps.

Since the Great Recession (2008), U.S. fertility has declined, and women's average age at first birth has increased (27 years in 2019) (Martin, Hamilton, Osterman, & Driscoll, 2021). In addition, U.S. women are having, on average, fewer children (1.7 in 2019) (Martin et al., 2021) than they intend (2.2 in 2013–2017) (Hartnett & Gemmill, 2020). In affluent Western countries, reasons for delaying first births include increased access to effective contraception, workforce participation, and educational and career opportunities; changing childbearing preferences; increased cohabitation and later marriage; relationship instability; economic uncertainty; and policies that hinder work–family balance (Mills, Rindfuss, McDonald, & te Velde,

The U.S. Department of Health and Human Services (HHS) (HHSP 233201700025U) funded development of the survey instrument and data collection through a MITRE Corporation subcontract (No. 105416, Task Order 3) to RTI International. Analysis and manuscript preparation were funded through an HHS contract (No. 75P00120P00146) to RTI International and the RTI International Fellow Program. The Office of Population Affairs staff member named as co-author (Alicia D. Richmond) participated in study oversight, manuscript conceptualization and interpretation of the data, manuscript review, and the decision to submit the article to Women's Health Issues.

The authors have no financial conflicts of interest to disclose.

* Correspondence to: Christina I. Fowler, PhD, RTI International, Research Triangle Park, 3040 E Cornwallis Rd, PO Box 12194, NC 27709. Phone: (919) 316-3447.

E-mail address: cfowler@rti.org (C.I. Fowler).

2011). Delaying childbearing until natural fertility is declining increases the risks of infertility, involuntary childlessness, or having fewer children than desired.

This study examines what young (aged 18–29 years) women in the U.S. general population know about three reproductive biology topics: age-related fertility decline (ARFD), egg supply or production in the ovaries, and the fertile period in the menstrual cycle. Having accurate information about the reproductive system and access to appropriate health care services, including (in)fertility-related care, support achieving optimal reproductive health and enabling individuals' right "to decide freely and responsibly the number, spacing, and timing of their children" (Starrs et al., 2018).

Past studies show that knowledge of reproductive biology varies by country, setting, and study population. Of the three study topics, ARFD has received the most attention. In a systematic review of 71 fertility knowledge studies (Pedro, Brandao, Schmidt, Costa, & Martins, 2018), more than 60 included at least one question about age and fertility decline, 11 included at least one question about the fertile period, and 5 included at least one question about egg supply. For each topic, we review relevant studies conducted in the United States and other Western countries, prioritizing U.S. and non-U.S. studies of women in the general population that measured knowledge of these topics using questions similar to those used here.

ARFD

Women's natural fertility declines gradually in their early 30s and markedly after their mid-30s, ending 5–10 years before menopause (American College of Obstetricians and Gynecologists [ACOG], 2014; American Society for Reproductive Medicine [ASRM], 2012, [ASRM], 2017). Knowledge of ARFD varies widely across studies measuring it using either multiple-choice questions about the age or age range when a marked decline in fertility occurs or a true/false question about whether fertility begins a marked or progressive decline after women's mid-30s. In various U.S. studies, ARFD knowledge was highest (79%) among healthy women seeking gynecologic care (Gossett, Nayak, Bhatt, & Bailey, 2013), followed by 50%–73% among medical trainees (e.g., medical students, residents) (Kudesia, Chernyak, & McAvey, 2017; Roberts, Kudesia, Zhao, Dolan, & Rose, 2020; Yu, Peterson, Inhorn, Boehm, & Patrizio, 2016), 40% among women in the general population (Kudesia, Chernyak, et al., 2017), 39% among postresidency obstetrician-gynecologists (Fritz et al., 2018), and 24% among female undergraduates (Peterson, Pirritano, Tucker, & Lampic, 2012). In studies of medical trainees (Kudesia, Chernyak, et al., 2017; Yu et al., 2016) or postresidency obstetrician-gynecologists (Fritz et al., 2018), 39%–47% overestimated the age when natural fertility declines markedly. In general population studies outside the United States, ARFD knowledge was 20 or more points higher, ranging from 60% in the U.K. and Denmark (Vassard, Lallemant, Nyboe Andersen, Macklon, & Schmidt, 2016) to 90% in Canada (Daniluk, Koert, & Cheung, 2012).

Egg Supply

A woman is born with all the egg-containing follicles she will ever have. The quantity and quality of eggs decline with age, reducing chances of conception (ASRM, 2012). During their reproductive years, women ovulate about 300 of the 1 to 2 million eggs they are born with (ACOG, 2014). Most eggs degenerate naturally and progressively, including when women are pregnant, using hormonal contraception, or receiving infertility treatment (ASRM, 2012). In a study (Lundsberg et al., 2014) of 1,000 women in the U.S. general population, 59% correctly reported as false that "Women's ovaries continue to create new eggs," and in a study (Bavan, Porzig, & Baker, 2011) of U.S. undergraduate women, 89% correctly reported as true that "A woman is born with all the eggs she will ever have." Two studies of childless women in Canada's general population found that 49% (Daniluk et al., 2012) and 52% (Daniluk & Koert, 2015) correctly reported as true that "A woman's eggs are as old as she is."

Fertile Period

Menstrual cycle patterns are an important indicator of women's overall health (ACOG, 2015). Menarche occurs at approximately 12 years of age in the United States. By age 16, ovulation and periods should occur regularly (ASRM, 2012), about every 28 days (ACOG, 2020b). The probability of conception is highest during 6 days in the middle of the cycle (fertile period) (ASRM, 2017). Irregular periods may signal potentially serious health conditions (ACOG, 2015; Popat, Prodanov, Calis, & Nelson, 2008; Wang et al., 2020) or irregular ovulation, making conception difficult. In studies of women in the general population, 42% of U.S. women (Berger, Manlove, Wildsmith, Peterson, & Guzman, 2012) and 32% of Australian women (Hammarberg et al., 2013) correctly identified the fertile period.

Studies of these three topics vary widely by study population (general population, university students, medical trainees, infertile or healthy patients), sample size and selection (non-probability, probability), mode (online, face to face, mail), and analytic strategies. Consequently, large differences in the results are unsurprising. Additionally, identification of individual factors (e.g., sex, age, education) associated with knowledge of these facts is incomplete because of sparse data and limited use of bivariate or multivariable analyses.

This study seeks to advance the understanding of women's knowledge of these topics and its association with various individual characteristics. It overcomes some limitations of previous studies by using data from a large probability sample of women from the U.S. general population; examining knowledge of all three topics, individually and together, in the same sample; and conducting multivariable analysis. The study helps to identify subgroups of women with knowledge differences. These results can be used to improve and target counseling and educational efforts that close knowledge gaps. For this study, female and woman refer to individuals whose sex assigned at birth is female, fertility is the ability of a woman to conceive, and infertility is being unable to get pregnant after at least 1 year of trying (Centers for Disease Control and Prevention, 2021). Reproductive biology knowledge is defined as knowledge of the three study topics, and fertility knowledge refers to knowledge of various aspects of fertility and infertility and may include one or more of the study topics.

Conceptual Framework

Although the study examines relationships between individual characteristics and knowledge of the three topics, we use a health literacy framework (Paasche-Orlow & Wolf, 2007; Squiers, Peinado, Berkman, Boudewyns, McCormack, 2012) to guide the study and show conceptually how knowing these three topics (prior knowledge) influences health literacy and ultimately health outcomes (Figure 1). Health literacy is defined as "The degree to which individuals have the capacity to obtain, process, and understand basic health information and services

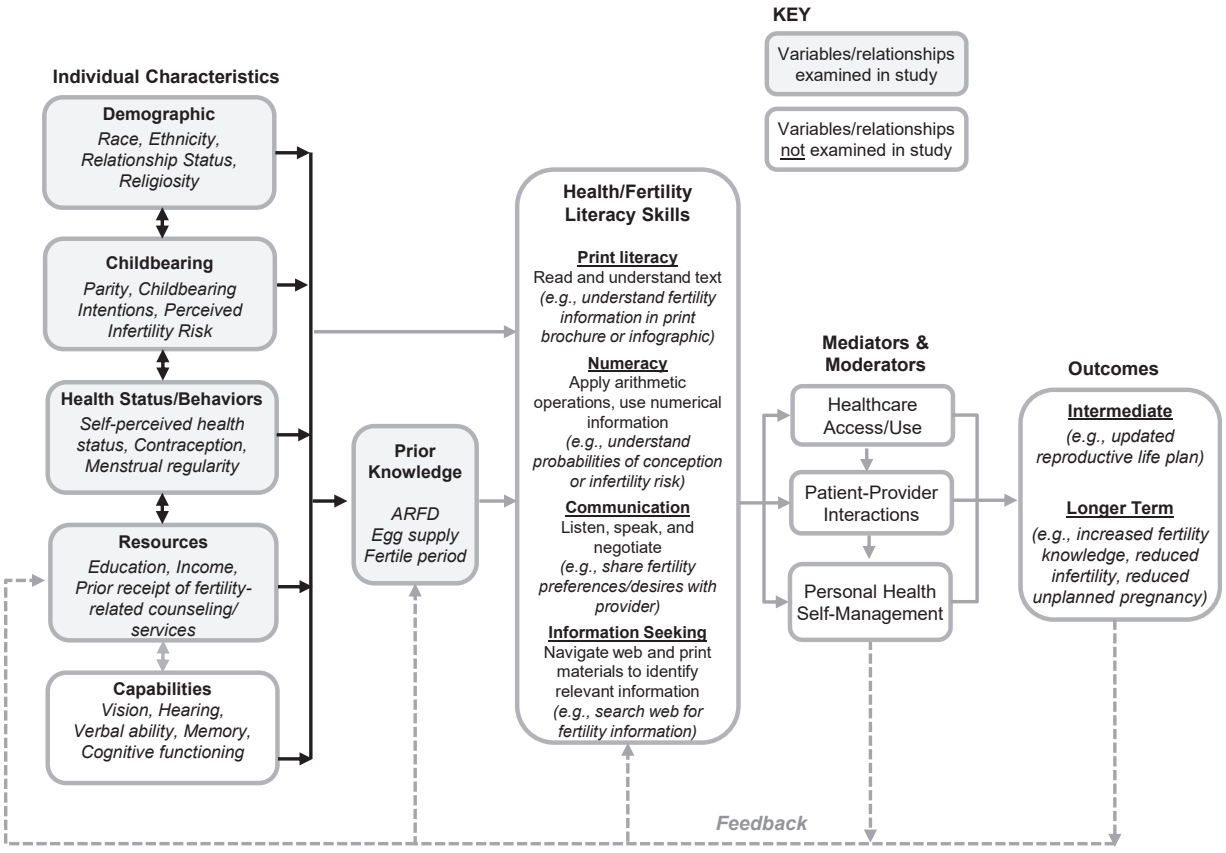

Figure 1. Conceptual framework: Factors influencing prior knowledge of reproductive biology. Shaded boxes, which display the variables examined in the study, show the relationships between individual characteristics (predictors) and prior knowledge (outcome variable). The figure also shows the relationships between prior knowledge and health literacy, health literacy and health outcomes, and the mediating and moderating factors affecting this relationship. The model has several feedback loops to depict a dynamic process. Abbreviations: ARFD, age-related fertility decline. Source: Adapted from Squiers et al., 2012; Paasche-Orlow & Wolf, 2007.

needed to make appropriate health decisions" (Institute of Medicine, 2004). This capacity depends on various skills (e.g., reading and writing, numeracy, communication) (Squiers et al., 2012). The framework posits that individual characteristics influence health literacy directly and indirectly through prior knowledge of the three topics. Individuals with prior knowledge about a topic will find it easier to obtain, process, and understand related information (Squiers et al., 2012). Health literacy skills influence how individuals interact with the health care system and its providers and manage their personal health (Paasche-Orlow & Wolf, 2007). Feedback loops show how health activities and outcomes influence future health literacy, knowledge, and individual resources. The shaded boxes in Figure 1 show the variables examined. Because the survey is cross-sectional and the questionnaire length was constrained, we did not collect data on all the framework concepts (e.g., individual capabilities, health literacy skills, future outcomes).

Methods

Data

Data for this cross-sectional study are from the online Fertility Knowledge Survey administered between February 7 and March 5, 2020, to a sample drawn from a national probability-based research panel (Ipsos, n.d. b). The median completion time was 16 minutes, and respondents received $10 or cash-equivalent ($5) incentive points. Consent was obtained in writing. RTI International's Institutional Review Board approved the study.

Participants in the panel from which the study sample was drawn are recruited from a frame of U.S. addresses (U.S. Postal Service Delivery Sequence File) covering all population segments; households without internet access receive a tablet and free internet access. The panel is weighted to bring it in line with known population benchmark distributions for sex, age, race/ethnicity, education, census region, household income, home ownership, metropolitan status, Hispanic/Latino origin, and language dominance from the March Current Population Survey and the American Community Survey (Ipsos, n.d. a). This weighting decreases bias for these characteristics and maximizes the degree to which the panel represents the national population along these weighting dimensions.

Sample

This analysis uses the subset of female data from a larger sample of 3,145 noninstitutionalized, English-speaking, and nonsterilized women and men[1] aged 18–29 years. For this larger sample, a stratified simple random sampling procedure with proportional allocation was used to select a sample of panelists

[1] Given men's contribution to infertility (CDC, 2021) and space limitations of this article, the authors have prepared a separate manuscript examining men's and women's knowledge of a broad range of fertility and infertility topics.

in four sex-by-age groups (female or male by ages 18–24 and 25–29 years). A power analysis (power = 0.8; $\alpha = 0.05$) determined the number of completed surveys (1,730 women, 1,286 men) required to detect differences of at least 5 percentage points between the sexes and 6 and 7 points between age groups within sex.

For women invited to participate in the survey, the screening completion rate was 37.2% (number confirming their age [$n = 1{,}841$]/number invited to take survey [$n = 4{,}953$]), and the main survey completion rate was 99.3% (number completing survey [$n = 1{,}789$]/number meeting all screening criteria [$n = 1{,}801$]) (See case disposition in Supplementary Figure A1). After excluding 10 cases for quality reasons, the final analytic sample was 1,779 for sample characteristics and 1,732 (excluding cases with missing data) for bivariate and multivariable regressions.

Questionnaire

The study questionnaire was designed to provide the U.S. Office of Population Affairs with information to help understand fertility knowledge levels and identify knowledge gaps among young (aged 18–29 years) women and men in the U.S. general population and guide the development of educational and counseling resources on fertility and infertility risk factors for health care providers and clients. Health providers that receive funding from the Title X National Family Planning Program are required to offer basic infertility services (42 Code of Federal Regulations x 59.A, 2022) and follow federal recommendations for quality family planning (Gavin et al., 2014), which include discussing clients' reproductive life plans (Johnson et al., 2006).

The questionnaire included questions to measure fertility knowledge and individual characteristics in four domains: sociodemographic; childbearing experiences, attitudes, and intentions; access to fertility-related health care and information; and health behavior and status. We reviewed the literature to identify relevant studies and existing questionnaires from which we compiled questions about fertility knowledge and for each domain. We used or adapted most of the questionnaire's fertility knowledge questions from this compilation, which included widely used (Bunting, Tsibulsky, & Boivin, 2013; Daniluk & Koert, 2015), validated (Kudesia, Chernyak, et al., 2017), or other (Lundsberg et al., 2014) fertility knowledge questionnaires and an instrument used in a large sexual and reproductive health (SRH) study among U.S. young adults (Guttmacher Institute, 2014). Fertility knowledge questions focused on modifiable and nonmodifiable infertility risk factors and topics relevant to achieving pregnancy and preventing unplanned pregnancy. The National Survey of Family Growth was a source for many questions on sociodemographic characteristics, health services, and contraception.

No single existing instrument covered all topics of interest, and none contained all the desired fertility knowledge or other questions worded and structured appropriately for both sexes and for the young age of the study population. We applied questionnaire construction principles to adapt or develop new fertility knowledge questions. We used primarily true/false questions to simplify reading and decrease cognitive burden and avoided using probabilities, given possible numeracy limitations among respondents (Peters, 2008).

Three subject matter experts helped to choose the fertility knowledge questions, their wording, and their number and balance across topics. The experts and survey methodologists reviewed the instrument once developed and before testing. The questionnaire then underwent cognitive and usability testing with nine women and men aged 16–29 years. Survey methodologists and subject matter experts reviewed changes to the questions after testing. Subsequently, the survey was piloted online ($n = 30$) and the data assessed for completeness, internal consistency, and programming; pilot cases were excluded from the final dataset. The final instrument had 76 main questions, including 19 fertility knowledge questions covering female fertility (6 items), male fertility (5 items), couples' fertility (2 items), postpartum fertility (2 items), and contraception-related misconceptions (4 items). For this study, we selected 3 of the 19 items for investigation.

Outcomes (Prior Knowledge About Reproductive Biology)

The study's four outcomes are based on responses to three questions; correct responses are bold and underlined.

- ARFD: After her mid-30s, a woman's chances of getting pregnant decrease sharply. [Options: **True**/False/Don't know]
- Fertile period: If a woman has sex with a man without using any birth control method, at what point in her menstrual cycle is she most likely to get pregnant? [Options: Right before her period (bleeding) starts, During her period, Right after her period ends, **Halfway between the start of one period and start of next period**, It's all the same, and Don't know.]
- Egg production: A woman's ovaries keep making new eggs from the time she starts having periods until she stops having periods (menopause). [Options: True/**False**/Don't know]

The first three outcomes—knowledge of ARFD, the fertile period, and egg production—were coded yes for a correct response and no if a response was wrong or don't know or if the question was skipped. The fourth outcome is a four-category variable with categories defined by the number of questions—3, 2, 1, or 0—answered correctly.

Predictors

We included 14 individual characteristics grouped according to the conceptual framework (Figure 1): demographic (race, Hispanic/Latino ethnicity, relationship status, religiosity); childbearing (parity, childbearing intentions, self-perceived infertility risk); health status/behaviors (self-rated health status, contraceptive use at last sex in past year, having a regular [21–35 days] menstrual cycle); and resources (education, income, ever received counseling on a fertility-related topic[2], ever received [by respondent or spouse/partner] a fertility-related service[3]). All predictor variables were constructed as categorical variables. The income variable is based on respondent household size and defined as a percentage of the U.S. Department of Health and Human Services poverty level using the 2020 poverty guidelines (Office of the Assistant Secretary for Planning and Evaluation, 2020). Income cutoffs are those the Title X National Family Planning Program uses to determine eligibility for free (≤100%) or subsidized (101%–250%) services.

[2] See list of topics in Table 1, note ¶.

[3] See list of services in Table 1, note #.

Table 1
Unweighted Number and Weighted Distribution of Respondents and Weighted Percentage of Respondents Who Correctly Answered Questions About the Fertile Period, Egg Supply, and Age-Related Fertility Decline, by Selected Characteristics

Characteristics	Sample Distribution (n = 1,779)			Correctly Answered Individual Knowledge Questions (n = 1,732)					
				Age-Related Fertility Decline		Fertile Period		Ovaries and Egg Supply	
	Unweighted n	Weighted%	(SE)	%	(SE)	%	(SE)	%	(SE)
Overall	1,779	100		62.4	(1.5)	59.2	(1.5)	44.7	(1.5)
Age, years									
18–19	160	14.8	(1.2)	60.6	(4.6)	55.2	(4.7)	31.6	(4.3)
20–24	725	41.5	(1.2)	59.0	(2.3)	56.1	(2.3)	44.6	(2.3)
25–29	894	43.7	(1.0)	66.3	(2.0)	63.4	(2.1)	49.2	(2.1)
Missing	0	0.0	(—)						
Education						*		*	
≤High school or GED	333	35.2	(1.6)	57.0	(3.1)	51.7	(3.1)	31.5	(2.9)
Technical school or some college	459	27.0	(1.3)	61.4	(2.7)	60.0	(2.7)	43.3	(2.7)
2-Year college degree	193	10.8	(0.9)	64.4	(4.0)	54.1	(4.2)	48.8	(4.1)
4-Year college degree or higher	792	26.9	(1.1)	69.8	(2.0)	70.0	(2.0)	61.6	(2.1)
Missing	2	0.1	(0.0)						
Race						*		†	
White	1,349	68.2	(1.5)	63.9	(1.7)	65.5	(1.6)	48.4	(1.7)
Black or African American	147	14.8	(1.3)	61.3	(4.8)	29.7	(4.2)	26.4	(4.2)
Asian	83	5.7	(0.7)	45.2	(6.5)	62.5	(6.5)	46.9	(6.6)
Other[‡]	195	11.1	(0.9)	63.5	(4.3)	57.1	(4.4)	45.1	(4.4)
Missing	5	0.3	(0.1)						
Hispanic/Latino ethnicity									
Yes	350	21.7	(1.3)	59.6	(3.3)	55.6	(3.3)	41.9	(3.3)
No	1,426	78.2	(1.3)	63.2	(1.6)	60.2	(1.7)	45.5	(1.7)
Missing	3	0.2	(0.1)						
Income (% of 2020 HHS poverty level)[§]						*		*	
≤100%	269	12.3	(0.9)	58.9	(3.9)	38.8	(3.7)	24.6	(3.1)
101%–250%	413	21.3	(1.2)	56.0	(3.2)	54.9	(3.2)	39.7	(3.1)
≥251%	1,080	65.1	(1.4)	65.2	(1.8)	64.3	(1.8)	50.0	(1.9)
Missing	17	1.2	(0.4)						
Importance of religion in daily life[‡]								†	
Very important	492	30.0	(1.4)	59.5	(2.9)	53.2	(2.9)	35.6	(2.7)
Moderately important	480	27.9	(1.4)	61.3	(2.8)	56.3	(2.9)	44.2	(2.9)
Not important	802	41.8	(1.4)	65.3	(2.1)	65.3	(2.1)	51.6	(2.2)
Missing	5	0.3	(0.1)						
Relationship status									
Married or cohabiting	734	37.1	(1.3)	66.3	(2.2)	63.5	(2.2)	51.1	(2.3)
Not married, in relationship	334	19.5	(1.2)	59.3	(3.5)	59.6	(3.5)	44.2	(3.5)
Not married, not in relationship	711	43.4	(1.5)	60.6	(2.4)	55.2	(2.4)	39.5	(2.3)
Missing	0	0.0	(—)						
Number of live births[‖]									
None	1,423	78.2	(1.2)	62.7	(1.7)	59.9	(1.7)	46.0	(1.7)
≥1	355	21.7	(1.2)	61.5	(3.2)	56.6	(3.3)	40.1	(3.1)
Missing	1	0.1	(0.1)						
Intention to have (more) children									
Definitely or probably yes	1,151	64.5	(1.4)	63.6	(1.8)	60.1	(1.9)	45.5	(1.8)
Definitely or probably no	498	28.5	(1.3)	59.0	(2.8)	58.4	(2.8)	43.3	(2.8)
Don't know	128	6.8	(0.7)	65.5	(5.8)	53.7	(6.0)	43.3	(5.8)
Missing	2	0.2	(0.2)						
Self-perceived difficulty of getting pregnant									
Not at all likely	360	21.3	(1.2)	55.6	(3.3)	56.5	(3.3)	38.7	(3.1)
Slightly or moderately likely	356	19.0	(1.1)	67.8	(3.1)	64.8	(3.2)	51.0	(3.2)
Very or extremely likely	150	9.0	(0.9)	67.9	(4.9)	58.7	(5.2)	39.3	(5.0)
Don't know	913	50.7	(1.5)	62.4	(2.1)	58.2	(2.1)	45.8	(2.1)
Missing	0	0.0	(—)						
Ever discussed fertility-related topic[¶] with medical care provider									
Yes	783	43.8	(1.5)	59.7	(2.3)	57.5	(2.3)	46.1	(2.2)
No	991	55.7	(1.5)	64.6	(1.9)	60.5	(2.0)	43.6	(2.0)
Missing	5	0.5	(0.2)						
Ever received fertility-related services[#]									
Yes	132	7.2	(0.7)	73.9	(4.7)	57.0	(5.4)	50.8	(5.3)
No	1,647	92.8	(0.7)	61.6	(1.5)	59.3	(1.6)	44.2	(1.5)
Missing	0	0.0	(—)						
Contraceptive use at last (in past year)									
Not sexually active (ever or in past year)	506	31.0	(1.4)	57.2	(2.9)	57.3	(2.8)	41.3	(2.8)
No	118	7.6	(0.8)	67.3	(5.4)	43.6	(5.6)	33.5	(5.3)
Yes	981	51.6	(1.5)	63.9	(2.0)	61.2	(2.0)	48.5	(2.0)

(*continued on next page*)

Table 1 (*continued*)

Characteristics	Sample Distribution (n = 1,779)			Correctly Answered Individual Knowledge Questions (n = 1,732)					
				Age-Related Fertility Decline		Fertile Period		Ovaries and Egg Supply	
	Unweighted n	Weighted%	(SE)	%	(SE)	%	(SE)	%	(SE)
No, seeking or would not mind pregnancy	168	9.4	(0.8)	67.5	(4.5)	66.6	(4.5)	43.5	(4.6)
Missing	6	0.3	(0.2)						
Self-perceived health status									
Excellent or very good	1,062	58.5	(1.5)	63.5	(1.9)	60.8	(1.9)	47.2	(1.9)
Good	543	31.2	(1.4)	62.1	(2.7)	58.2	(2.7)	42.7	(2.7)
Fair/poor	172	10.2	(0.9)	57.4	(4.7)	52.3	(4.7)	36.1	(4.5)
Missing	2	0.2	(0.1)						
Regular menstrual cycle (every 21–35 days)						*		†	
Yes	1,139	60.8	(1.5)	64.6	(1.8)	65.9	(1.8)	49.6	(1.8)
No**	632	38.8	(1.5)	59.0	(2.6)	48.5	(2.6)	37.0	(2.4)
Missing	8	0.4	(0.2)						

Abbreviations: GED, General Education Development Test; HHS, U.S. Department of Health and Human Services; SE, standard error.
Note: Sample sizes (n) are unweighted. Distributions (%) are weighted; p values are adjusted for multiple tests using the Holm-Bonferroni method (Holm, 1979).

* $p < .001$.

† $p < .01$.

‡ Other includes American Indian or Alaska Native, Native Hawaiian or Other Pacific Islander, other race, or those who self-identify with two or more of the race categories.

§ Income as a percentage of the 2020 HHS poverty guidelines is calculated by dividing the respondent's household income by the HHS poverty level that corresponds with the respondent's household size and then multiplying by 100.

‖ For respondents who reported that they or their partner were currently pregnant, we assumed that the pregnancy would end in live birth and added 1 to the number of live births (parity).

¶ Fertility-related topics of discussion include ways to help respondent get pregnant, respondent's ability to get pregnant and give birth, respondent's plans or goals for having or not having children, how respondent could improve their health before pregnancy, the impact of diet or lifestyle factors (smoking, alcohol, or drugs) on respondent's ability to get pregnant, the impact of sexually transmitted diseases on respondent's ability to get pregnant, how age could affect respondent's ability to get pregnant, and factors affecting the ability of a spouse or partner to get respondent pregnant.

Fertility-related services ever received by the respondent, a spouse, or a partner include advice/counseling on fertility, infertility testing, surgery to repair damaged or blocked tubes (female or male), intrauterine insemination, drugs to help ovulation, treatment for conditions of the ovaries or uterus (e.g., polycystic ovary syndrome, endometriosis, or uterine fibroids), other help for female infertility (e.g., problems with intercourse or genetic conditions), and other help for male infertility (e.g., treatment for low/abnormal sperm count, varicocele, or hydrocele).

** Includes <21 days, >35 days, length varies from month to month, no periods, and don't know.

We excluded age from the multivariable model because it is highly confounded with education.

We expected lower knowledge among respondents from economically or socially marginalized groups (Black or African American, Asian, other non-White, or two or more races; Hispanic or Latino; low education; low income), potentially more sexually conservative (more religious) groups, and those who may have less sexual experience or for whom fertility-related issues may be less salient (not married or cohabiting, not sexually active). We expected greater knowledge among respondents from groups with more experience, more exposure to information, or potentially more interest in fertility-related issues (greater parity, intention to have children, self-perceived infertility risk, ever discussing a fertility-related topic or receiving fertility-related health services, contraceptive use at last sex, higher self-rated health status, and having an irregular menstrual cycle).

Statistical Analyses

We described the distribution of the sample across individual characteristics (Table 1) and conducted bivariate analysis to examine relationships between individual characteristics and knowledge of each topic (Table 1). We adjusted Table 1 p values for multiple testing using the Holm-Bonferroni adjustment (Holm, 1979). Finally, we conducted unadjusted and adjusted multinomial logistic regression to estimate the associations between the four-category dependent variable (base = 0 questions correctly answered) and individual characteristics (Table 2). We considered a proportional odds model, but parameter estimates for several variables violated the proportional odds assumption.

Using the multivariable model, we produced predicted marginal probabilities (Table 3), which show the probability of correctly answering 3, 2, 1, or 0 questions when all respondents assume the value of each category (e.g., all poor) while holding all other variables constant. For all weighted estimates, we used SUDAAN release 11 (Research Triangle Institute, 2012) to account for complex survey design and weights adjusted for differential nonresponse and deviation from national population benchmarks (March Current Population Survey and American Community Survey) (Ipsos, n.d. a). (Supplementary Table A1 shows distributions for various characteristics for the weighted combined sample [n = 3,145] vs. a U.S. benchmark.)

Results

Approximately 40% of respondents were either 20-24 or 25–29 years of age, 35% had completed high school or less education, 68% self-identified as White, 78% self-identified as non-Hispanic, 65% had incomes above 250% of the poverty level, 63% were not married or cohabiting, and 30% reported that religion was very important in their daily lives (Table 1). Regarding childbearing, 78% were childless, 65% intended to have (more) children, and 51% did not know whether they would have difficulty conceiving. Finally, 56% had never discussed a fertility-related topic, including plans for having or not having children, with a health care provider; 93% reported neither they nor a

Table 2
Unadjusted and Adjusted Odds Ratios (95% Confidence Intervals) From Weighted Multinomial Logistic Regression (n = 1,732)

Characteristic	Unadjusted ORs (95% CIs)						Adjusted ORs (95% CIs)					
	Correct Knowledge of 3 vs. 0 Items		Correct Knowledge of 2 vs. 0 Itemsl		Correct Knowledge of 1 vs. 0 Items		Correct Knowledge of 3 vs. 0 Items		Correct Knowledge of 2 vs. 0 Items		Correct Knowledge of 1 vs. 0 Items	
Education												
≤High school or GED	**0.12**	**(0.07,0.22)***	**0.19**	**(0.11,0.32)***	**0.50**	**(0.29,0.85)†**	**0.19**	**(0.10,0.38)***	**0.25**	**(0.13,0.47)***	**0.48**	**(0.26,0.89)†**
Technical school or some college	**0.20**	**(0.12,0.35)***	**0.29**	**(0.17,0.48)***	**0.37**	**(0.21,0.64)***	**0.24**	**(0.13,0.45)***	**0.32**	**(0.17,0.58)***	**0.32**	**(0.17,0.58)***
2-Year college degree	**0.25**	**(0.12,0.53)***	**0.39**	**(0.19,0.79)‡**	0.55	(0.26,1.14)	**0.26**	**(0.12,0.57)***	**0.40**	**(0.19,0.84)†**	0.49	(0.22,1.07)
4-Year college degree or higher	Ref		Ref		Ref		Ref		Ref		Ref	
Race												
White	Ref		Ref		Ref		Ref		Ref		Ref	
Black	**0.19**	**(0.09,0.39)***	**0.20**	**(0.11,0.36)***	0.60	(0.34,1.04)	**0.28**	**(0.13,0.62)‡**	**0.23**	**(0.12,0.43)***	0.56	(0.30,1.03)
Asian	**0.29**	**(0.10,0.81)†**	0.73	(0.30,1.76)	0.49	(0.19,1.25)	**0.15**	**(0.05,0.44)***	0.45	(0.17,1.16)	0.38	(0.15,1.01)
Other§	0.70	(0.36,1.36)	1.03	(0.55,1.93)	1.11	(0.58,2.11)	1.11	(0.50,2.48)	1.49	(0.69,3.21)	1.56	(0.72,3.38)
Hispanic or Latino ethnicity												
Yes	0.65	(0.40,1.06)	0.73	(0.46,1.16)	0.78	(0.48,1.24)	0.55	(0.30,1.01)	0.49	(0.27,0.88)‖	0.49	(0.27,0.87)‖
No	Ref		Ref		Ref		Ref		Ref		Ref	
Income (% of HHS poverty level)¶												
≤100%	**0.15**	**(0.09,0.27)***	**0.35**	**(0.21,0.58)***	0.71	(0.42,1.19)	**0.34**	**(0.17,0.65)‡**	0.67	(0.38,1.18)	0.84	(0.48,1.50)
101%–250%	**0.55**	**(0.31,0.96)†**	0.76	(0.45,1.27)	1.52	(0.89,2.58)	0.96	(0.53,1.74)	1.23	(0.71,2.10)	**1.88**	**(1.08,3.26)†**
≥251%	Ref		Ref		Ref		Ref		Ref		Ref	
Importance of religion in daily life												
Very important	**0.36**	**(0.21,0.61)***	**0.55**	**(0.34,0.89)†**	0.87	(0.53,1.45)	**0.44**	**(0.25,0.78)‡**	0.77	(0.46,1.29)	1.02	(0.60,1.75)
Moderately important	**0.56**	**(0.33,0.94)†**	0.67	(0.40,1.10)	0.92	(0.55,1.55)	0.72	(0.41,1.27)	0.89	(0.52,1.53)	1.06	(0.62,1.83)
Not important	Ref		Ref		Ref		Ref		Ref		Ref	
Relationship status												
Married or cohabiting	Ref		Ref		Ref		Ref		Ref		Ref	
Not married, in relationship	**0.52**	**(0.28,0.95)†**	0.75	(0.42,1.34)	0.80	(0.44,1.46)	0.77	(0.37,1.59)	0.91	(0.45,1.83)	1.09	(0.55,2.19)
Not married, not in relationship	**0.37**	**(0.23,0.60)***	**0.54**	**(0.34,0.85)‡**	**0.59**	**(0.37,0.94)†**	0.70	(0.35,1.38)	0.87	(0.45,1.69)	0.92	(0.48,1.76)
Number of live births#												
None	1.03	(0.62,1.69)	1.23	(0.76,2.00)	0.70	(0.43,1.14)	0.77	(0.38,1.54)	0.92	(0.46,1.84)	0.83	(0.42,1.64)
≥1	Ref		Ref		Ref		Ref		Ref		Ref	
Intends to have (more) children												
Definitely or probably yes	Ref		Ref		Ref		Ref		Ref		Ref	
Definitely or probably no	0.91	(0.56,1.47)	1.05	(0.66,1.65)	1.37	(0.86,2.17)	0.94	(0.54,1.63)	1.01	(0.61,1.68)	1.25	(0.75,2.09)
Don't know	0.83	(0.32,2.11)	0.99	(0.41,2.39)	1.06	(0.42,2.68)	0.88	(0.33,2.32)	0.95	(0.40,2.24)	0.99	(0.39,2.51)
Self-perceived difficulty getting pregnant												
Not at all likely	Ref		Ref		Ref		Ref		Ref		Ref	
Slightly or moderately likely	**2.53**	**(1.27,5.05)‡**	**2.01**	**(1.03,3.91)†**	1.09	(0.55,2.15)	2.22	(1.14,4.35)‖	1.79	(0.94,3.41)	1.27	(0.66,2.44)
Very or extremely likely	1.50	(0.67,3.33)	1.00	(0.45,2.19)	0.85	(0.39,1.88)	1.45	(0.59,3.57)	1.00	(0.42,2.40)	1.06	(0.45,2.51)
Don't know	1.28	(0.75,2.19)	1.23	(0.74,2.04)	0.74	(0.44,1.23)	1.26	(0.68,2.31)	1.08	(0.60,1.94)	0.84	(0.46,1.55)
Ever discussed fertility-related topic** with medical care provider												
Yes	0.86	(0.56,1.31)	0.63	(0.41,0.94)‖	0.79	(0.52,1.21)	0.76	(0.46,1.24)	0.59	(0.37,0.94)‖	0.70	(0.43,1.13)
No	Ref		Ref		Ref		Ref		Ref		Ref	
Ever received fertility-related services††												
Yes	1.64	(0.74,3.63)	1.08	(0.49,2.41)	1.01	(0.44,2.34)	1.61	(0.67,3.89)	1.32	(0.55,3.19)	1.13	(0.47,2.71)
No	Ref		Ref		Ref		Ref		Ref		Ref	
Contraceptive use at last sex (in past year)												
Not sexually active (ever or in past year)	**0.47**	**(0.29,0.78)‡**	**0.51**	**(0.32,0.82)‡**	**0.53**	**(0.33,0.85)‡**	0.85	(0.45,1.60)	0.61	(0.34,1.11)	0.60	(0.32,1.12)
No	0.46	(0.21,1.04)	0.51	(0.24,1.08)	0.98	(0.46,2.07)	0.96	(0.38,2.42)	0.91	(0.38,2.19)	1.22	(0.52,2.87)
Yes	Ref		Ref		Ref		Ref		Ref		Ref	
No, seeking or would not mind pregnancy	0.88	(0.44,1.76)	0.56	(0.29,1.11)	0.52	(0.25,1.08)	0.97	(0.41,2.27)	0.75	(0.34,1.66)	0.56	(0.25,1.24)

(*continued on next page*)

Table 2 (*continued*)

Characteristic	Unadjusted ORs (95% CIs)						Adjusted ORs (95% CIs)					
	Correct Knowledge of 3 vs. 0 Items		Correct Knowledge of 2 vs. 0 Itemsl		Correct Knowledge of 1 vs. 0 Items		Correct Knowledge of 3 vs. 0 Items		Correct Knowledge of 2 vs. 0 Items		Correct Knowledge of 1 vs. 0 Items	
Self-perceived health status												
Excellent or very good	Ref		Ref		Ref		Ref		Ref		Ref	
Good	0.81	(0.50,1.32)	0.94	(0.59,1.49)	1.08	(0.67,1.75)	0.90	(0.54,1.51)	1.07	(0.66,1.73)	1.13	(0.70,1.84)
Fair/poor	0.42	(0.20,0.85)‖	0.68	(0.36,1.28)	0.83	(0.44,1.57)	0.61	(0.28,1.35)	0.92	(0.471.81)	0.84	(0.43,1.65)
Regular menstrual cycle (every 21–35 days)												
Yes	Ref		Ref		Ref		Ref		Ref		Ref	
No‡‡	**0.31**	**(0.20,0.48)***	**0.50**	**(0.33,0.75)***	0.72	(0.47,1.10)	**0.41**	**(0.26,0.65)***	**0.63**	**(0.41,0.96)†**	0.80	(0.53,1.22)

Abbreviations: CI, confidence interval; GED, General Education Development Test; HHS, U.S. Department of Health and Human Services; OR, odds ratio; SE, standard error; Ref, reference category.
Significant results (at least p < .05) shown in bold text.

* $p < .001$.

† $p < .05$.

‡ $p < .01$.

§ Other includes American Indian or Alaska Native, Native Hawaiian or Other Pacific Islander, other race, or those who self-identify with two or more of the race categories.

‖ Even though the 95% CI excludes 1.0, the variable is not significant because the Wald F p value is > .05.

¶ Income as a percentage of the 2020 HHS poverty guidelines is calculated by dividing the respondent's household income by the HHS poverty level that corresponds with the respondent's household size and then multiplying by 100.

For respondents who reported that they or their partner were currently pregnant, we assumed that the pregnancy would end in live birth and added 1 to the number of live births (parity).

** Fertility-related topics of discussion include ways to help respondent get pregnant, respondent's ability to get pregnant and give birth, respondent's plans or goals for having or not having children, how respondent could improve their health before pregnancy, the impact of diet or lifestyle factors (smoking, alcohol, or drugs) on respondent's ability to get pregnant, the impact of sexually transmitted diseases on respondent's ability to get pregnant, how age could affect respondent's ability to get pregnant, and factors affecting the ability of a spouse or partner to get respondent pregnant.

†† Fertility-related services ever received by the respondent, a spouse, or a partner include advice/counseling on fertility, infertility testing, surgery to repair damaged or blocked tubes (female or male), intrauterine insemination, drugs to help ovulation, treatment for conditions of the ovaries or uterus (e.g., polycystic ovary syndrome, endometriosis, or uterine fibroids), other help for female infertility (e.g., problems with intercourse or genetic conditions), other help for male infertility (e.g., treatment for low/abnormal sperm count, varicocele, or hydrocele).

‡‡ Includes <21 days, >35 days, length varies from month to month, no periods, and don't know.

Table 3
Marginal Probabilities From Weighted Multinomial Logistic Regression for Significant Predictors (n = 1,732)

Characteristic	Wald F	Marginal Probabilities, % (SE)								Total (n = 1,732), %
	p value	Correct Knowledge of All 3 Items (n = 438), % (SE)		Correct Knowledge of 2 Items (n = 637), % (SE)		Correct Knowledge of 1 Item (n = 481), % (SE)		Correct knowledge of 0 items (n = 176), % (SE)		
Overall		22.1	(1.2)	35.0	(1.4)	29.9	(1.4)	12.9	(1.1)	100.0
Education	<.001									
≤High school or GED		17.8	(2.6)	30.0	(3.0)	36.6	(3.0)	15.6	(2.2)	100.0
Technical school or some college		21.7	(2.1)	37.5	(2.6)	24.9	(2.2)	16.0	(2.2)	100.0
2-Year college degree		18.7	(3.0)	37.8	(3.9)	30.6	(3.9)	12.8	(3.1)	100.0
4-Year college degree or higher		28.6	(2.0)	38.9	(2.3)	26.7	(2.2)	5.7	(1.1)	100.0
Race	<.001									
White		24.3	(1.4)	36.6	(1.6)	28.3	(1.6)	10.7	(1.1)	100.0
Black		18.2	(4.2)	20.9	(3.6)	37.2	(4.5)	23.7	(4.3)	100.0
Asian		9.8	(3.0)	40.8	(6.7)	25.7	(5.6)	23.7	(7.2)	100.0
Other[*]		20.0	(3.4)	40.1	(4.6)	32.0	(4.3)	7.9	(2.3)	100.0
Income (% of HHS poverty level)[†]	.001									
≤100%		12.9	(2.5)	36.3	(3.8)	32.7	(3.6)	18.1	(2.8)	100.0
101%–250%		18.4	(2.3)	33.8	(2.9)	37.8	(3.0)	9.9	(1.8)	100.0
≥251%		24.4	(1.7)	35.7	(1.9)	26.8	(1.9)	13.1	(1.6)	100.0
Importance of religion in daily life	.018									
Very important		16.1	(1.9)	35.4	(2.6)	34.0	(2.7)	14.5	(2.1)	100.0
Moderately important		21.6	(2.2)	34.9	(2.7)	30.7	(2.6)	12.7	(1.9)	100.0
Not important		26.5	(1.9)	35.1	(2.2)	26.5	(2.1)	11.8	(1.6)	100.0
Regular menstrual cycle (every 21–35 days)	<.001									
Yes		25.3	(1.6)	35.7	(1.8)	28.0	(1.7)	11.0	(1.3)	100.0
No[‡]		16.5	(1.7)	34.6	(2.3)	33.2	(2.3)	15.7	(1.7)	100.0

Abbreviations: GED, General Education Development Test; HHS, U.S. Department of Health and Human Services; SE, standard error.
Note: See Supplemental Table A2 for marginal probabilities for all variables in the fully adjusted multiple regression model.
Sample sizes (n) are unweighted. Distributions (%) are weighted; p values are adjusted for multiple tests using the Holm-Bonferroni method (Holm, 1979).

[*] Other includes American Indian or Alaska Native, Native Hawaiian or Other Pacific Islander, "other" race, or those who self-identify with two or more of the race categories.

[†] Income as a percentage of the 2020 HHS poverty guidelines is calculated by dividing the respondent's household income by the HHS poverty level that corresponds with the respondent's household size and then multiplying by 100.

[‡] Includes <21 days, >35 days, length varies from month to month, no periods, and don't know.

spouse or partner had received fertility-related services; 52% used contraception at last sex; and 61% had regular cycles.

Some 62% knew that women's fertility declines sharply after their mid-30s, 59% correctly identified the fertile period, and 45% knew that ovaries do not continuously produce eggs (Table 1). Only 22% of respondents correctly answered all three questions. Across respondent characteristics, the percentages correctly answering were 45%–74% (ARFD), 30%–70% (fertile period), and 25%–62% (egg supply). Knowledge of ARFD was not associated with respondent characteristics. Correct knowledge of the fertile period and egg supply differed (all $p < .01$) by education, race, income, and menstrual regularity. Religiosity was only associated with knowledge of egg supply.

In bivariate and multivariable models, education, race, income, religiosity, and regular menstrual cycles were associated with the number of questions correctly answered (Table 2). Relationship status, parity, self-perceived difficulty of conceiving, and contraceptive use at last sex were significant in bivariate models only. Compared with respondents in the highest education category, those in the two lowest categories had lower odds of knowing three, two, or one topic (vs. none), and those in the second-highest category had lower odds of knowing three or two topics (vs. none). Black respondents had 28% ($p < .01$) the odds of White respondents of knowing three topics (vs. none) and 23% ($p < .001$) the odds of knowing two topics (vs. none). Respondents in the lowest income group had 34% ($p < .01$) the odds of those in the highest group of knowing three topics (vs. none), while those in the middle-income group had 1.9 ($p < .05$) times the odds of respondents in the highest group of knowing one topic (vs. none). Respondents for whom religion was very important in their daily lives had 44% ($p < .01$) the odds of those for whom it was not of knowing three topics (vs. none). Finally, compared with respondents with regular periods, those with irregular periods had 41% ($p < .001$) the odds of knowing all three topics (vs. none) and 63% ($p < .05$) the odds of knowing two topics (vs. none).

The marginal probabilities (Table 3) for significant variables in the multivariable model show that if all respondents had at least 4 years of college, 29% would know all three topics, and 6% would know none. Conversely, if all respondents had completed high school/GED or less, the percentage knowing all three topics would decrease to 18%, and the percentage knowing none would increase to 16%. Being Black was associated with the lowest probability of knowing two topics and the second-lowest probability, after Asian respondents (10%), of knowing all three topics (18%). The probability of knowing no topic was 24% each for Black and Asian respondents compared with 11% for White respondents. Being in the highest income group, compared with the lowest, increased the probability of knowing all three topics by 11 points (24% vs. 13%). Similarly, the probability of knowing three topics was 25% for those having regular periods and 17% for those having irregular periods (Supplementary Table A2 shows the marginal probabilities for all variables.).

Discussion

To our knowledge, this study is the first using a large probability sample of women in the U.S. general population to examine knowledge of these three reproductive biology topics and use a multivariable analysis to explore associations between this knowledge and individual characteristics. Only 22% of respondents answered all three questions correctly, and from 45% to 62% answered each question correctly. Compared with other studies of women in the U.S. general population, we found knowledge levels that were 22 percentage points higher for ARFD (Kudesia, Chernyak, et al., 2017), 17 points higher for fertile period (Berger et al., 2012), and 14 points lower for egg supply (Lundsberg et al., 2014). Differences in study design, samples, and question wording likely account for some of these differences.

Our finding of differences in reproductive biology knowledge between respondents who are from economically and socially marginalized groups and those who are not is consistent with previous, but limited, research. By race and ethnicity, knowledge differences favoring White over Black and non-Hispanic over Hispanic respondents are consistent with previous general fertility knowledge (Siegel, Sheeder, & Polotsky, 2021) and fertile period (Berger et al., 2012) studies. We found lower knowledge among Hispanic versus non-Hispanic respondents; however, although this relationship approached it did not attain significance (Wald F $p = .08$); with more cases, this difference may have become significant. Unlike previous studies, our larger sample permitted inclusion of an Asian race category, revealing lower knowledge among Asian versus White respondents.

Our finding of a positive relationship between education and reproductive biology knowledge is consistent with previous fertility knowledge studies, including 19 of 24 studies in a systematic review by Pedro et al. (2018), a multi-country study ($n = 10{,}045$) by Bunting et al. (2013), and a study ($n = 143$) by Hoffman et al. (2020).

Regarding income, we found that respondents in the poorest income group had lower knowledge than those in the highest one. Evidence for this relationship is limited and mixed. Pedro et al. (2018) excluded income from their systematic review, whereas in their large multicountry study, Bunting et al. (2013) found that respondents who had paid work or a partner with paid work had higher fertility knowledge than those who did not. In contrast, Hoffman et al. (2020) found no income-related differences in fertility knowledge among infertility care clients ($n = 143$), who are likely better informed, regardless of income, than the general population.

Studies on the association of religiosity with general fertility knowledge are limited, but research examining the association between religiosity and SRH knowledge, attitudes, and behaviors helps to interpret our results. Studies in the United States (Martin, Baralt, & Garrido-Ortega, 2018; Stidham Hall, Moreau, & Trussell, 2012) and Croatia (Stulhofer, Soh, Jelaska, Bacak, & Landripet, 2011) found that higher religiosity (more frequent religious attendance, greater importance of religion) was associated with more conservative sexual practices (delayed sexual initiation, fewer partners, less casual sex) and lower SRH knowledge or service use. Higher religiosity may signal to clinicians a need for education on reproductive biology.

The association between having irregular menstrual cycles and lower reproductive biology knowledge was unexpected. Reasons why women with irregular periods may have lower reproductive biology knowledge include 1) lacking access to counseling and health care to manage this condition (ACOG, 2020a), 2) lacking awareness that irregular cycles are not normal and require evaluation, or 3) receiving care from health care providers who lack knowledge or dismiss concerns about irregular cycles (Armour et al., 2021; Holmes et al., 2021). Under these possible scenarios, women with irregular periods may be less likely to have received menstruation education that included study topics.

Finally, the lack of a positive association between knowledge of reproductive biology topics and having received fertility-related counseling or services suggests that these encounters may not effectively impart this knowledge. Studies on policy- and practice-

level factors may help to understand these results. At the policy level, a review (Trawick, Pecoriello, Quinn, & Goldman, 2021) of 19 clinical practice guidelines and consensus statements informing ARFD counseling found them "inconsistent" and "incomplete." Of the 11 (of 19) guidelines or statements deemed high quality, 10 stated the age or age range when fertility is compromised, 9 identified who should be counseled about ARFD, and only 6 described what topics should be addressed. The existence and adequacy of clinical practice guidelines related to other reproductive biology topics are unknown.

At the practice level, previous fertility knowledge studies have identified several factors that may hamper provision of reproductive biology counseling and education, including the following.

- Gaps in providers' fertility knowledge (Fritz et al., 2018; Kudesia, Chernyak, et al., 2017; Roberts et al., 2020; Yu et al., 2016).
- Variations in beliefs about or practices regarding ARFD discussions with clients during routine visits (Fritz et al., 2018; Kudesia, Chernyak, et al., 2017; Roberts et al., 2020; Yu et al., 2016) or at which age (Fritz et al., 2018; Kudesia, Chernyak, et al., 2017; Roberts et al., 2020; Yu et al., 2016).
- Providers' reluctance to discuss ARFD because clients might misunderstand the purpose or providers' motives (Yu et al., 2016).
- Lack of time (Fritz et al., 2018; Kudesia, Chernyak, et al., 2017; Roberts et al., 2020; Yu et al., 2016).

Furthermore, only 44% of respondents reported ever discussing a fertility-related topic, including "plans or goals for having or not having children," with a health care provider, despite federal recommendations (Gavin et al., 2014; Johnson et al., 2006) that health care providers help individuals to articulate their childbearing preferences (number, timing) to inform SRH counseling and services. Evidence of the effectiveness of reproductive life plan counseling in changing knowledge is limited, mixed, or weak (Hipp, Chung-Do, & McFarlane, 2019). The extent to which reproductive life plan counseling consistently addresses the study topics is unknown.

This study has several limitations: cross-sectional data allow only an examination of associations, items measuring knowledge of reproductive biology were limited to selected aspects, and recall error and social desirability bias may have affected the accuracy of answers to some questions. Our survey did not include all variables posited in our conceptual framework because the data are cross-sectional and because of limits on questionnaire length. Finally, like other online probability-based panels, this panel has lower cumulative response rates because of the many steps between original contact to recruit into the panel and final survey participation; unmeasured nonresponse bias may exist.

Implications for Practice and/or Policy

Despite a consensus that having accurate information about the reproductive system and access to a range of appropriate SRH services support optimal reproductive health, infertility care, including its prevention, has received less attention than other SRH services (Starrs et al., 2018). Based on these findings, assuming all young women know about the fundamental aspects of their reproductive biology or that a single intervention (health encounter, sex education) will suffice is unjustified. Suggested actions to increase reproductive biology knowledge, which might also address identified gaps in overall fertility knowledge (Kudesia, Chernyak, et al., 2017; Lundsberg et al., 2014), include the following.

- Developing, harmonizing, and disseminating high-quality clinical practice guidelines for the fertility-related counseling of reproductive age women at all reproductive life stages (Centers for Disease Control and Prevention, 2014; Trawick et al., 2021). The recommendations of Kudesia, Talib, & Pollack. (2017) for fertility-related counseling topics and clinical services specific to the needs of young women (aged 13–21 years) is one such example.
- Developing, testing, and disseminating effective strategies to provide respectful and patient-centered fertility-related counseling to diverse groups of women, especially those from economically or socially marginalized groups who are more likely to lack reproductive biology knowledge and encounter barriers to accessing fertility-related care (ACOG, 2018; ASRM, 2015; Centers for Disease Control and Prevention, 2014; Galic et al., 2020; Kelley, Qin, Marsh, & Dupree, 2019).
- Developing, testing, and disseminating effective strategies to increase menstruation education during preventive care visits, consistent with ACOG's guidance and recommendations (ACOG, 2015).
- Developing, testing, and disseminating effective strategies for communicating fertility-related information, including study topics, via public health messaging and school-based sex education (Centers for Disease Control and Prevention, 2014).

Conclusions

This study identified reproductive biology knowledge gaps among young U.S. women, especially those from economically or socially marginalized groups. Incomplete knowledge of reproductive biology may negatively affect women's health care access, patient–provider conversations, and self-care and lead to behaviors and decisions that undermine reproductive health and childbearing aspirations.

Acknowledgments

The authors acknowledge subject matter experts Dr. Judith Daniluk (University of British Columbia), Dr. Rebecka Lundgren (University of California San Diego), and Dr. Rashmi Kudesia (CCRM Fertility of Houston, Texas) for their invaluable assistance in selecting and refining fertility knowledge questions, and Margaret Johnson and Amy Morrow (RTI International) for editorial support. The study team had sole responsibility for the preparation of this article. Dr. Fowler and Ms. Asman had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

References

42 Code of Federal Regulations § 59.A. (2022). Project grants for family planning services. Available: www.ecfr.gov/current/title-42/chapter-I/subchapter-D/part-59/subpart-A. Accessed: May 3, 2022.

American College of Obstetricians and Gynecologists (ACOG). (2014). Female age-related fertility decline. Committee Opinion No. 589. *Fertility and Sterility*, 101(3), 633–634.

American College of Obstetricians and Gynecologists (ACOG). (2015). Menstruation in girls and adolescents: Using the menstrual cycle as a vital sign

(Committee Opinion No. 651). *Obstetrics and Gynecology*, 126(6), e143–e146.
American College of Obstetricians and Gynecologists (ACOG). (2018). Importance of social determinants of health and cultural awareness in the delivery of reproductive health care (Committee Opinion No. 729). *Obstetrics and Gynecology*, 131(1), e43–e48.
American College of Obstetricians and Gynecologists (ACOG). (2020a). FAQs: Abnormal uterine bleeding. Available: www.acog.org/womens-health/faqs/abnormal-uterine-bleeding. Accessed: February 3, 2022.
American College of Obstetricians and Gynecologists (ACOG). (2020b). FAQs: Amenorrhea: absence of periods. ACOG. Available: www.acog.org/womens-health/faqs/amenorrhea-absence-of-periods. Accessed: February 3, 2022.
Armour, M., Hyman, M. S., Al-Dabbas, M., Parry, K., Ferfolja, T., Curry, C., … Holmes, K. (2021). Menstrual health literacy and management strategies in young women in Australia: A national online survey of young women aged 13-25 years. *Journal of Pediatric and Adolescent Gynecology*, 34(2), 135–143.
American Society for Reproductive Medicine (ASRM). (2012). Age and fertility: A guide for patients. Available: https://www.reproductivefacts.org/globalassets/rf/news-and-publications/bookletsfact-sheets/english-fact-sheets-and-info-booklets/Age_and_Fertility.pdf. Accessed: September 24, 2021.
American Society for Reproductive Medicine (ASRM). (2015). Disparities in access to effective treatment for infertility in the United States: An Ethics Committee opinion. *Fertility and Sterility*, 104(5), 1104–1110.
American Society for Reproductive Medicine (ASRM). (2017). Optimizing natural fertility: A committee opinion. *Fertility and Sterility*, 107(1), 52–58.
Bavan, B., Porzig, E., & Baker, V. L. (2011). An assessment of female university students' attitudes toward screening technologies for ovarian reserve. *Fertility and Sterility*, 96(5), 1195–1199.
Berger, A., Manlove, J., Wildsmith, E., Peterson, K., & Guzman, L. (2012). What young adults know and don't know about women's fertility patterns: Implications for reducing unintended pregnancies. Child Trends. Available: https://www.childtrends.org/wp-content/uploads/2013/04/Child_Trends-2012_09_21_RB_FertilityPatterns.pdf. Accessed: February 3, 2022.
Bunting, L., Tsibulsky, I., & Boivin, J. (2013). Fertility knowledge and beliefs about fertility treatment: Findings from the International Fertility Decision-making Study. *Human Reproduction*, 28(2), 385–397.
Centers for Disease Control and Prevention (CDC). (2014). National Public Health Action Plan for the detection, prevention, and management of infertility. Available: https://www.cdc.gov/reproductivehealth/infertility/pdf/DRH_NAP_Final_508.pdf. Accessed: February 3, 2022.
Centers for Disease Control and Prevention (CDC). (2021). Infertility FAQs. Available: https://www.cdc.gov/reproductivehealth/infertility/index.htm. Accessed: February 3, 2022.
Daniluk, J. C., & Koert, E. (2015). Fertility awareness online: The efficacy of a fertility education website in increasing knowledge and changing fertility beliefs. *Human Reproduction*, 30(2), 353–363.
Daniluk, J. C., Koert, E., & Cheung, A. (2012). Childless women's knowledge of fertility and assisted human reproduction: Identifying the gaps. *Fertility and Sterility*, 97(2), 420–426.
Fritz, R., Klugman, S., Lieman, H., Schulkin, J., Taouk, L., Castleberry, N., & Buyuk, E. (2018). Counseling patients on reproductive aging and elective fertility preservation-A survey of obstetricians and gynecologists' experience, approach, and knowledge. *Journal of Assisted Reproduction and Genetics*, 35(9), 1613–1621.
Galic, I., Negris, O., Warren, C., Brown, D., Bozen, A., & Jain, T. (2020). Disparities in access to fertility care: Who's in and who's out. *F&S Reports*, 2(1), 109–117.
Gavin, L., Moskosky, S., Carter, M., Curtis, K., Glass, E., Godfrey, E., & Zapata, L. (2014). Providing quality family planning services: Recommendations of CDC and the U.S. Office of Population Affairs. *MMWR. Morbidity and Mortality Weekly Report*, 63(RR-04), 1–54.
Gossett, D. R., Nayak, S., Bhatt, S., & Bailey, S. C. (2013). What do healthy women know about the consequences of delayed childbearing? *Upsala Journal of Medical Sciences*, 18(Suppl 1), 118–128.
Guttmacher Institute. (2014). 2009 survey of unmarried young adults' contraceptive knowledge and practices ("The Fog Zone"): Data users' guide and codebook. Guttmacher Institute. Available: https://www.guttmacher.org/sites/default/files/dataset_documents/ns-userguidecb2009.pdf. Accessed: February 3, 2022.
Hammarberg, K., Setter, T., Norman, R. J., Holden, C. A., Michelmore, J., & Johnson, L. (2013). Knowledge about factors that influence fertility among Australians of reproductive age: A population-based survey. *Fertility and Sterility*, 99(2), 502–507.
Hartnett, C. S., & Gemmill, A. (2020). Recent trends in U.S. childbearing intentions. *Demography*, 57(6), 2035–2045.
Hipp, S. L., Chung-Do, J., & McFarlane, E. (2019). Systematic review of interventions for reproductive life planning. *Journal of Obstetrics, Gynecology, and Neonatal Nursing*, 48(2), 131–139.
Hoffman, J. R., Delaney, M. A., Valdes, C. T., Herrera, D., Washington, S. L., Aghajanova, L., … Herndon, C. N. (2020). Disparities in fertility knowledge among women from low and high resource settings presenting for fertility care in two United States metropolitan centers. *Fertility Research and Practice*, 6, 15.
Holm, S. (1979). A simple sequentially rejective multiple test procedure. *Scandinavian Journal of Statistics*, 6(2), 65–70.
Holmes, K., Curry, C., Sherry, S., Ferfolja, T., Parry, K., Smith, C., … Armour, M. (2021). Adolescent menstrual health literacy in low, middle and high-income countries: A narrative review. *International Journal of Environmental Research and Public Health*, 18(5), 2260.
Institute of Medicine. (2004). *Health literacy: A prescription to end confusion*. Washington, DC: National Academies Press. https://doi.org/10.17226/10883
Ipsos. (n.d., a). KnowledgePanel® sampling and weighting methodology. Available: https://www.ipsos.com/sites/default/files/kpsamplingandweighting.pdf. Accessed: January 18, 2022.
Ipsos. (n.d., b). KnowledgePanel®: A methodological overview. Available: https://www.ipsos.com/sites/default/files/ipsosknowledgepanelmethodology.pdf. Accessed: January 18, 2022.
Johnson, K., Posner, S. F., Biermann, J., Cordero, J. F., Atrash, H. K., … Curtis, M. G., & CDC ATSDR Preconception Care Work Group, & Select Panel on Preconception Care (2006). Recommendations to improve preconception health and health care–United States. A report of the CDC/ATSDR Preconception Care Work Group and the Select Panel on Preconception Care. *MMWR. Morbidity and Mortality Weekly Report*, 55(RR-6), 1–23.
Kelley, A. S., Qin, Y., Marsh, E. E., & Dupree, J. M. (2019). Disparities in accessing infertility care in the United States: Results from the National Health and Nutrition Examination Survey, 2013-16. *Fertility and Sterility*, 112(3), 562–568.
Kudesia, R., Chernyak, E., & McAvey, B. (2017). Low fertility awareness in United States reproductive-aged women and medical trainees: Creation and validation of the Fertility & Infertility Treatment Knowledge Score (FIT-KS). *Fertility and Sterility*, 108(4), 711–717.
Kudesia, R., Talib, H. J., & Pollack, S. E. (2017). Fertility awareness counseling for adolescent girls; Guiding conception: The right time, right weight, and right way. *Journal of Pediatric and Adolescent Gynecology*, 30(1), 9–17.
Lundsberg, L. S., Pal, L., Gariepy, A. M., Xu, X., Chu, M. C., & Illuzzi, J. L. (2014). Knowledge, attitudes, and practices regarding conception and fertility: A population-based survey among reproductive-age United States women. *Fertility and Sterility*, 101(3), 767–774.
Martin, J. A., Hamilton, B. E., Osterman, M. J. K., & Driscoll, A. K. (2021). Births: Final data for 2019. *National Vital Statistics Report*, 70(2), 1–51Available: https://www.cdc.gov/nchs/data/nvsr/nvsr70/nvsr70-02-508.pdf. Accessed: February 3, 2022.
Martin, N., Baralt, L., & Garrido-Ortega, C. (2018). What's religion got to do with it? Exploring College students' sexual and reproductive health knowledge and awareness of sexual and reproductive health services in relation to their gender and religiosity. *Journal of Religion and Health*, 57(5), 1856–1875.
Mills, M., Rindfuss, R. R., McDonald, P., & te Velde, E. (2011). Why do people postpone parenthood? Reasons and social policy incentives. *Human Reproduction Update*, 17(6), 848–860.
Office of the Assistant Secretary for Planning and Evaluation. (2020). 2020 poverty guidelines. Available: https://aspe.hhs.gov/2020-poverty-guidelines. Accessed: February 23, 2022.
Paasche-Orlow, M. K., & Wolf, M. S. (2007). The causal pathways linking health literacy to health outcomes. *American Journal of Health Behavior*, 31(Suppl 1), S19–S26.
Pedro, J., Brandao, T., Schmidt, L., Costa, M. E., & Martins, M. V. (2018). What do people know about fertility? A systematic review on fertility awareness and its associated factors. *Upsala Journal of Medical Sciences*, 123(2), 71–81.
Peters, E. (2008). Numeracy and the perception and communication of risk. *Annals of the New York Academy of Science*, 1128, 1–7.
Peterson, B. D., Pirritano, M., Tucker, L., & Lampic, C. (2012). Fertility awareness and parenting attitudes among American male and female undergraduate university students. *Human Reproduction*, 27(5), 1375–1382.
Popat, V. B., Prodanov, T., Calis, K. A., & Nelson, L. M. (2008). The menstrual cycle: A biological marker of general health in adolescents. *Annals of the New York Academy of Science*, 1135, 43–51.
Research Triangle Institute. (2012). *SUDAAN® language manual, Volumes 1 and 2, Release 11*. Research Triangle, NC: Research Triangle Institute.
Roberts, L. M., Kudesia, R., Zhao, H., Dolan, S., & Rose, M. (2020). A cross-sectional survey of fertility knowledge in obstetrics and gynecology residents. *Fertility Research and Practice*, 6(1), 22.
Siegel, D. R., Sheeder, J., & Polotsky, A. J. (2021). Racial and ethnic disparities in fertility awareness among reproductive-aged women. *Womens Health Reports (New Rochelle)*, 2(1), 347–354.
Squiers, L., Peinado, S., Berkman, N., Boudewyns, V., & McCormack, L. (2012). The health literacy skills framework. *Journal of Health Communication*, 17(Suppl 3), 30–54.
Starrs, A. M., Ezeh, A. C., Barker, G., Basu, A., Bertrand, J. T., Blum, R., … Ashford, L. S. (2018). Accelerate progress–Sexual and reproductive health and rights for all: Report of the *Guttmacher-Lancet Commission*. *Lancet*, 111(1), 23–53.
Stidham Hall, K., Moreau, C., & Trussell, J. (2012). Lower use of sexual and reproductive Health services among women with frequent religious participation, regardless of sexual experience. *Journal of Women's Health*, 21(7), 739–747.

Stulhofer, A., Soh, D., Jelaska, N., Bacak, V., & Landripet, I. (2011). Religiosity and sexual risk behavior among Croatian college students, 1998-2008. *Journal of Sex Research*, 48(4), 360–371.

Trawick, E., Pecoriello, J., Quinn, G., & Goldman, K. N. (2021). Guidelines informing counseling on female age-related fertility decline: A systematic review. *Journal of Assisted Reproduction and Genetics*, 38(1), 41–53.

Vassard, D., Lallemant, C., Nyboe Andersen, A., Macklon, N., & Schmidt, L. (2016). A population-based survey on family intentions and fertility awareness in women and men in the United Kingdom and Denmark. *Upsala Journal of Medical Sciences*, 121(4), 244–251.

Wang, Y. X., Arvizu, M., Rich-Edwards, J. W., Stuart, J. J., Manson, J. E., Missmer, S. A., … Chavarro, J. E. (2020). Menstrual cycle regularity and length across the reproductive lifespan and risk of premature mortality: prospective cohort study. *BMJ*, 371, m3464.

Yu, L., Peterson, B., Inhorn, M. C., Boehm, J. K., & Patrizio, P. (2016). Knowledge, attitudes, and intentions toward fertility awareness and oocyte cryopreservation among obstetrics and gynecology resident physicians. *Human Reproduction*, 31(2), 403–411.

Author Descriptions

Christina I. Fowler, PhD, MPH, is a senior public health analyst with RTI International. Her research focuses on delivery and use of sexual/reproductive health services provided through safety-net providers, contraceptive decision making, and fertility knowledge.

Helen P. Koo, DrPH, MPH, MS, is a social demographer and independent consultant. Her research focuses on adolescent and unintended pregnancy, contraceptive use, microbicide acceptability, timing of childbearing, infant mortality, marital disruption and remarriage, and household structure.

Alicia Richmond, MSW, is deputy director at the U.S. Department of Health and Human Services' Office of Population Affairs. Her research interests include equitable access to high-quality reproductive health care and adolescent health.

Daryl Creel, MS, is a senior research statistician with RTI International. His research interests are survey sample design, nonresponse bias analysis, imputation, reproducible research, and analysis of data for simple random samples and complex survey data.

Kat Asman, MSPH, is a research statistician with RTI International. Her work focuses on analyzing survey data, responding to analysis requests, data management, and generating reports.