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Medical, behavioural and social preconception and interconception risk factors among pregnancy planning and recently pregnant Canadian women

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ABSTRACT

Objectives The objective of this study is to describe the clustering of medical, behavioural and social preconception and interconception health risk factors and determine demographic factors associated with these risk clusters among Canadian women.

Design Cross-sectional data were collected via an online questionnaire assessing a range of preconception risk factors. Prevalence of each risk factor and the total number of risk factors present was calculated. Multivariable logistic regression models determined which demographic factors were associated with having greater than the mean number of risk factors. Exploratory factor analysis determined how risk factors clustered, and Spearman's r determined how demographic characteristics related to risk factors within each cluster.

Setting Canada.

Participants Participants were recruited via advertisements on public health websites, social media, parenting webpages and referrals from ongoing studies or existing research datasets. Women were eligible to participate if they could read and understand English, were able to access a telephone or the internet, and were either planning a first pregnancy (preconception) or had ≥1 child in the past 5 years and were thus in the interconception period.

Results Most women (n=1080) were 34 or older, and were in the interconception period (98%). Most reported risks in only one of the 12 possible risk factor categories (55%), but women reported on average 4 risks each. Common risks were a history of caesarean section (33.1%), miscarriage (27.2%) and high birth weight (13.5%). Just over 40% had fair or poor eating habits, and nearly half were not getting enough physical activity. Three-quarters had a body mass index indicating overweight or obesity. Those without a postsecondary degree (OR 2.35; 95% CI 1.74 to 3.17) and single women (OR 2.22, 95% CI 1.25 to 3.96) had over twice the odds of having more risk factors. Those with two children or more had 60% lower odds of having more risk factors (OR 0.68, 95% CI 0.52 to 0.86). Low education and being born outside Canada were correlated with the greatest number of risk clusters.

Conclusions Many of the common risk factors were behavioural and thus preventable. Understanding which groups of women are prone to certain risk behaviours provides opportunities for researchers and policy-makers to target interventions more efficiently and effectively.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Preconception and interconception health are key for optimising maternal and fetal/infant outcomes; however, many women enter pregnancy in suboptimal health due to sociodemographic, physiological or behavioural risk factors. This study aimed to describe preconception and interconception risk factors in a Canadian population, and to identify potential targets for public health intervention.

WHAT THIS STUDY ADDS

⇒ Common risk factors for poor preconception and interconception health were mostly sociodemographic and behavioural, with over 50% of participants reporting risks in only one risk category (most commonly reproductive health); and participants reporting on average four risks each. Low education and being born outside Canada were associated with the greatest number of risk factors.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Most of the common risk factors for poor preconception and interconception health are preventable, through individual behaviour change and/or systemic healthcare improvements. This study provides targets for promoting preconception and interconception healthcare intervention in Canada.

INTRODUCTION

Despite medical advances, disparities in reproductive, maternal and infant health outcomes persist in industrialised countries.[1] Research is increasingly showing that health prior to each pregnancy (preconception or interconception health) strongly influences reproductive and perinatal outcomes.[2] The preconception and interconception periods

are an opportune time to address reproductive intentions, and to promote and support well-being and healthy behaviour change, and interventions during this time have been shown to be effective when used.[3 4] However, many women are in suboptimal health prior to pregnancy, with ever-growing rates of chronic disease and obesity.[5] Negative health behaviours such as smoking, alcohol use, poor nutrition, and low physical activity persist during pregnancy[6 7] despite evidence that these factors affect reproductive health and perinatal growth and metabolic health outcomes.[2 3] Research over the last 30 years has shown the influence of a range of preconception behaviours on pregnancy, maternal and infant health outcomes, including the positive influence of pregnancy planning, healthy diet and micronutrient supplementation, physical activity and oral hygiene.[2 3 8–10] Conversely, excess weight, smoking, recreational drug and alcohol use, poor mental health and chronic health conditions negatively impact the health of the mother during and postpregnancy, and can affect offspring growth in utero, metabolic programming, future obesity risk, and thus future health and morbidity.[2 3 8 9 11 12] The importance of creating health interventions to optimise individuals' health behaviours prior to pregnancy is thus clear. However, further data are needed on high-risk groups that should be targeted and on their specific preconception or interconception health needs, so that resources can be used efficiently and effectively.

In 2006, the Centers for Disease Control and Prevention (CDC) published 10 recommendations to improve preconception and interconception healthcare for women before pregnancy.[13] It defined a set of interventions to identify and modify biomedical, behavioural and social risks to women's pregnancy health outcomes through prevention and management, including increasing public awareness of the importance of preconception health, providing risk assessments and education during primary healthcare visits, and focusing on interconception care, among others. However, in order to implement such programmes, it is essential to have sufficient knowledge of the prevalence and patterns of preconception and interconception risk factors. Developing specific monitoring systems that track maternal health behaviours, experiences, and health conditions would be beneficial.

To guide the development of universal preconception and interconception care programmes, the overall objective of this study was to examine the medical, behavioural, and social preconception and interconception health risk factors among Canadian women planning for a pregnancy and/or recently pregnant. Using the risk factors outlined in the evidence-based Preconception Health Care Tool,[14] which is a Canadian tool developed to encourage healthcare providers to engage patients in developing reproductive health plans, our aims were threefold: (1) to determine the prevalence, and quantity of preconception and interconception risk factors; (2) to identify how these risk factors cluster together and (3) to determine which demographic characteristics are associated with (A) a higher number of risk factors and (B) each cluster of risk factors identified.

METHODS

Sample

This study was part of a large cross-sectional survey of preconception care attitudes, beliefs and intervention preferences of women and men across Canada, undertaken in May to June 2019. Participants were recruited via advertisements on public health unit websites and social media accounts and parenting webpages, referrals from ongoing studies and identification of eligible individuals through existing research datasets. Women and men were eligible to participate if they could read and understand English, were able to access a telephone or the internet, were either planning a pregnancy (preconception) or had ≥1 child in the past 5 years and were thus in the interconception period. Individuals interested in participating in the study received an introductory email after contacting the research team. Those who were eligible and agreed to participate received a link to an online consent form and questionnaire using the Research Electronic Data Capture system. Research staff assisted individuals who had difficulty accessing the online questionnaire and sent reminder follow-up telephone calls. For this study, only women were included. This study was completed as formative work for a large randomised controlled trial evaluating a preconception–early childhood intervention on the prevention of child obesity among pregnancy-planning women and their partners (HeLTI Canada).[15]

Measures

The measures selected for this study were guided by the Centre for Effective Practice Preconception Health Care Tool, which is used in the province of Ontario to guide preconception and interconception healthcare during primary care visits.[14] Twelve of the 15 risk categories of the tool were assessed: reproductive history, sexual health, chronic medical conditions, medications, mental health, tobacco use, alcohol and other substance use, infectious diseases, nutrition, weight status, physical activity and psychosocial stressors. Three categories were omitted due as they were not relevant for the future trial: vaccinations and immunity, family and genetic history, and environmental exposures.

Pregnancy planning

Women were defined as pregnancy planning if they indicated that they were currently trying to get pregnant, or considering a pregnancy in the next 5 years.

Reproductive history

Reproductive history was assessed using the question, 'Have you ever experienced any of the following with a pregnancy?' Response options were: miscarriage,

stillbirth, use of artificial reproductive therapies (ART), uterine abnormalities, caesarean section (planned and unplanned), preterm birth, low or high birth weight, gestational diabetes, high blood pressure that developed during pregnancy and birth defects. Five sexually transmitted infections (STIs) were assessed to evaluate sexual health using the question, 'Have you ever tested positive for any of the following in the past year?' with response options: chlamydia, syphilis, trichomoniasis, gonorrhoea and genital herpes. Responses were combined to create an indicator for testing positive for any STI.

Chronic medical conditions were assessed using the question, 'Have you ever been diagnosed with any of the following conditions?' Response options were: asthma, cancer, diabetes, hypertension, inflammatory bowel disease (IBD), phenylketonuria, renal disease, seizure disorder, systemic lupus erythematosus or rheumatoid arthritis or another autoimmune disease, thromboembolic disease and thyroid disease. Infectious diseases were evaluated using the same question as for chronic medical conditions but for the following response options: cytomegalovirus, hepatitis B, hepatitis C, HIV, parvovirus, toxoplasmosis and tuberculosis. An indicator was created for a diagnosis of any of the listed infectious disease. Medication use was evaluated using the question, 'Do you currently use any of the following medications?' with the response options: prescribed medications, over-the-counter medications and alternative/complimentary medications (including herbal, natural, and weight-loss medications, and athletic products or supplements).

Mental health was ascertained using two screening tools. Depressive symptoms were measured using the Patient Health Questionnaire (PHQ-9),[16] a 9-item scale assessing a range of potential symptoms experienced in the last 2 weeks. Response options range from 'not at all' (0) to 'nearly every day' (3). Items are summed to create a total score; those scoring >10 are considered to have moderate to severe depressive symptoms. This scale has been shown to be valid and reliable in similar populations[17] and in our sample had a Cronbach's alpha of 0.83. Anxiety symptoms were measured using the Generalised Anxiety Disorder (GAD-7),[18] a 7-item scale assessing symptoms experienced in the last 2 weeks. Response options, scoring and threshold for identifying significant symptoms are the same as for the PHQ-9. The GAD-7 has been shown to be valid and reliable in similar populations[19] and had a Cronbach's alpha of 0.89 in our sample. Those who scored >10 on the PHQ-9 and the GAD-7 were considered to have comorbid symptoms of depression and anxiety.

Tobacco use was assessed based on a question asking, 'On a typical day, how many cigarettes do you smoke?' Responses were collapsed into none vs any. Regular alcohol use was defined as drinking more than once per week, which was evaluated using the question, 'How often do you drink a beverage containing any alcohol?'. Regular cannabis use was defined as at least monthly medicinal or recreational use based on the question, 'In the past 12 months, have you used cannabis (marijuana) for non-medical/recreational reasons?' A similar question was asked for medical drug use. For those with a positive response to either of those questions, another question was asked about frequency of use.

Nutrition

The PRIMEScreen tool[20] consists of 18 questions about the average frequency of consumption, over the previous year, of specified foods and food groups and another seven items about vitamin and supplement intake. It particularly targets intake of fruits, vegetables, whole and low-fat dairy products, whole grains, fish and red meat as well as other foods that are major contributors to the intake of saturated and trans fats. Those with a total score of <12 were categorised as having fair/poor eating habits. Weight status was assessed using self-reported weight and height, which were used to calculate body mass index (BMI) based on the kg/m^2 formula. An indicator was created for those with calculated BMI ≥25 kg/m^2 (ie, overweight or obese). Physical activity was evaluated using the WHO guidelines for healthy physical activity levels, which define low physical activity as getting less than 600 metabolic equivalent (METS) per week. The number of METS obtained weekly was estimated using the Global Physical Activity Questionnaire (GPAQ).[21] Based on responses to the GPAQ, an indicator was created to identify those achieving less than 600 METS weekly.

Psychosocial stressors included three measures: loneliness, low household income and unemployment. Loneliness was assessed using the three-item UCLA Loneliness Scale;[20 22] individuals scoring >5 were defined as being lonely. Socioeconomic status was assessed using self-reported household income, which was defined as low if reported as <$C50 000 annually. Current unemployment was determined by self-report.

The following maternal demographic variables were also assessed: age (years and categorised as <35 or ≥35), birth outside Canada (yes or no), marital status (married or common-law, and single, divorced, or widowed), number of children (<2 or ≥2) and education level (postsecondary degree, and less than postsecondary degree).

Statistical analysis

A description of the sample was provided using summary statistics, including means and SDs for continuous variables, and frequencies and percentages for categorical variables. Analyses were undertaken in SPSS (V.25), unless otherwise indicated. Statistical significance was established at $p<0.05$.

Objective 1

For each of the 12 risk categories investigated, the prevalence of having a risk factor was calculated by dividing positive cases by the sample of those with non-missing data on that risk factor. For multifactorial categories, prevalence was also calculated for having at least one risk factor from the category. Next, the total number of risk factors experienced by each woman was determined and

the mean, median, and range were calculated, along with the SDs and IQR.

Objective 2

To establish clusters of risk factors, exploratory factor analysis was undertaken using Mplus, V.7.[23] Tetrachoric correlations were estimated to address the binary nature of the risk factors using the categorical option in Mplus. The analysis was undertaken using a robust mean and variance adjusted weighted least squares estimator. The Geomax rotation was used, which allows for correlation between the clusters. Model convergence was initially a problem due to the inclusion of risk factors that were present in a very small proportion of the sample. To obtain a reliable solution, therefore, we included only risk factors prevalent in ≥5% of the sample. To determine the optimal number of clusters to extract, parallel analysis was undertaken using a SAS V9.4 program.[24] The goal of parallel analysis is to determine if the number of factors found in the solution accounts for more variation than the number of factors extracted using random data. Model fit was assessed using root mean square error of approximation (RMSEA<0.06, recommended), Comparative Fit Index (CFI>0.95), Tucker-Lewis Index (TLI<0.95, recommended) and standardised root mean square residual (SRMR <0.08, recommended).[25] Once the optimal number of clusters was determined and adequate model fit was confirmed, the final solution was reviewed for clinical meaningfulness.

Objective 3

Based on the number of risk categories established in objective 1, the sample was divided into two groups: those with the mean number of risk factors or fewer and those with greater than the mean number of risk factors. Using this measure as the outcome, a multivariable logistic regression model was specified to determine the demographic factors that were associated with having greater than the mean number of risk factors. Demographic variables were selected a priori including age, education level, marital status, parity and country of birth. These variables were selected because they were not directly included in the Centre for Effective Practice Preconception Health Care Tool, but were hypothesised to be related to many of the risk categories based on the literature. All independent variables were entered into the model simultaneously and left in regardless of p value. Next, for each of the risk clusters established in objective 2, a score was calculated based on the number of risk factors present for the individual. For example, for a cluster with three risk factors, women either received a score of 0, 1, 2 or 3, depending on if she had none of the risk factors, one, two or all the risk factors in the cluster. Spearman's rho was calculated to determine how the demographic characteristics listed above related to the scores derived for each of the clusters. The sample included both pregnancy planning and recently pregnant individuals. To test if the findings would in those who were actively pregnancy planning vs those who were in the interconception period but not actively pregnancy planning, we ran a sensitivity analysis focusing on only women who reported that they were planning for a pregnancy (n=529).

RESULTS

In total, 1080 women were included in the main analysis. Almost all women had a previous pregnancy (97.8%) and at least one live birth (97.3%). The average age was 33.8 years (SD=4.4), with 42.9% of the women being 35 years or older. Just under a quarter had less than a university degree (23.2%). Approximately one in five women were born outside of Canada (17.7%) and more than half had at least two children (61.7%). Exactly 529 (49.0%) women reported that they were planning for a pregnancy in the next 5 years.

Characteristics of preconception and interconception risk factors

Overall, the mean number of risk factors was 4.47 (SD=2.51), the median was 4 (IQR=3–6) and the range was 0–14. This was highly consistent in the subsample of pregnancy-planning women (mean=4.34, SD=2.45; median=4; IRQ=2–6; range=0–13). Table 1 presents the prevalence of each of the risk factors comprising the 12 preconception and interconception risk categories found in the Preconception Health Care Tool. While the majority had risks in only 1 of the possible 12 risk factors categories (55%), 27% had risk in 2 risk factor categories and 17.8% had risk in 3 categories or more. Almost two-thirds of the women (62.8%) had one or more risk factors related to their reproductive health history. When looking at the reproductive health risk factors separately, the most common risks were a history of caesarean section (33.1%), miscarriage (27.2%) and high birth weight (13.5%). The remaining risk factors occurred less frequently and ranged in prevalence from a high of 7.3% for a history of ART to a low of <1% for stillbirth. A total of 24 (2.2%) reported a diagnosis of an STI in the past year, while more than one in four relayed a diagnosis of one of the 12 chronic medical conditions assessed (26.3%). The most prevalent diagnosis was asthma (15.1%), followed by thyroid disease (7.3%) and IBD (2.9%). Each of the other conditions was prevalent in less than 2% the sample (data not shown). Only two participants reported one of the seven infectious diseases assessed (0.02%). Slightly over one in two participants (52.0%) were taking medication. Taking a prescribed medication was most common (35.2%) followed by an over-the-counter medication (21.2%); over 1 in 10 women was using a complimentary or alternative therapy medication (14.2%).

Approximately 1 in 10 women scored >10 on the GAD-7, indicating significant symptoms of anxiety (9.1%). Slightly fewer (8.5%) were found to have moderate or severe symptoms of depression. One in 20 had significant symptoms of both anxiety and depression (4.9%). Occasional or daily tobacco use was reported by just over 1 in 20

Table 1 Characterisation of risk categories and risk factors

	Full sample		Pregnancy planning	
Risk category	**N (%)**	**Total N**	**N (%)**	**Total N**
Reproductive history		1080		529
Any risk factor from category	678 (62.8)		318 (60.1)	
Top three from category:				
1. Caesarean section	358 (33.1)		152 (28.7)	
2. Miscarriage	294 (27.2)		142 (26.8)	
3.High birth weight	146 (13.5)		57 (10.8)	
Sexual health		1080		529
Any risk factor from category	24 (2.2)		12 (2.3)	
Chronic medical conditions		1080		529
Any risk factor from category	284 (26.3)		125 (23.6)	
Top three from category:				
1. Asthma	163 (15.1)		72 (13.6)	
2. Thyroid disease	79 (7.3)		35 (6.6)	
3. Inflammatory bowel disease	31 (2.9)		12 (2.3)	
Medications		1080		529
Any risk factor from category	562 (52.0)		278 (52.6)	
Prescription	380 (35.2)		182 (34.4)	
Over-the-counter	229 (21.2)		116 (21.9)	
Complimentary/alternative	153 (14.2)		69 (13.0)	
Mental health				
Any risk factor from category	134 (12.4)		70 (13.2)	
Anxiety (GAD-7 >10)	96 (9.1)	1055	53 (10.2)	518
Depression (PHQ >10)	90 (8.5)	1060	48 (9.2)	520
Both risk factors	52 (4.9)	1055	31 (6.0)	518
Tobacco use	58 (5.4)	1080	26 (4.9)	529
Alcohol and other substance use				
Any risk factor from category	290 (26.9)		110 (21.1)	
Alcohol use (>1/week)	228 (22.2)	1026	80 (16.0)	501
Cannabis use	86 (8.1)	1067	40 (7.7)	522
Infectious diseases		1080		
Any risk factor from category	2 (0.02)		0 (0)	
Nutrition	418 (40.7)	1027	215 (42.8)	502
Weight status		1043		505
BMI ≥25	526 (50.4)		265 (52.5)	
Overweight (BMI=25–29.9)	286 (27.4)		142 (28.1)	
Obese (BMI >29.9)	240 (23.0)		123 (24.4)	
Underweight (BMI <20)	33 (3.0)		17 (3.4)	
Low physical activity	434 (43.1)	1008	221 (44.9)	492
Psychosocial stressors				
Any risk factor from category	466 (43.1)		225 (42.5)	
Loneliness	336 (32.0)	1050	157 (30.5)	515
Low income	152 (14.1)	1080	88 (16.6)	529
Unemployment	116 (10.7)	1080	57 (10.8)	529

BMI, body mass index; GAD, Generalized Anxiety Disorder; PHQ, Patient Health Questionnaire.

(5.4%), while regular alcohol (22.2%) and/or cannabis use (8.1%) was reported by over a quarter of the sample (26.9%). Just over 40% had fair or poor eating habits, and one in two had a BMI ≥25 kg/m^2, of which just under half (23.0%) had a BMI >29.9 kg/m^2 (23.0). Additionally, 43% were not getting enough physical activity. Exactly 43.1% reported at least one psychosocial stressor—loneliness was the most common single stressor reported in this sample (32.0%), followed by low income (14.1%) and unemployment (10.7%). The distribution of risk factors was very similar when focusing on pregnancy-planning women only, falling within a few percentage points of the full sample. An exception was frequent alcohol use, which was slightly lower among pregnancy planning women.

Risk factor clusters

A solution based on nine clusters was initially selected using parallel analysis; however, the result had several cross-loaded items and lacked clinical meaningfulness. A solution based on eight clusters resolved many of the cross-loaded items and was far more clinically applicable, so was selected as the final model. The eight-cluster model had very good fit, as reflected by model fit indices (RMSEA=0.013; CFI=0.985; TLI=0.963; SRMR=0.045) (see table 2 for the risk factors, loading values and clusters extracted).

The first cluster 'thyroid' included risk factors of having thyroid disease and taking prescription medication. The second named 'fertility' included ART, a history

Table 2 Unstandardised factor loadings for the eight-dimensional model of preconception and interconception health risk factors in the full sample (n=1080)

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8
	Thyroid	Fertility	Smoking	Delivery outcomes	Mental health	Pregnancy outcomes	Low income	Health behaviours
Prescription medication	1.416	0	0.001	0.029	0.013	0.007	0.025	0.025
Thyroid disease	0.451	0.296	0.012	0.055	0.282	0.018	0.098	0.055
ART use	0.014	0.621	0.045	0.144	0.005	0.025	0.171	0.105
Miscarriage	0.032	0.36	0.04	0.073	0.017	0.098	0.123	0.033
Complementary medication	0.018	0.358	0.04	0.009	0.022	0.025	0.129	0.062
Cannabis use	0.097	0.045	0.654	0.075	0.045	0.031	0.011	0.128
Tobacco use	0.007	0.365	0.548	0.021	0.066	0.207	0.143	0.034
Preterm birth	0.189	0.108	0.51	0.171	0.053	0.013	0.178	0.016
Planned c-section	0.011	0.087	0.013	0.847	0.036	0.02	0.008	0.039
Unplanned c-section	0.009	0.048	0.025	0.691	0.029	0.324	0.019	0.063
High birth weight	0.021	0.088	0.166	0.256	0.094	0.054	0.18	0.052
Depression	0.016	0.099	0.05	0.006	0.985	0.007	0.078	0.027
Anxiety	0.1	0.09	0	0.033	0.792	0.018	0.041	0.02
Loneliness	0.017	0.021	0.096	0.062	0.618	0.014	0.139	0.015
BMI status	0.004	0.012	0.04	0.017	0.062	0.714	0.183	0.013
Gestation diabetes	0.009	0.022	0.376	0.021	0.031	0.678	0.054	0.209
High pregnancy blood pressure	0.033	0.319	0.271	0.029	0.058	0.368	0.034	0.098
Over-the-counter medication	0.124	0.204	0.028	0.029	0.023	0.258	0.156	0.058
Asthma	0.045	0.284	0.066	0.081	0.088	0.251	0.053	0.161
Unemployment	0.001	0.001	0.006	0.084	0.05	0.268	0.807	0.014
Low income	0.044	0.117	0.144	0.133	0.041	0.008	0.574	0.061
Frequent alcohol use	0.044	0.09	0.16	0.057	0.213	0.116	0.415	0.013
Fair/poor eating habits	0.005	0.022	0.354	0.006	0.202	0.02	0.028	0.629
Low physical activity	0.034	0.027	0.045	0.006	0.094	0.078	0.224	0.533

Only risk factors prevalent in ≥5% of the sample were included in this model.
Shaded boxes represent the items that load onto each cluster
ART, artificial reproductive therapy; BMI, body mass index.

of miscarriage, and the use of complementary/alternative medications. The third cluster 'smoking' included cannabis and tobacco use and preterm birth. The fourth cluster called 'delivery outcomes' included planned or emergency caesarean section and high birth weight. 'Mental health' was the fifth cluster, and included anxiety, depression and loneliness. The sixth was called 'pregnancy outcomes' and included BMI status, high blood pressure that developed during pregnancy, gestational diabetes, over-the-counter medication use and an asthma diagnosis. The seventh cluster, 'low income' comprised unemployment, low income and alcohol use. The final cluster 'health behaviours' included poor eating habits and low physical activity. Some lack of separation was noted for two clusters: fertility and poor pregnancy outcomes. With the exception of asthma, which had a slightly higher loading on the 'fertility' cluster but was moved to the 'pregnancy outcomes' cluster, we left the item in the cluster it loaded highest.

Several statistically significant correlations among clusters were observed. 'Poor mental health' was correlated with 'thyroid', 'smoking', ' pregnancy outcomes' and 'low income'. A correlation was also found between 'thyroid' and 'pregnancy outcomes'. When the EFA was run in the subsample of pregnancy-planning women only, an eight-cluster solution was also found, as indicated by parallel analysis. This model also had good fit (RMSEA=0.00, CFI=1.00, TLI=1.06, SRMR=0.053). Six out of the eight clusters were nearly identical to the full sample including 'thyroid', 'low income', 'delivery outcomes', 'mental health', 'smoking' and 'health behaviours'. However, 'pregnancy outcomes' and 'fertility', which had some lack of separation in the full sample, were not well separated in this model. See online supplemental appendix 1 for the eight-cluster model in the subsample.

Demographic correlates of number and type of risk factors

Multivariable logistic regression was used to determine the demographic correlates of having more than the mean number of risk factors. As shown in table 3, significant correlates included multiparity, being single, low education, and being aged 35 years or older. Specifically, after accounting for all other model variables, those aged 35 or older had 43% higher odds of have more than the mean number of risk factors (OR 1.43, 95% CI 1.11 to 1.84). Those without a postsecondary degree (OR 2.35, 95% CI 1.74 to 3.17) and single women (OR 2.22, 95% CI 1.25 to 3.96) had over twice the odds of having over the mean number of risk factors, over and above all other model variables. Finally, those with two children or more had 60% lower odds of having over the mean number of risk factors (OR 0.68, 95% CI 0.52 to 0.86). The results were highly similar when focusing on pregnancy-planning women only, with the exception that single marital status was not significant (see table 3 for details).

As shown in table 4, every demographic characteristic investigated was significantly correlated with at least one cluster of risk factors. Low education and being born outside Canada were correlated with the greatest number of risk clusters. Low education was positively correlated with 'smoking', ' mental health', 'pregnancy outcomes' and 'low income'. Being born outside of Canada was negatively correlated with 'thyroid', 'smoking' and 'pregnancy outcomes', but positively correlated with 'health behaviours'. Age was positively correlated with 'fertility' and 'delivery outcomes', and negatively correlated with 'low income'. Multiparity was negatively correlated with 'delivery outcomes' and 'low income'. Finally, being single was positively correlated with 'mental health' and 'low income'. The analysis was repeated focusing only on pregnancy-planning mothers but using only the clusters that were the same in the overall sample. The pattern of findings was very similar, except that the correlations with multiparity were larger in some cases, and a few correlations were not statistically significant in the smaller sample, despite being of a similar magnitude as those in the full sample (see table 4).

DISCUSSION

A broad range of preconception and interconception risk factors were found in this sample of women, who fell largely within the inter-conception period, with over one-third having a risk factor from five or more risk categories contained in the Preconception Health Care Tool.

Table 3 Multivariable logistic regression of associations between demographic variables and of having greater than average number of preconception and interconception health risk factors among pregnancy planning and recently pregnant women

	Full sample (N=1080)				Pregnancy planning women (N=529)			
		95% CI				95% CI		
Risk factor	OR*	Lower	Upper	P value	OR*	Lower	Upper	P value
Multiparity	0.67	0.52	0.86	0.002	0.53	0.37	0.76	0.001
Single marital status	2.22	1.25	3.96	0.007	1.29	0.56	2.95	0.55
Low education	2.35	1.74	3.17	0.000	2.51	1.66	3.81	0.000
Not born in Canada	0.80	0.58	1.10	0.17	0.84	0.53	1.34	0.46
Aged ≥35 years	1.43	1.11	1.84	0.006	1.50	1.02	2.20	0.04

*OR is adjusted for all other variables in the model.

Table 4 Correlation coefficients for the relationship between demographic characteristics and risk scores derived for the eight clusters of risk factors

	Full sample (n=1080)					Pregnancy planning women (n=529)				
Cluster	Multiparity	Single marital status	Low education	Born outside Canada	Age 35+	Multiparity	Single marital status	Low education	Born outside Canada	Age 35+
Thyroid	0.02	0.05	0.05	−0.09**	0.00	0.02	−0.01	0.02	−0.09*	−0.03
Fertility	−0.04	0.06	0.04	−0.05	0.16***	--	--	--	--	--
Smoking	−0.02	0.06	0.14***	−0.07*	0.04	−0.04	0.09*	0.09*	−0.08	0.05
Delivery outcomes	−0.12***	−0.04	0.02	0.00	0.09**	−0.16***	−0.08	0.01	0.03	0.15**
Mental health	−0.03	0.16***	0.12***	−0.03	−0.04	−0.04	0.07	.15***	−0.04	−0.06
Pregnancy outcomes	0.02	0.00	0.11***	−0.09**	0.00	--	--	--	--	--
Low income	−0.08**	0.14***	0.18***	0.01	−0.07*	−0.13**	0.13**	0.26***	0.05	−0.06
Health behaviours	−0.05	0.06	0.06	0.09**	−0.01	−0.11*	0.06	0.09*	0.08	−0.01

-- correlations were not computed because the factors did not line up identically.
*P<.05; **p<0.01; ***p<0.001.

Overall, women had approximately four risk factors each, and just under one in four women had two risk factors or fewer. Common risk factors included reproductive history, medication use and having a BMI ≥25 kg/m^2, low physical activity levels, having at least one of the psychosocial stressors assessed and having poor eating habits. Women who were single, had a lower education or were older than 35 years had higher odds of having a greater than average number of risk factors. Women who already had children had lower odds of having a greater than average number of risk factors, adjusting for age, education, marital status and nativity.

There was some evidence of socioeconomic inequalities in risk profiles. Those with lower education had higher odds of having a greater number of risk factors independently of the demographic variables included, and low education was correlated with risk clusters including 'smoking', ' mental health', 'pregnancy outcomes' and 'low income'. Similarly, higher preconception and pregnancy risk in lower socioeconomic groups has been shown in Canada and globally.[26–28] This suggests that the same people who are likely to have barriers to accessing healthcare might actually need the most comprehensive preconception and interconception health counselling programs.[29] Educational and socioeconomic risk factors may be linked to how healthcare is being allocated or accessed,[30] and it is possible that women who are less educated do not know to seek out healthcare when pregnancy planning.[31 32] This highlights the importance of providing universal preconception counselling to all those of reproductive age, and piggybacking opportunities for such counselling onto routine medical care.[13] It also suggests that to reduce preconception and interconception risks at a population level, we need to address systematic factors such as basic income and education in addition to individual factors and use broad public health messaging to entire populations.

Unsurprisingly, older age was independently associated with having a higher-than-average number of risk factors, and the risk clusters of 'fertility' and 'delivery outcomes'. These risk clusters contain factors that are largely medical or biological, and thus not always preventable. However, since older age is a well-known preconception risk factor in and of itself,[33] strategies already exist in the healthcare sector to minimise poor pregnancy outcomes in these pregnancies. Conversely, age (and multiparity) was negatively associated with the 'low-income' cluster. Women who are older may therefore be at risk for pregnancy complications due to their biology, but could counteract this to a certain degree by having less chance of socioeconomic risk factors impacting pregnancy outcomes, possibly by delaying pregnancy for education or career opportunities. A study conducted in Korea showed that in woman at risk for poor pregnancy outcomes due to low income, those aged >35 years were at even greater risk of maternal morbidity.[34] Women who already have children are likely choosing to fall pregnant again only when they are in a comfortable position economically.

Since many women are choosing to have children later (the CDC shows that the mean age at first birth in the USA is currently 27 years),[35] potentially to focus on career development and income generation prior to conception, it is important to understand the benefits and risks of doing so for pregnancy outcomes. It would be interesting to examine whether better economic standing is able to counteract the detrimental effect of advanced maternal age on pregnancy and delivery outcomes in this population.

Not being married or living common-law was associated with having a higher than average number of risk factors and the 'mental health' and 'low-income' clusters of risk factors in the full sample. However, in the subsample of pregnancy-planning women, single marital status was not associated with a higher number of risk factors or the 'mental health' cluster of risks, which may indicate a selection effect. While it is possible that fewer women who are unmarried and not living with a partner are planning pregnancies overall, those who are may have been in better health due to their planning. Nonetheless, the 'low-income' cluster of risks was related to being unmarried and not living with a partner in both the overall and subsample, meaning that those women had a higher risk scores than women in relationships based on factors including unemployment, low-income and regular alcohol consumption. In the USA, 40% of all births are to unmarried women.[35] Research has shown lower uptake of prenatal care in single mothers.[36] It is thus important to consider the relationship context when providing preconception and interconception risk counselling to women without a partner, especially as indicators suggest that this is a growing segment of the Canadian population.[37]

Interestingly, being born outside of Canada was negatively correlated with risk clusters 'thyroid', 'smoking' and 'pregnancy outcomes' but positively correlated with 'health behaviours'. The 'Healthy Immigrant Effect' is well documented; however, studies generally show worse maternal and infant health among foreign-born mothers.[38 39] Our findings suggest that the latter may be true with respect to health risk behaviours, specifically physical activity and eating habits. Cultural assimilation has been shown to result in health risk behaviours relating to lifestyle.[38] The women born outside Canada in our sample may also have had less opportunities for healthy living due to socioeconomic status or other barriers. This population group could therefore be considered the healthiest from a medical perspective; however, their health risk behaviours may be of concern and ultimately lead to the development of conditions such as gestational diabetes, gestational hypertension and obesity. Indeed, immigrant health has been shown to decline with duration of time spent in Canada.[38 39] This group should therefore be the target of culturally appropriate lifestyle interventions preconception and interconception, regardless of pregnancy planning. It would be important to conduct further research in this group to understand their social and home environments and their perceptions of their own health behaviours in general, in order to understand how best to intervene and avoid preventable pregnancy and offspring health complications.

Preconception and interconception health messages, recommendations, and guidelines originated in the USA, and the preconception movement has gained momentum internationally with a variety of strategies developed and tested for improving preconception and interconception health, and related outcomes. The shift to integrate preconception and interconception health promotion into the continuum of women's healthcare requires a diverse multilevel and multistrategic approach involving a range of sectors and health professionals to address the determinants of health.[40] The findings from this study provide an indication of intervention targets to improve preconception and interconception health in Canada, and point towards population groups that may be at higher risk. Improving preconception and interconception health and integrating health promotion strategies requires a system-wide effort to raise awareness of the importance of women's health prior to every pregnancy, creating supportive environments, as well as optimising clinical practice, policy and programmes informed by high-quality research and longitudinal studies.

Limitations of the study include the use of self-reported data, which may bias our estimates of risk factors; and the cross-sectional design of the study, which prevented investigation into the effect of the timing of these risk factors in relation to pregnancy. Further, we did not capture information on vaccinations and immunity, family and genetic history, and environmental exposures, which are also important components of preconception health. The sensitivity analyses demonstrated that, in general, the results applied to women who were recently pregnant or pregnancy planning. However, some divergence was noted between these two subsamples in the risk factor cluster models. Although an eight-cluster model was selected for both, the solution in the subsample was not as well separated as that in the full sample. Even in the full sample, some cross-loading was noticed between the clusters of fertility and pregnancy outcomes. This work was exploratory in nature and requires validation using confirmatory methods in a separate sample. Despite the study's large sample size, participants were mostly from one large province (Ontario), who were married or common-law; the sample under-represented those with very low education and income. As a result, the prevalence of some risk factors may be underestimated, especially those sensitive to low socioeconomic status. Future studies should aim to determine whether these risk factors are similar in other provinces and among different socioeconomic groups in Canada, as well as globally. This study took place prior to the COVID-19 pandemic; it is possible that preconception risks have increased due to restricted access to primary care. Future research

should look at the impact of the pandemic on preconception health specifically. The vast majority of participants already had at least one child. This means that the risk factors identified may have been precipitated by a previous pregnancy, suggesting that the profile of risk reported here is best interpreted as representing the interconception period. As interconception health should be an important part of broader preconception health counselling efforts, the information from this study remains highly relevant. While unplanned pregnancies can happen in the interconception period, it is possible that the risk factors associated with unplanned pregnancies in nulliparous women are unique. Future research should look at risk factors specific to nulliparous women, whether actively planning a pregnancy or not, to determine whether preconception counselling should vary in according to parity.

In conclusion, this study has shown that various biological as well as socioenvironmental factors are associated with preconception and interconception health risk in Canadian women. Many of the common risk factors were behavioural and thus preventable. Understanding which groups of women are prone to certain risk behaviours provides opportunities for researchers and policy-makers to target interventions more efficiently and effectively.

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