

Men's knowledge of their own fertility: a population-based survey examining the awareness of factors that are associated with male infertility

D. Daumler¹, P. Chan², K.C. Lo³, J. Takefman⁴, and P. Zelkowitz^{1,5,6,*}

¹Department of Psychiatry, Jewish General Hospital, McGill University, 4333 Côte-Sainte-Catherine Road, Montreal, QC H3T 1E4, Canada

²Department of Urology, McGill University Health Centre, McGill University, 1001 Décarie Boulevard, Montreal, QC H4A 3J1, Canada

³Department of Urology, Mount Sinai Hospital, University of Toronto, 60 Murray Street, Toronto, ON M5G 1X5, Canada ⁴McGill

Reproductive Centre, McGill University Health Centre, McGill University, 888 de Maisonneuve Boulevard East, Suite 200, Montreal,

QC H2L 4S8, Canada ⁵Lady Davis Institute for Medical Research, Jewish General Hospital, McGill University, 3755 Côte-Sainte-Catherine

Road, Montreal, QC H3T 1E2, Canada ⁶Department of Psychiatry, McGill University, Ludmer Research and Training Building, 1033 Pine

Avenue West, Montreal, QC H3A 1A1, Canada

*Correspondence address. Tel: +(5258) 1-514-340-8222; E-mail: phyllis.zelkowitz@mcgill.ca

Submitted on March 18, 2016; resubmitted on September 22, 2016; accepted on September 28, 2016

STUDY QUESTION: How knowledgeable are men about the medical, environmental and psychological factors that are associated with male infertility?

SUMMARY ANSWER: Men, across most demographic groups, have limited knowledge of the various factors that are associated with male infertility.

WHAT IS KNOWN ALREADY: Few surveys have focused on men's knowledge of their own fertility. Studies of both men and women have found that men are comparatively less knowledgeable about issues of fertility and reproductive health.

STUDY DESIGN, SIZE, DURATION: A regionally representative sample of Canadian men completed a web-based survey of male fertility and reproductive health, over a 2-month period in 2015.

PARTICIPANTS/MATERIALS, SETTING, METHODS: Men, aged 18–50 years, were recruited for the study. There were 701 male participants, with a mean age of 34.1 years. Each participant was asked to identify factors associated with male infertility; fertility knowledge was assessed through two open-ended questions and a comprehensive list of risk factors and attendant health issues.

MAIN RESULTS AND THE ROLE OF CHANCE: Men were only able to identify 51% of the risk factors and 45% of the health issues associated with male infertility. Men were most aware of the modifiable risk factors for infertility (e.g. sexually transmitted infections, smoking cigarettes), relative to their knowledge of fixed risk factors (e.g. delayed puberty, size of testicles) and the attendant health issues (e.g. cardiovascular disease, diabetes). The overall level of fertility knowledge did not vary by most demographic characteristics (e.g. age, education, employment, income), though men from ethnic minority groups displayed moderately greater awareness. Additionally, younger men, those with lower incomes and those who had no desire to have future biological children were more likely to identify themselves as unaware of associations with infertility in the open-ended questions. Self-reported knowledge was significantly associated with higher overall knowledge scores. More than half of the sample expressed an interest in obtaining information about male fertility and reproductive health, with the majority of these men indicating that medical professionals and online sources were their preferred methods for receiving information.

LIMITATIONS, REASONS FOR CAUTION: Participants were self-selected and required to have Internet access in order to participate. This may affect the generalizability of results.

WIDER IMPLICATIONS OF THE FINDINGS: Previous studies of fertility knowledge have either omitted men from their samples or when men have been included, they were asked about general fertility or women's fertility. This is the first large-scale survey that focuses solely on men's knowledge of male fertility. Insight into the areas where men's knowledge may be lacking can inform strategies for

disseminating fertility-related information and improving men's fertility awareness. Public health initiatives should tailor campaigns to educate men about the lesser known associations with male infertility, particularly those that are most prevalent and preventable through lifestyle modification.

STUDY FUNDING/COMPETING INTEREST(S): The study was funded by a grant from CIHR TE1-138296. No competing interests.

Key words: male infertility / fertility knowledge / risk factors / health issues / infertility awareness / web-based survey

Introduction

Most men express a desire to become fathers at some point in their lives (Lampic et al., 2006; Peterson et al., 2012). Insufficient knowledge of factors associated with male infertility could lead some men to engage, unknowingly, in activities that reduce their ability to have biological children. Male infertility can lead to impaired quality of life in many domains, including general and mental health, social functioning and role performance (Chachamovich et al., 2010). Male factors, such as low sperm count and abnormal sperm morphology, are primary or contributing causes in almost half of the diagnosed cases of infertility (Wiser et al., 2012). Certain medical conditions affect male fertility rates; for example, male cancer survivors are half as likely to produce biological children compared to healthy men (Green et al., 2010). Male infertility is associated with poor general health status; compared to fertile men, infertile men exhibit more health problems, including cardiovascular disease, diabetes, prostate cancer and testicular cancer (Walsh, 2011; Eisenberg et al., 2016). Therefore, it is important to assess awareness of the factors associated with reduced fertility in order to promote the general and reproductive health of men.

Research that specifically measures men's fertility knowledge is limited. Several studies of fertility knowledge in the general population only sampled women (Bretherick et al., 2010; Daniluk et al., 2012; Lundsberg et al., 2014), and studies on men have tended to use samples of secondary and postsecondary students, thereby limiting the generalizability of the results (e.g. Trent et al., 2006; Bunting and Boivin, 2008; Quach and Librach, 2008; Ekelin et al., 2012). Two studies measured men's fertility knowledge using population-based samples (Bunting et al., 2013; Daniluk and Koert, 2013), though their samples were restricted to coupled individuals and childless individuals, respectively. Both surveys included a few questions about male fertility (3/13 and 4/20 questions, respectively). This study builds upon previous research, by assessing a general population sample from a broad age range of men, single and coupled, with and without biological children and by focusing exclusively on male fertility.

To assess men's fertility knowledge, we compiled a comprehensive set of risk factors for male infertility, as well as health issues associated with male factor infertility. We classified these items into three categories: (i) modifiable risk factors that are controllable by lifestyle modification or medical management; (ii) fixed risk factors that are congenital or outside the control of the individual and (iii) attendant health issues, including illnesses and disorders that are linked with an infertility diagnosis. Our survey also incorporated questions about men's information-seeking and the use of technology in an attempt to inform novel modalities for reaching men and increasing fertility awareness. The objective of this study was to investigate fertility knowledge among Canadian men, examining: (i) what men know about their own

fertility, (ii) demographic factors associated with fertility knowledge and (iii) where men receive their fertility information and whether they are interested in learning more about this topic.

Material and Methods

Data

Between 20 April and 29 May 2015, a web-based survey was administered to Canadian men who met the study's inclusion criteria; respondents were required to be male and between the ages of 18 and 50 years. Data were gathered by a polling and market research company, which follows the ethical principles outlined in the Code of Conduct for Market and Social Research (MRIA, 2015). The questionnaire, which was available in both French and English, was pilot-tested by the survey company to ensure clarity and acceptability of the items. Participants were guaranteed anonymity, and no identifying information was recorded or saved.

Participants

A total of 701 men, aged 18–50 years (mean, 34.1; *SD*, 9.1), completed the survey. The sample's margin of error was $\pm 3.7\%$. Most men identified as heterosexual (92.3%), Canadian born (73.2%), full-time employed (59.6%) and either married or in a common-law relationship (49.0%). Although 60.1% of men had no biological children, 46.8% expressed the intention to have future biological children. Our survey is representative of Canadian men with respect to regional distribution, immigrant status and paternity, as the composition of our sample was statistically consistent with Canadian men of equal age in the 2011 General Social Survey, a nationally representative survey of 22,435 Canadians (Statistics Canada, 2012). Our sample had slightly higher levels of education and mean income than the general population; most men possessed a postsecondary degree (64.6%), and the mean income fell within the \$40,000–\$79,999 bracket. We oversampled visible minorities (38.5%) to allow for statistical comparisons of subpopulations. A complete demographic overview and comparison with weighted survey data are presented in [Supplementary data, Table S1](#).

Men's fertility knowledge

The survey questions were designed by the research team, including two male fertility specialists with >20 years of clinical practice. The full survey questionnaire is available in [Supplementary data, Table SII](#). The survey began with questions about the respondent's demographic characteristics and fertility experiences. Then two open-ended questions asked men to list up to 15 risk factors and health issues associated with male infertility; respondents had the option to indicate that they were unaware of any associations. Two close-ended questions provided a list of 34 possible risk factors, 10 of which were decoy items and 11 possible health issues, 4 of which were decoy items. Responses were coded as "1: correctly identified" if men correctly identified an item as "definitely a risk factor" or "probably a risk factor." Responses were coded as "0: not correctly

identified" if men identified an item as "definitely not a risk factor," "probably not a risk factor," or "unsure." To assess men's fertility knowledge, we created two overall knowledge scores, ranging from 0 to 100, based on the aggregate percentage of correctly identified risk factors and attendant health issues. Inclusion of incorrectly identified decoy items did not substantially alter the results; we therefore present the data on actual risk factors and attendant health issues. To create the overall knowledge scores, we summed each man's responses (e.g. 1 + 1 + 0 + 0 + [...] + 0 + 1) and divided the sum by the total number of items to create an aggregate percentage (e.g. 18 correctly identified/24 actual risk factors = 66.7%). We also created two dichotomous variables for men's unprompted awareness of risk factors and attendant health issues. Each variable focuses on the respondent's self-assessment in the open-ended questions; they were coded as "1: aware" if men reported being aware of associations and "0: unaware" if men reported being unaware of any associations with male infertility.

Items were selected based on expert opinion and systematic reviews. Risks factors included advanced age (Harris *et al.*, 2011), complications with male reproductive organs and genetic abnormalities (Morey *et al.*, 2004; Juul *et al.*, 2014), exposure to heat sources and injurious daily activities (Shefi *et al.*, 2007; Wright *et al.*, 2014), exposure to pesticides and environmental toxins (Oliva *et al.*, 2001), substance use (Close *et al.*, 1990; De Souza and Hallak, 2011), urinary tract infections (Pellati *et al.*, 2008) and various medical treatments (Green *et al.*, 2010; Abarikwu, 2013). Attendant health issues included depression (Martins *et al.*, 2016), prostate cancer (Walsh, 2011) and testicular cancer (Peng *et al.*, 2009). Several items were classified in both categories. We asked respondents about their knowledge of the clinical sequelae of metabolic syndrome (Sermondade *et al.*, 2013; Schisterman *et al.*, 2014; Pergialiotis *et al.*, 2016) and sexually transmitted infections (Gimenes *et al.*, 2014) in two different survey questions, one relating to risk factors and the other to attendant health issues, as various studies have posited that the associations may precede and/or follow an infertility diagnosis (Lunenfeld and Van Steirteghem, 2004; Michalakis *et al.*, 2013; Eisenberg *et al.*, 2016). Accordingly, it was possible that men could be aware of an item being a risk factor for infertility but not an attendant health issue or the inverse scenario. This study, however, was concerned only with whether men had any knowledge of such associations rather than causal or directional claims.

Covariates

For our analyses, we included 10 demographic covariates (age, ethnicity, immigration, education, employment, income, sexual orientation, marital status, current biological children and intention to have biological children) and six fertility covariates (self-reported knowledge, awareness that male factors can contribute to infertility, fertility concerns, experience with fertility assessment, experience with fertility treatment, interest in learning more about fertility).. For an overview of covariates and how each was recorded, see [Supplementary data, Table SIII](#).

Statistical analyses

For the univariate analysis, the overall knowledge scores were compared for each covariate; a one-way ANOVA or two-sample t-test was used, where appropriate. Pearson's chi-squared tests were conducted to examine groups that were most interested in fertility-related information. We corrected for multiple comparisons using the stepwise Benjamini-Hochberg procedure that controls for the false discovery rate (Benjamini and Hochberg, 1995). To assess which factors were independent predictors of overall knowledge scores, we conducted a multivariate regression analysis to test four models. The first two models assessed the odds of correctly identifying risk factors: Model 1 with demographic variables only and Model 2 with the addition of fertility covariates. Similarly, Models 3

and 4 assessed the likelihood of correctly identifying attendant health issues. For the two open-ended questions, we ran multivariate logistic regression analyses of the odds that men were aware of associations with male infertility without prompting. All models were run with robust standard errors, and *P*-values were reported at 0.05, 0.01 and 0.001 levels. Statistical analyses were conducted using Stata 13.0 statistical software (StataCorp, USA).

Results

Men's fertility experience

Most men (88.5%) considered themselves to be somewhat, very or extremely knowledgeable about male reproduction and fertility. Although 35.8% of men had at least some concerns about their fertility, only 13.6% had undergone fertility assessment, and 8.8% had experienced fertility treatment. A small number of men (8.8%) were unaware that male factors can contribute to a couple's infertility (Table I).

Sources of fertility knowledge

Most respondents (78.7%) indicated that they had obtained fertility information from at least one source with the remaining 21.3% never having acquired information about male fertility. As Table I indicates, many men learned about fertility from online sources (55.8%), and fewer men gained information from medical professionals (41.5%), written materials (40.9%) and educational institutions (25.2%).

Gaining fertility information

Overall, 58.2% of men were interested in receiving information about male reproduction and fertility. Among those who wished to learn more, medical professionals (65.9%) and online sources (58.3%) were their preferred methods for receiving information (Table I). When asked about their use of technology, most men reported using a smartphone (81.2%) or laptop computer (76.3%) to access online information.

Knowledge of male infertility

Modifiable risk factors

Though most men (88.5%) considered themselves to be knowledgeable, respondents could identify only half (53.1%) of the modifiable risk factors for male infertility (Table II). While several factors were widely known—including the long-term use of steroids, sexually transmitted infections, pain or injury to the testicles or scrotum, stress and smoking cigarettes—fewer men identified the fertility risk associated with obesity, diabetes, high cholesterol, alcohol consumption and frequent bicycling.

Fixed risk factors

Men were comparatively less knowledgeable about fixed risk factors for male infertility, identifying less than half (46.9%). More than 67% of respondents correctly identified three such factors (cancer treatment, genetic abnormality, age greater than 45 years), but <50% of respondents were aware that factors, such as X-rays, hernia repair, delayed puberty and size of testicles were associated with male infertility (Table II).

Table I Fertility characteristics and informational preferences for the total sample of Canadian men, aged 18–50 years.

Fertility characteristics	N	%
Self-reported knowledge of male reproduction		
Very or extremely knowledgeable	389	55.5
Somewhat knowledgeable	231	33.0
Slightly or not at all knowledgeable	81	11.6
Underestimated the extent to which male factors contribute to infertility		
Believes that male factors can cause infertility	639	91.2
Believes that male factors do not cause infertility	62	8.8
Fertility concerns		
Very or extremely concerned	47	6.7
Somewhat concerned	204	29.1
Not very concerned	450	64.2
Experience with fertility assessment		
Respondent and/or partner has had experience with fertility assessment	95	13.6
No experience with fertility assessment	606	86.5
Experience with fertility treatment		
Respondent and/or partner has had experience with fertility treatment	62	8.8
No experience with fertility treatment	639	91.2
Sources of knowledge about men's fertility ^a		
Friends/family	201	28.7
Medical professionals	291	41.5
Online sources	391	55.8
School/university	177	25.2
TV/radio	210	30.0
Written materials	287	40.9
Other	3	0.4
Have not received information on men's fertility	149	21.3
Interested in learning more about men's fertility in the future		
Very or extremely interested	111	15.8
Somewhat interested	297	42.4
Not very or not at all interested	293	41.8
Preferred method for receiving information about men's fertility ^{a,b}		
Medical professionals	269	65.9
Online sources	238	58.3
TV/radio	105	25.7
Written materials	120	29.4
Other	5	1.2
Use of technology to access information ^a		
Desktop computer	420	59.9
Laptop computer	535	76.3
Smartphone	569	81.2
Tablet	349	49.8
None of the above	3	0.4
Total sample	701	100.0

^aRespondents were able to select multiple options for the indicated variables; therefore, the sums may not add up to 100.

^bFor the indicated variable, only those who reported having an interest in learning more about fertility were asked about their preferred method for receiving fertility information (N = 408).

Table II Proportion of men who correctly identified each risk factor and health issue that is associated with male infertility.

Item associated with male infertility	Correct % ^a
Category 1: Modifiable risk factors for male infertility	
Long-term use of steroids	77.8
Sexually transmitted infections (e.g. chlamydia, gonorrhoea, etc.)	74.3
Pain or injury to the testicles or scrotum	72.9
Stress	68.9
Smoking cigarettes	67.8
Use of drugs such as marijuana, narcotics, or cocaine	64.6
Alcohol consumption (>10 drinks a week)	63.2
Exposure to pesticides or environmental toxins (e.g. paint, solvents, etc.)	62.2
Overweight/obesity	54.2
Urinary tract (bladder) infection	49.5
Diabetes	46.9
Wearing tight pants	41.1
High cholesterol	37.0
Frequent use of a laptop on your lap	36.2
Frequent hot tub use	33.0
Frequent bicycling or riding horses	27.5
Overuse of electronic devices such as cellphones or computers	26.0
Category mean	53.1
Category 2: Fixed risk factors for male infertility	
Cancer treatment such as radiation or chemotherapy	76.6
Genetic abnormality	69.8
Age (older than 45 years)	69.5
X-rays	46.7
Hernia repair	24.4
Delayed puberty	22.1
Size of testicles	19.1
Category mean	46.9
Category 3: Attendant health issues for which infertile men are at greater risk:	
Testicular cancer	58.5
Depression	52.9
Prostate cancer	52.5
Sexually transmitted infections ^b	45.4
Obesity ^b	37.2
Cardiovascular disease (heart disease, high blood pressure)	35.0
Diabetes ^b	33.8
Category mean	45.0
N	701

^aProportion of respondents that correctly identified the item; those who were incorrect or uncertain about the item were coded as having not correctly identified the item.

^bIndicates that the item or variations of the item was listed in more than one category.

Attendant health issues

Men were aware of less than half (45.0%) of the health issues associated with male infertility. As Table II indicates, testicular cancer, depression and prostate cancer were most commonly known. Less than 50% of men were able to correctly identify sexually transmitted infections, obesity, cardiovascular disease and diabetes.

Open-ended responses

While 64.6% of respondents listed risk factors, only 26.1% listed health issues associated with male infertility. The most common risk factors that men reported included: smoking (16.5%), alcohol consumption (16.4%), medical conditions (16.1%) and drug usage (13.6%). The most frequently listed health issues included: cancer (8.0%), diabetes (3.1%), erectile dysfunction (2.9%) and depression (2.6%).

Demographic variation in knowledge

Variation in overall knowledge

There was little demographic variation in the overall knowledge scores. Of 10 demographic covariates in the univariate analysis, only 4 were associated with significant disparities in knowledge of attendant health issues, and there were no significant differences regarding risk factors. As Table III indicates, those with at least one biological child, men from immigrant and minority groups and those without a partner demonstrated greater levels of knowledge. Men's fertility knowledge did not vary by age, education, employment, income, sexual orientation and intention to have biological children. The overall knowledge scores did, however, vary by men's fertility characteristics. Self-reported knowledge, awareness of male factors contributing to infertility, fertility concerns, experience with fertility treatment and interest in learning more were associated with the knowledge of risk factors and/or attendant health issues.

Variation in unprompted responses

Men who were younger than 30 years, those who earned <\$80,000 and those who did not intend to have any future children were the least likely to report any risk factors, controlling for the 10 demographic variables. Furthermore, men who did not wish to have biological children were less likely to report awareness of health issues associated with male infertility ($P < 0.05$).

Predictors of fertility knowledge

As Table IV shows, only one demographic covariate from Models 1 and 3 remained significant when fertility covariates were introduced in Models 2 and 4; men who identified as a visible minority had more knowledge of attendant health issues, controlling for every variable. After introducing fertility covariates into the analysis, only two variables consistently predicted higher levels of relative knowledge: self-identified knowledge and interest in receiving fertility information (see Models 2 and 4).

Men who were interested in fertility-related information

Four demographic groups exhibited greater interest in fertility information: employed men ($P < 0.05$), immigrants ($P < 0.01$), men from visible minority groups and those who intend to have biological children ($P < 0.001$). Additionally, men who self-identified as knowledgeable, those who were aware that male factors can contribute

to infertility ($P < 0.05$), those who have experienced fertility assessment and treatment ($P < 0.01$) and men with fertility concerns ($P < 0.001$) expressed a greater interest in receiving fertility-related information.

Discussion

To the best of our knowledge, this study is the first large-scale survey that focuses solely on men's knowledge of male fertility, inquiring about risk factors and health issues related to male infertility. We developed a three-category classification scheme to facilitate the discussion of areas where men's knowledge is lacking. Our survey also incorporated questions about men's use of information and technology in order to recommend strategies for disseminating fertility-related resources to men. Our results demonstrate that (i) Canadian men's knowledge of their own fertility was limited, (ii) men's level of fertility knowledge was similar across most demographic groups and (iii) the majority of men were interested in learning more about their reproductive health.

Overall, men were able to correctly identify only half of the risk factors and health issues associated with male infertility. Men were relatively familiar with the modifiable risk factors for infertility. They tended to be aware of how substance use (e.g. smoking cigarettes) and health-related risks (e.g. sexually transmitted infections) were related to male infertility, though a substantial minority of men (20–40%) remain unaware of these associations. Less than 50% of the respondents were aware of the effects of common health problems, such as high cholesterol, obesity and diabetes. Men were even less knowledgeable about how daily activities and excessive heat sources, such as the use of laptops and frequent hot tub use, can impact male fertility. It is crucial that men be made aware of modifiable risk factors, as a lack of awareness could lead to the missed opportunity to actively improve one's fertility health. Men were moderately aware of certain fixed risk factors (e.g. cancer treatment) though there was a considerable lack of knowledge regarding the male reproductive anatomy (e.g. size of testicles, delayed puberty) and its association with male infertility. Poor knowledge of fixed risks could lead to delayed recognition or diagnosis of infertility; greater awareness may promote early assessment and treatment. We found that men were least informed about the health issues associated with male infertility. In particular, there was a clear lack of knowledge of the heightened risks that infertile men face regarding the clinical sequelae of metabolic syndrome (e.g. cardiovascular disease). Only ~50% of men identified depression as a consequence of infertility. These findings highlight the importance of educating men about such health risks in order to address modifiable risk factors through health promotion activities, such as diet, exercise and stress reduction techniques. Greater fertility awareness has also been associated with the decision to seek out fertility services (Bunting and Boivin, 2007). Therefore, the more information that individuals have about fertility, the more likely they are to exhibit positive health-seeking behaviours to improve their own fertility.

Contrary to expectations, the overall level of fertility knowledge did not vary by most demographic characteristics. Ethnicity was the only demographic characteristic that remained significant after controlling for fertility covariates. Men from cultural groups with strong pronatalist views may have a particular interest in fertility information, due to the

Table III Mean percentages for the univariate analysis assessing men's overall knowledge scores of items associated with male infertility.

Variable	Risk factors		Attendant health issues	
	M	SD	M	SD
Total sample	51.30	23.47	45.04	33.68
Demographic characteristics:				
Age of respondent (years)				
<30	49.36	23.31	42.64	31.83
30–39	52.50	23.82	45.03	34.07
40–50	52.39	23.21	48.16	35.41
Ethnicity				
Visible minority	51.33	25.39	50.74**	32.81
Not a visible minority (white)	51.28	22.22	41.47	33.76
Immigrant status				
Immigrant (born outside of Canada)	51.86	25.50	51.75**	32.40
Not an immigrant (born in Canada)	51.09	22.70	42.58	33.83
Education				
Less than a high school degree	46.16	27.47	48.87	32.48
High school graduate	50.62	21.36	46.67	32.85
College/university graduate	52.04	24.03	43.96	34.17
Employment status				
Unemployed	48.44	23.42	43.87	33.92
Not unemployed	51.76	23.47	45.23	33.66
Income				
<\$40,000	50.61	24.34	46.85	34.52
\$40,000–\$79,999	51.80	23.33	46.40	33.60
≥\$80,000	51.34	22.95	42.09	32.99
Sexual orientation				
Heterosexual	50.88	23.60	45.00	33.79
Not heterosexual (homosexual/bisexual)	56.25	21.46	45.50	32.61
Marital status				
Partner lives in household (married/common-law)	49.36	23.52	41.82*	33.20
No partner lives in household	53.32	23.28	48.40	33.90
Fathered children				
At least one biological child	52.02	24.35	50.41**	34.04
No biological children	50.81	22.89	41.47	33.00
Future children				
Wants to have biological children	52.15	24.55	45.82	34.02
Does not want to have biological children	52.12	22.94	44.60	33.44
Undecided about having biological children	48.94	21.96	44.10	33.47
Fertility characteristics:				
Self-reported knowledge				
Very knowledgeable	55.90***	23.28	49.25**	33.72
Somewhat knowledgeable	45.96	22.96	41.37	33.27
Not very knowledgeable	44.39	21.02	35.27	31.71
Awareness that male factors can contribute to infertility				
Male factors can cause fertility problems	52.20**	23.14	45.12	33.55
Male factors do not cause fertility problems	42.00	25.01	44.24	35.25
Fertility concerns				

Continued

Table III *Continued*

Variable	Risk factors		Attendant health issues	
	M	SD	M	SD
Very concerned	54.26	29.39	61.70**	32.37
Somewhat concerned	51.84	25.52	48.18	34.44
Not very concerned	50.74	21.79	41.87	32.88
Experience with fertility assessment				
Respondent and/or partner has had experience with fertility assessment	56.32	24.42	50.38	32.94
No experience with fertility assessment	50.51	23.24	44.20	33.74
Experience with fertility treatment				
Respondent and/or partner has had experience with fertility treatment	56.38	25.02	54.61*	32.77
No experience with fertility treatment	50.80	23.28	44.11	33.65
Interested in learning more about fertility in the future				
Very interested	60.96***	24.95	55.98***	31.89
Somewhat interested	52.68	23.21	46.99	34.83
Not very interested	46.23	21.84	38.91	31.93
Number of items in the dependent variable	24	24	7	7
N	701	701	701	701

*** $P < 0.001$, ** $P < 0.01$, * $P < 0.05$.

Statistical significance based on corrected P -values; controlled for the false discovery rate using the stepwise Benjamini–Hochberg procedure

cultural importance of having biological children (Becker et al., 2006; Whitten et al., 2013). Furthermore, men from ethnic minority groups may have more experience with, and therefore knowledge of, certain medical conditions that are associated with infertility, given the ethnic disparities in obesity and its metabolic and cardiovascular comorbidities (Cossrow and Falkner, 2004). Three demographic groups were unable to identify, without prompting, associations with male infertility; younger men may not be thinking about having children, those with lower incomes may have less exposure to fertility-related information and those who do not want to have biological children would not be concerned about their own fertility. Although Daniluk and Koert (2013) found a negligible relationship between self-reported knowledge and overall fertility awareness, our study found that a man's self-assessment of his own knowledge was an accurate indicator of his relative fertility knowledge; those who rated themselves as knowledgeable achieved higher knowledge scores than those who rated themselves as less knowledgeable. Disparate findings may be due to the different methodologies that were used to measure fertility knowledge; rather than focus on widespread beliefs, our study examined the awareness of specific associations with infertility.

Since a lack of knowledge was not restricted to particular demographic groups, the results of this study highlight the need for universal public education regarding male fertility. Some men (~9% in our study) may be unaware that male factors contribute to a couple's infertility, and many others overestimated the extent of their knowledge. More than 33% of our sample expressed concerns about their own fertility, and almost 60% indicated that they wished to learn more about male fertility. The survey results suggest several strategies for improving men's fertility awareness. (i) Few men indicated that they gained fertility knowledge from schools or universities. Educational institutions provide an excellent forum for disseminating information to the wider

population. It would therefore be beneficial to incorporate fertility-related topics in sexual education curricula. (ii) After exiting the education system, the responsibility to keep individuals informed about fertility shifts logically to primary health providers. Indeed, our study found that most men would prefer to receive fertility information from medical professionals. Men tend to ask fewer questions and get less information from their healthcare providers (Wenger, 2011), so primary care physicians should incorporate a discussion of reproductive health when men access healthcare. (iii) our results showed that men seek fertility information from online sources, confirming what other studies have indicated about men's preference for finding medical information on the Internet (Berger et al., 2005), particularly when it concerns stigmatized illnesses, such as infertility (Ollife and Phillips, 2008). While the Internet can be an excellent medium for disseminating reproductive health information, quality reviews of fertility websites have demonstrated that this information may not be wholly accurate or accessible (Okamura et al., 2002; Marriott et al., 2008); as such, public health agencies should consider providing improved online resources regarding infertility. (iv) As online articles, by themselves, may be an ineffective tool for generating long-term retention of fertility knowledge (Daniluk and Koert, 2015), other technological platforms ought to be considered. Our results suggest that mobile devices might be an effective way to reach men, as the majority of our sample reported that they use a smartphone. The accessibility and interactive nature of mobile technology may enhance men's engagement with health interventions (Short et al., 2014). Therefore, future initiatives to increase men's knowledge should capitalize on emerging technologies, such as mobile health applications, to educate men about their own fertility.

A limitation of our study is that the sample consisted of men who volunteered to take the survey resulting in the self-selection of

Table IV Coefficients for the multivariate regression analysis assessing men's overall knowledge scores of items associated with male infertility.

Variable	Risk factors		Attendant health issues	
	1	2	3	4
Demographic characteristics				
Age of respondent (ref: <30) (years)				
30–39	2.10	2.53	0.55	0.53
40–50	3.04	2.22	4.98	4.40
Ethnicity (ref: not a visible minority)				
Visible minority	0.56	−0.22	7.95**	6.56*
Immigrant status (ref: not an immigrant/born in Canada)				
Immigrant (born outside of Canada)	−0.55	−0.85	3.66	2.50
Education (ref: college/university graduate)				
Less than a high school degree	−3.96	−1.26	6.19	6.87
High school graduate	−0.48	0.19	4.05	5.12
Employment status (ref: not unemployed)				
Unemployed	−2.38	−0.84	−3.11	−2.21
Income (ref: ≥\$80,000)				
<\$40,000	2.57	1.51	7.12*	6.04
\$40,000–\$79,999	1.34	1.24	5.76	5.51
Sexual orientation (ref: heterosexual)				
Not heterosexual (homosexual/bisexual)	6.71*	4.98	4.49	2.03
Marital status (ref: no partner lives in household)				
Partner lives in household (married/common-law)	−4.46	−3.55	−6.20	−4.90
Fathered children (ref: no biological children)				
At least one biological child	−0.89	−2.76	7.14*	5.94
Future children (ref: wants to have biological children)				
Does not want to have biological children	−1.87	2.83	−4.22	1.52
Undecided about having biological children	−3.73	−1.02	−2.14	0.69
Fertility characteristics:				
Self-reported knowledge (ref: very knowledgeable)				
Somewhat knowledgeable	—	−8.15***	—	−6.80*
Not very knowledgeable	—	−7.83**	—	−10.98**
Awareness that male factors can contribute to infertility (ref: male factors can cause fertility problems)				
Male factors do not cause fertility problems	—	−6.90	—	2.78
Fertility concerns (ref: not very concerned)				
Very concerned	—	−3.82	—	10.47
Somewhat concerned	—	−0.91	—	5.48
Experience with fertility assessment (ref: no experience)				
Respondent and/or partner has had experience with fertility assessment	—	3.18	—	−5.14
Experience with fertility treatment (ref: no experience)				
Respondent and/or partner has had experience with fertility treatment	—	−2.05	—	6.34
Interested in learning more about fertility in the future (ref: not very interested)				
Very interested	—	13.76***	—	9.06*
Somewhat interested	—	6.93***	—	6.66*
Number of items in the dependent variable				
	24	24	7	7
<i>df</i>	14	23	14	23
<i>N</i>	701	701	701	701

****p* < 0.001, ***p* < 0.01, **p* < 0.05.

respondents. The sample may be skewed toward individuals with Internet access, just as telephone-based surveys exclude respondents without a telephone in the household. There may be some question about our choice of decoy items, as there is ongoing research of the associations with infertility. Insomnia, for example, has been shown to be associated with an infertility diagnosis (Bak et al., 2012). However, as the decoy items did not factor into our overall knowledge scores, they did not impact our results. Future studies will be required to evaluate the associations that have mixed evidentiary support in the literature. Additionally, we interpreted respondents' correct identification of associations with male infertility as being an indication of fertility knowledge, but it is possible that respondents were demonstrating awareness of how certain behaviours, such as smoking, can negatively impact general health status (Bunting and Boivin, 2008). Likewise, men may erroneously think that frequent bicycling is not a risk factor for male infertility, because they believe that nearly all exercise has a positive impact on general health.

By focusing solely on men, our study is among the first to provide insight into the current state of men's fertility knowledge. While further studies are required to confirm these findings, we identified specific gaps in knowledge in the general population. Public health initiatives should tailor campaigns to educate men about the lesser known associations with male infertility, particularly those that are most prevalent and preventable through lifestyle modification. Our results also reveal men's preferences for receiving information. By increasing fertility knowledge, one can promote general health, through early diagnosis of related medical conditions and reduce the risk of infertility, with its attendant physical, emotional and financial costs.

Supplementary data

Supplementary data are available at <http://humrep.oxfordjournals.org/>.

Acknowledgements

We would like to thank Stephanie Robins for her assistance with all aspects of study design and implementation.

Authors' roles

P.Z., P.C., K.C.L., J.T. designed the survey questionnaire. P.Z. supervised data analysis and manuscript writing. D.D. conducted data analysis and wrote the manuscript. P.C., K.C.L., J.T. reviewed and revised the manuscript.

Funding

Canadian Institutes of Health Research (TE1-138296).

Conflict of interest

None declared.

References

Abarikwu SO. Causes and risk factors for male-factor infertility in Nigeria: a review. *Afr J Reprod Health* 2013; **17**:150–166.

- Bak CW, Seok HH, Song SH, Kim ES, Her YS, Yoon TK. Hormonal imbalances and psychosocial scars left behind in infertile men. *J Androl* 2012; **33**:181–189.
- Becker G, Castrillo M, Jackson R, Nachtigall RD. Infertility among low-income Latinos. *Fertil Steril* 2006; **85**:882–887.
- Benjamini Y, Hochberg Y. Controlling the false discovery rate: a practical and powerful approach to multiple testing. *J R Stat Soc* 1995; **57**:289–300.
- Berger M, Wagner TH, Baker LC. Internet use and stigmatized illness. *Soc Sci Med* 2005; **61**:1821–1827.
- Bretherick KL, Fairbrother N, Avila L, Harbord SHA, Robinson WP. Fertility and aging: do reproductive-aged Canadian women know what they need to know? *Fertil Steril* 2010; **93**:2162–2168.
- Bunting L, Boivin J. Decision-making about seeking medical advice in an internet sample of women trying to get pregnant. *Hum Reprod* 2007; **22**:1662–1668.
- Bunting L, Boivin J. Knowledge about infertility risk factors, fertility myths and illusory benefits of healthy habits in young people. *Hum Reprod* 2008; **23**:1858–1864.
- Bunting L, Tsubulsky I, Boivin J. Fertility knowledge and beliefs about fertility treatment: findings from the International Fertility Decision-making Study. *Hum Reprod* 2013; **28**:385–397.
- Chachamovich JR, Chachamovich E, Ezer H, Fleck MP, Knauth D, Passos EP. Investigating quality of life and health-related quality of life in infertility: a systematic review. *J Psychosom Obstet Gynaecol* 2010; **31**:101–110.
- Close CE, Roberts PL, Berger RE. Cigarettes, alcohol and marijuana are related to psyspermia in infertile men. *J Urol* 1990; **144**:900–903.
- Cossrow N, Falkner B. Race/ethnic issues in obesity and obesity-related comorbidities. *J Clin Endocrinol Metab* 2004; **89**:2590–2594.
- Daniluk JC, Koert E, Cheung A. Childless women's knowledge of fertility and assisted human reproduction: identifying the gaps. *Fertil Steril* 2012; **97**:420–426.
- Daniluk JC, Koert E. The other side of the fertility coin: a comparison of childless men's and women's knowledge of fertility and assisted reproductive technology. *Fertil Steril* 2013; **99**:839–846.
- Daniluk JC, Koert E. Fertility awareness online: the efficacy of a fertility education website in increasing knowledge and changing fertility beliefs. *Hum Reprod* 2015; **30**:353–363.
- De Souza GL, Hallak J. Anabolic steroids and male infertility: a comprehensive review. *BJU Int* 2011; **108**:1860–1865.
- Eisenberg ML, Shufeng L, Cullen MR, Baker LC. Increased risk of incident chronic medical conditions in infertile men: analysis of United States claims data. *Fertil Steril* 2016; **105**:629–636.
- Ekelin M, Åkesson C, Ångerud M, Kvist LJ. Swedish high school students' knowledge and attitudes regarding fertility and family building. *Reprod Health* 2012; **9**:1–8.
- Gimenes F, Souza RP, Bento JC, Teixeira JVV, Maria-Engler SS, Bonini MG, Consolaro MEL. Male infertility: a public health issue caused by sexually transmitted pathogens. *Nat Rev Urol* 2014; **11**:672–687.
- Green DM, Kawashima T, Stovall M, Leisenring W, Sklar CA, Mertens AC, Donaldson SS, Byrne J, Robison LL. Fertility of male survivors of childhood cancer: a report from the Childhood Cancer Survivor Study. *J Clin Oncol* 2010; **28**:332–339.
- Harris ID, Fronczak C, Roth L, Meacham RB. Fertility and the aging male. *Rev Urol* 2011; **13**:e184–190.
- Juul A, Almstrup K, Andersson AM, Jensen TK, Jørgensen N, Main KM, Rajpert-De Meyts E, Toppari J, Skakkebaek NE. Possible fetal determinants of male infertility. *Nat Rev Endocrinol* 2014; **10**:553–562.
- Lampic C, Svanberg AS, Karlstrom P, Tyden T. Fertility awareness, intentions concerning childbearing, and attitudes towards parenthood among female and male academics. *Hum Reprod* 2006; **21**:558–564.
- Lundsberg LS, Pai L, Garipey AM, Xu X, Chu MC, Illuzzi JL. Knowledge, attitudes, and practices regarding conception and fertility: a population-based survey among reproductive-age United States women. *Fertil Steril* 2014; **101**:767–774.

- Lunenfeld B, Van Steirteghem A. Infertility in the third millennium: implications for the individual, family and society: condensed meeting report from the Bertarelli Foundation's second global conference. *Hum Reprod Update* 2004;**10**:317–326.
- Marriott JV, Stec P, El-Toukhy T, Khalaf Y, Braude P, Coomarasamy A. Infertility information on the World Wide Web: a cross-sectional survey of quality of infertility information on the internet in the UK. *Hum Reprod* 2008;**23**:1520–1525.
- Martins MV, Basto-Pereira M, Pedro J, Peterson B, Almeida V, Schmidt L, Costa ME. Male psychological adaptation to unsuccessful medically assisted reproduction treatments: a systematic review. *Hum Reprod Update* 2016;**22**:466–478.
- Michalakis K, Mintziori G, Kaprara A, Tarlatzis BC, Goulis DG. The complex interaction between obesity, metabolic syndrome and reproductive axis: a narrative review. *Metabolism* 2013;**62**:457–478.
- Morey AF, Metro MJ, Carney KJ, Miller KS, McAninch JW. Consensus on genitourinary trauma: external genitalia. *BJU Int* 2004;**94**:507–515.
- MRIA (Marketing Research and Intelligence Association). *MRIA's Code of Conduct for Market and Social Research*. 2015. <http://mria-arim.ca/sites/default/uploads/files/MRIA-Revised-Standards-Navigable-PDF-rev.pdf>. (7 January 2016, date last accessed).
- Oliva A, Spira A, Multigner L. Contribution of environmental factors to the risk of male infertility. *Hum Reprod* 2001;**16**:1768–1776.
- Okamura K, Bernstein J, Fidler AT. Assessing the quality of infertility resources on the world wide web: tools to guide clients through the maze of fact and fiction. *J Midwifery Womens Health* 2002;**47**:264–268.
- Oliffe JL, Phillips MJ. Men, depression and masculinities: a review and recommendations. *J Mens Health* 2008;**5**:194–202.
- Pellati D, Mylonakis I, Bertoloni G, Fiore C, Andrisani A, Ambrosini G, Armanini D. Genital tract infections and infertility. *Eur J Obstet Gynecol Reprod Biol* 2008;**140**:3–11.
- Peng X, Zeng X, Peng S, Deng D, Zhang J. The association risk of male subfertility and testicular cancer: a systematic review. *PLOS ONE* 2009;**4**: e5591. doi:10.1371/journal.pone.0005591.
- Pergialiotis V, Prodromidou A, Frountzas M, Korou LM, Vlachos GD, Perrea D. Diabetes mellitus and functional sperm characteristics: A meta-analysis of observational studies. *J Diabetes Complications* 2016;**30**: 1167–1176.
- Peterson BD, Pirritano M, Tucker L, Lampic C. Fertility awareness and parenting attitudes among American male and female undergraduate university students. *Hum Reprod* 2012;**27**:1375–1382.
- Quach S, Librach C. Infertility knowledge and attitudes in urban high school students. *Fertil Steril* 2008;**90**:2099–2106.
- Schisterman EF, Mumford SL, Chen Z, Browne RW, Boyd Barr D, Kim S, Buck Louis GM. Lipid concentrations and semen quality: the LIFE study. *Andrology* 2014;**2**:408–415.
- Sermondade N, Faure C, Fezeu L, Shayeb AG, Bonde JP, Jensen TK, Van Wely M, Cao J, Martini AC, Twigt JM et al. BMI in relation to sperm count: an updated systematic review and collaborative meta-analysis. *Hum Reprod Update* 2013;**19**:221–231.
- Shefi S, Tarapore PE, Walsh TJ, Croughan M, Turek PJ. Wet heat exposure: a potentially reversible cause of low semen quality in infertile men. *Int Braz J Urol* 2007;**33**:50–56.
- Short CE, Vandelanotte C, Dixon MW, Rosenkranz R, Caperchione C, Hooker C, Karunanithi M, Kolt GS, Maeder A, Ding H et al. Examining participant engagement in an information technology-based physical activity and nutrition intervention for men: the Manup randomized controlled trial. *JMIR Res Protoc* 2014;**3**:e2.
- Statistics Canada. *General Social Survey, Cycle 25, 2011 [Canada]: Family [public microdata file]*. Ottawa: Statistics Canada, 2012.
- Trent M, Millstein SG, Ellen JM. Gender-based differences in fertility beliefs and knowledge among adolescents from high sexually transmitted disease-prevalence communities. *J Adolesc Health* 2006;**38**:282–287.
- Walsh TJ. Male reproductive health and prostate cancer risk. *Curr Opin Urol* 2011;**21**:506–513.
- Wenger LM. Beyond ballistics: expanding our conceptualization of men's health-related help seeking. *Am J Mens Health* 2011;**5**:488–499.
- Whitten A, Remes O, Sabarre K, Khan Z, Phillips K. Canadian university students' perceptions of future personal infertility. *Open J Obstet Gynecol* 2013;**3**:561–568.
- Wiser HJ, Sandlow J, Köhler TS. Causes of male infertility. In: Parekattil JS, Agarwal A (eds). *Male Infertility: Contemporary Clinical Approaches, Andrology, ART & Antioxidants*. New York: Springer New York, 2012:3–14.
- Wright C, Milne S, Leeson H. Sperm DNA damage caused by oxidative stress: modifiable clinical, lifestyle and nutritional factors in male infertility. *Reprod Biomed Online* 2014;**28**:684–703.