2023-09-17

Neighbourhood Socioeconomic Disparity in Exposure to Preterm Birth Risk During the Pandemic: Secondary Analysis of Pregnancy During the Pandemic Cohort

Jung, Won Kyu

UNIVERSITY OF CALGARY

Neighbourhood Socioeconomic Disparity in Exposure to Preterm Birth Risk During the Pandemic: Secondary Analysis of Pregnancy During the Pandemic Cohort

by

Won Kyu Jung

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE

DEGREE OF MASTER OF SCIENCE

GRADUATE PROGRAM IN CLINICAL PSYCHOLOGY

CALGARY, ALBERTA

SEPTEMBER, 2023

Abstract

Background: Preterm birth (PTB) is defined as a live birth before 37 weeks of gestation and remains a major public health concern, affecting an estimated 15 million births annually with a global prevalence of 11%. Socioeconomic disparities play a crucial role in PTB rates, with both individual- and neighborhood-level factors contributing. Stress response pathway has been identified as a key mechanism in the relationship between neighborhood socioeconomic status (nSES) and PTB risk. As such, the new challenges added due to the COVID-19 pandemic, such as disruption to the support networks and increased psychosocial distress for pregnant individuals, were expected to increase PTB rates. However, studies found lack of change or even decrease in the incidence during this period. It is suggested that such counter intuitive findings are due to lack of consideration for the differential exposure to the pandemic-related hardships based on nSES. Therefore, the primary aim of the present study is to test whether a measure of objective pandemic hardship and psychological distress mediate the relationship between nSES and PTB.

Methods: Present study is a secondary analysis of the data collected from a prospective longitudinal cohort study, Pregnancy during the Pandemic (PdP). Two serial mediation path models with a measure of baseline objective pandemic hardship and psychological distress included as mediators between nSES and PTB/gestational age (GA) were tested.

Results: In both models, the main indirect pathway of interest from nSES to pandemic objective hardship, psychological distress, then PTB/GA was non-significant with minimal effect. Secondary indirect pathway of interest from pandemic objective hardship to psychological distress then PTB/GA was significant in both models while controlling for months into the pandemic at birth and baseline sociodemographic characteristics.

Discussion: The present paper is the first to test a comprehensive model of the role of nSES on PTB risk with an explicit measure of pandemic objective hardship and psychological distress included as mediators. While the main indirect serial mediation pathway was non-significant, partial support for the proposed mechanism was observed where increase in pandemic-related hardship elevated psychological distress, which then heightened the risk of PTB risk and shortened gestational age at birth.

Acknowledgement

I would like to thank the committee members for generously dedicating their time and expertise to review my work. I am deeply grateful to my supervisor, Dr. Lianne Tomfohr-Madsen, for her invaluable guidance and mentorship. The trust you showed in my ability as an aspiring researcher and your encouragements played a pivotal role in completing the thesis. I would also like to acknowledge the brilliant members of the Healthy Families Lab, as well as the amazing students in the University of Calgary clinical psychology program for their comradery and friendship. Finally, warmest thanks and gratitude to my family for their unconditional love and support. And to my partner, Hanmoui, for her patience and understanding. Your unwavering support and belief have been a source of strength and motivation.

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Introduction

Preterm Birth

Preterm birth (PTB) is defined as a live birth that occurs prior to 37 weeks of gestation (Deressa et al., 2018; Walani, 2020). There are an estimated 15 million PTBs per year, with a prevalence of 11% worldwide. Due to its significant short and long-term ramifications, PTB associated with increased medical and educational spending and loss in productivity, which amounts to an annual cost of 26.2 billion US dollars (Birth, 2007). Short term, PTB is the leading cause of infant mortality where up to 35% of deaths that occur in neonates less than 28 days old are born preterm (Walani, 2020). Additionally, PTB has been found to be associated with admission to neonatal intensive care, prolonged hospital stay after birth, and re-admission to hospital in the first year of life (Petrou et al., 2003; Riley et al., 2008). Long term, cognitive impairment has been found to be the most common and severe disability in preterm born population (Arpino et al., 2010). A meta-analysis has found significant reduction in cognitive test scores among school-aged children born preterm compared to their counterparts born at-term (Bhutta et al., 2002). The same study has also found increase in externalizing and internalizing behaviours, as well as greater chance of having Attention-Deficit/Hyperactivity Disorder (ADHD) diagnosis, which demonstrates the diverse impact PTB has on infant development. Furthermore, increased risk of developing cerebral palsy (Soleimani et al., 2014), chronic lung disease (Doyle et al., 2006), and attentional and social problems (Johnson, 2007) have been identified in this population as well.

The impact of PTB is not limited to the infant. Studies show an increased prevalence of postnatal depression in parents over the first year after PTB (Blom et al., 2010; O’Hara & McCabe, 2013; Vigod et al., 2010), with some observing the effect lasting up to seven years postpartum

(Treyvaud et al., 2014). Elevated levels of parenting stress and decrease in family functioning are also common (Lakshmanan et al., 2017; Treyvaud et al., 2014). In some cases, social isolation (Lakshmanan et al., 2017), marital discord (Cronin et al., 1995; Saigal et al., 2000), slower educational attainment by the mother (Saigal et al., 2010), and negative impact on employment for parents (Singer et al., 2010) are also observed. Taken together, PTB encompasses both the immediate difficulties experienced during the neonatal period, along with a potential risk of prolonged decrease in the quality of life for the infant and their family.

Neighbourhood Socioeconomic Status as a Risk Factor

Due to far-reaching and lasting impact of PTB, and the cost it bears on the society, numerous studies and reviews have focused on identifying risk factors for PTB, with a convergence of evidence suggesting large socioeconomic disparities in PTB rates. In a systematic review conducted in 2010, the authors found that regardless of the socioeconomic status (SES) indices used or the country of residence, a significant association existed between SES and PTB at individual, family, and neighbourhood levels (Blumenshine et al., 2010). Similarly, higher prevalence of adverse birth outcomes including PTB and low birth weight, have been found in neighbourhoods with low SES, as well as in individuals with low income and education (Campbell & Seabrook, 2016; Zeka et al., 2008).

While both individual- and neighbourhood-level SES indices have been found to predict PTB as demonstrated above, as posited by a review published in the Annual Review of Sociology in 1999 (Robert, 1999), mounting evidence suggests that community socioeconomic contexts are independent predictors that contribute directly *and* indirectly to birth outcomes. For example, in the US, postal code census measures of race, poverty, and rurality were found to significantly predict PTB and low birth weight rates, and this relationship remained significant even when the models were adjusted for individual-level socioeconomic risk factors (Kent et al., 2013). Additionally, significant direct and indirect effects of neighbourhood-level socioeconomic factors on low birth weight and PTB were observed by Meng *et al*., where 20-30% of total effects were mediated by individual-level risk factors, such as individual SES, perceived stress, health, and health behaviours (Meng et al., 2013). Similar findings were replicated in a study by Clayborne and colleagues where neighbourhood SES and its association with PTB were mediated by maternal body mass index and gestational weight gain after controlling for household income (Clayborne et al., 2017).

This is consistent with established epidemiological evidence demonstrating social stratification in various health outcomes based on neighbourhood characteristics such as poverty and median income of residents. Commonly defined as a geographical area with a high proportion of residents with low SES, neighbourhood deprivation has been found to be associated with adverse outcomes such as lower level of self-rated health and respiratory functioning, as well as increase in all-cause mortality and coronary heart disease, even after controlling for individual-level SES (Anderson et al., 1997; Robert, 1998; Roux et al., 2001). It is posited that such robust association exists due to neighbourhood deprivation being a marker for community characteristics important for health such as availability of public services and environmental support (Ribeiro, 2018; Stafford & Marmot, 2003). Additionally, neighbourhood deprivation has been found to impact individual's perception of self within their environment such level of social integration and sense of control (Feldman & Steptoe, 2004), further contributing towards its association with one's physical functioning.

Stress Response as a Mechanism of Effect

Among number of mediating pathways mentioned above, one of the supported mechanism of effect for the association between neighbourhood SES and PTB risk is via the stress pathway as posited by Culhane *et al*. (Culhane & Elo, 2005). Those living in deprived neighbourhoods are more likely to perceive higher levels of stress (Algren et al., 2018) and experience psychosocial distress such as depressive symptoms with increased severity (Generaal et al., 2019). It is well-established in the literature that both clinical and subclinical manifestations of depression, anxiety, and perceived stress are significant contributors to the risk of having PTB (Staneva et al., 2015). Perception of stress is known to initiate hypothalamus-pituitary-adrenal (HPA) axis response which leads to the release of cortisol. While appropriate level of cortisol is important for fetal maturation (Reynolds, 2013) and thus increase in cortisol level during pregnancy is expected (Sandman et al., 2006), excessive or prolonged exposure beyond normal levels is associated with impairments in fetal development (Bolten et al., 2011; Zijlmans et al., 2015). Therefore, the heightened risk of experiencing significant and chronic stress in those living in deprived neighbourhoods, and the subsequent impact it has on fetal maturation via the stress pathway, is a potent mediator for the observed effect of neighbourhood SES on PTB risk.

Neighbourhood SES and PTB within the Context of COVID-19 Pandemic

In the wake of COVID-19 global pandemic, social distancing rules and restrictions in social gathering were widely adopted and enforced to curb the infection rate. While such measures may have been efficacious in reducing physical contact and therefore containing the viral spread, they also meant sudden and complete stop to social interactions and thus, isolation. In the context of pregnancy and pregnant individuals, this meant disruption to the existing network of obstetric and psychological support. Prenatal care appointments were rearranged, cancelled, or changed to a virtual meeting despite preferences for physical in-person appointments, and partners were largely barred from accompanying appointments and sometimes, even birth (Brislane et al., 2021). Intergenerational support from parents of adult children undergoing pregnancy was also disturbed since infection carries severe health risk for older adults and many opted to avoid face-to-face interactions to limit this risk (Gilligan et al., 2020).

Consistently, pregnant individuals reported decrease in the level of perceived social support due to interaction with friends and family members being severely limited (Brik et al., 2021; Matvienko-Sikar et al., 2021; Zhou et al., 2021). Increased psychosocial distress such as feelings of loneliness and isolation (Milne et al., 2020; Talbot et al., 2021), and higher risk of developing anxiety and depressive symptoms, and insomnia (Chmielewska et al., 2021; Yan et al., 2020; Zhou et al., 2021) were also observed. This is concerning considering the aforementioned importance of psychological distress as a risk factor for PTB. With the disruption of support network and observation of elevated stress and mood symptoms, there may have been a heightened risk of PTB during the pandemic as per the stress response mechanism previously described.

However, on the contrary, multiple studies have found either no change (Main et al., 2021; Pasternak et al., 2021; Shah et al., 2021) or even decrease (Berghella et al., 2020; Meyer et al., 2021; S. N. Wood et al., 2022; Calvert et al., 2023) in PTB rates during the pandemic. However, considering that these studies were epidemiological studies that took place in high-income countries such as the United States, Canada, Sweden, or England, it is suggested that the counterintuitive findings are partly due to lack of consideration for neighbourhood socioeconomic disparity and the subsequent inequal exposure to COVID-19 and related hardships. One study that specifically investigated the contributing factors for the decreased PTB rate found that the findings were mostly driven by white individuals living in more affluent neighbourhoods (Lemon et al., 2021). Consistently, a population-based cross-sectional study conducted in Manitoba, Canada, demonstrated an SES-dependent impact of COVID-19 on PTB risk where those with high SES showed a decrease in PTB rate while the low SES counterpart showed an increase (Aboulatta et al., 2023). Similarly, neighbourhood measure of structural racism and community unemployment rate was found to predict PTB rate as well (Janevic et al., 2022).

Indeed, there is a growing body of evidence supporting discrepancy in COVID-19 consequences depending on neighbourhood SES. A study investigating age-standardized incidence and mortality rate across neighbourhoods with varying SES in Rio de Janeiro, Brazil found disproportionate representation from racialized and vulnerable communities (Julio Silva & Marcelo Ribeiro-Alves, 2021). Similar findings were replicated in Geneva, Switzerland, where researchers found elevated incidence of COVID-19 infection and mortality in communities with low employment rate and income (Mongin et al., 2022). Scoping review of 95 studies conducted by McGowan and Bambra further confirms the disparity as majority of included studies found higher mortality rate in socioeconomically disadvantaged areas (McGowan & Bambra, 2022). Consistently, mental health consequences of the pandemic also followed a similar pattern. Parents with lower household income reported higher levels of distress facing uncertainty and health concerns during the pandemic, compared to higher income counterparts (Scrimin et al., 2022). In the US, those with less than high school level education, below $25,000 income, and rented housing displayed higher odds of reporting severe depressive symptoms (H. Lee & Singh, 2021). Significant association between low income and prevalence of depressive symptoms during the pandemic were replicated in Nigerian and Japanese contexts as well (Agberotimi et al., 2020; Nagasu et al., 2021). Taken together, experiences of the pandemic including incidence, mortality, and mental health consequences differ significantly depending on socioeconomic factors.

Considering the stress response mechanism via which psychosocial stressors affect risk, the inequal exposure to the pandemic-related stressors can lead to disparity in PTB risk as well.

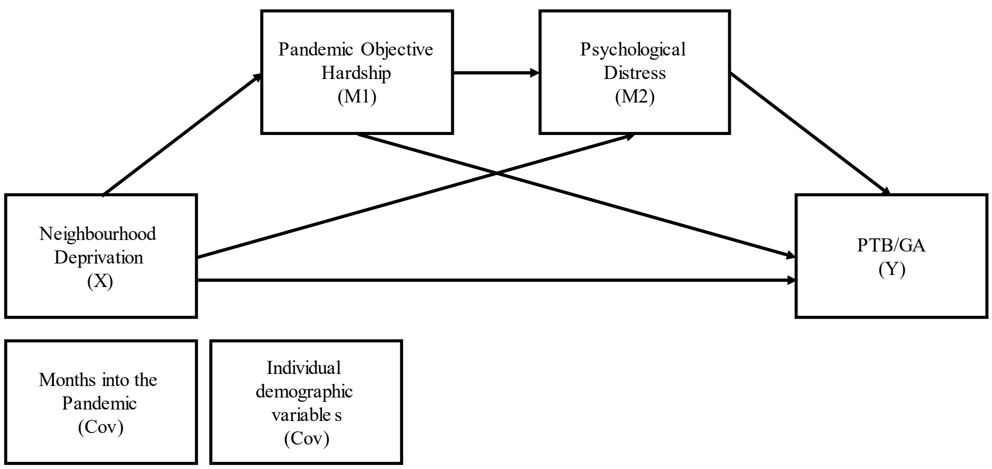
However, to date, few studies have investigated the effects of neighbourhood SES on PTB risk during the COVID-19 pandemic and they have yielded mixed findings. While some support for socioeconomic disparity was observed using neighbourhood characteristics (e.g., Janevic et al., 2022), others have observed a replication of the aforementioned decrease in PTB rate during the pandemic even in deprived neighbourhoods (Fisher et al., 2022). Thus, there is a pressing need to further investigate and clarify how neighbourhood socioeconomic disparities impacted PTB risk during the pandemic, as preliminary evidence is mixed on the role of neighbourhood SES.

Present Study

The present study aimed to address this gap in the literature and examined the relationship between neighbourhood SES, objective pandemic hardship, psychological distress, and PTB risk during the COVID-19 pandemic. While socioeconomic disparity and effects of psychological distress in PTB is well-documented in the existing literature, the pandemic has introduced unique hardships that appear to differentially impact those living in neighbourhoods with varying SES. Specifically, no study to date has examined how the increase in levels of pandemic-related hardships and psychological distress among those residing in deprived neighbourhoods, impact PTB risk. Therefore, based on the stress response mechanism, the current study proposes and tests a path analysis model with a measure of objective pandemic hardship and psychological distress as serial mediators between neighbourhood socioeconomic status (nSES) and PTB. The primary objective was to test the indirect pathway where high neighbourhood deprivation was theorized to increased objective pandemic hardship and lead to a subsequent elevation of psychological distress (depression and anxiety symptoms). The elevated levels of psychological distress were then hypothesized to increase the risk of PTB, with individual sociodemographic factors and time since onset of the pandemic accounted for as covariates. The secondary objective was to examine the following indirect effects: 1) neighbourhood deprivation on PTB risk via pandemic objective hardship, 2) neighbourhood deprivation on PTB risk via psychological distress, 3) pandemic objective hardship on PTB risk via psychological distress. Above model and the analyses were then repeated using gestational age (GA) as the main outcome (Figure 1).

Figure 1

Path diagram of proposed direct and indirect effects of neighbourhood deprivation on PTB risk



Methods

Study Sample and Data Collection

Data collected from a prospective longitudinal cohort study known as Pregnancy during the Pandemic (PdP) was utilized for the analyses in the present study (Giesbrecht et al., 2021). In PdP study, pregnant individuals were recruited across Canada through advertisements posted online (i.e., lab website, Facebook, Instagram, and Twitter) to complete series of online survey about demographics, mental health variables, medical/obstetric information, etc., throughout their pregnancy and postpartum period.

Eligibility Criteria

Participants were eligible if they were pregnant, ≥17 years old, at ≤35 weeks of gestation at study enrollment, living in Canada, and able to read and write in English or French. For the first three months following the initial survey, participants received a monthly email link to complete a follow-up survey that asked about their experiences since the previous survey. After three months, follow-up surveys were sent every other month to reduce participant burden. For each of these surveys, participants were first asked if they were still pregnant and then routed either to the next prenatal survey or to the delivery survey. In the postpartum period, surveys were sent at 3, 6, and 12 months of infant age to assess maternal stress, psychological distress, and infant development. For the present study, data collected at enrollment and from the delivery survey were used.

Measures

Neighbourhood SES

Neighbourhood SES was evaluated using the Vancouver Area Deprivation Index (VANDIX) (Bell & Hayes, 2012). VANDIX is a census-based tool where participant postal codes are matched to census dissemination areas (DA) (i.e., smallest standard geographic area for which census information is reported) which is then used to extract the corresponding area socioeconomic information from the Canadian census. Extracted data are then used to derive neighbourhood SES scores for each individual. Each defined neighbourhoods are rated on seven indicators: the percentage without university completion, unemployment rate, proportion of lone-parent families, average annual household income, proportion of homeowners, and employment ratio. Score from each indicator is transformed to a standardized z score, which is then multiplied by their corresponding weight before being summed. The resulting weighted sum of standardized indicator scores represent neighbourhood deprivation, with higher score representing greater neighbourhood deprivation.

For the present study, socioeconomic information for DAs across Canada were obtained from 2021 Census of Population database, which is publicly accessible via Statistics Canada website. The census DAs with relevant socioeconomic information were then matched to that of the participants which were identified based on their postal code reported at baseline.

Edinburgh Postnatal Depression Scale (EPDS)

The Edinburgh Postnatal Depression Scale (EPDS; Cox et al., 1987) is a widely used self-report measure designed to assess the severity of depressive symptoms during the postpartum period. It consists of 10 items, and respondents rate the frequency of experiencing each symptom using a four-point scale. The total score is obtained by summing the scores of individual items, resulting in a range of 0 to 30. Higher scores on the EPDS indicate higher levels of symptom severity. The internal consistency reliability of the EPDS was assessed using Cronbach’s alpha and yielded a Cronbach’s alpha coefficient of 0.88, which indicates adequate consistency.

Patient-Reported Outcomes Measurement Information System (PROMIS) Anxiety Scale

The Patient-Reported Outcomes Measurement Information System (PROMIS) Anxiety Scale (Cella et al., 2010) is a seven-item self-report measure of anxiety symptoms, such as worry, nervousness, and restlessness. Participants are asked to rate each item based on the frequency and intensity of these symptoms over the past week, using a five-point Likert-type scale ranging from “never” to “always”. Total score is generated by summing responses to each item which is then converted to a t-score ranging from 36.3 to 82.7 using US general population norms. Higher scores on the PROMIS Anxiety indicate greater anxiety symptoms with t-scores ≥ 60 suggesting clinical significance. The internal consistency reliability of the PROMIS Anxiety was assessed using Cronbach's alpha and yielded a coefficient of 0.93, which indicates adequate consistency.

Psychological Distress

A composite psychological distress score was generated from transforming the total score of EPDS and PROMIS Anxiety to a standardized z-score, then taking the sum. The composite score was used instead of the individual scales as both depression and anxiety are commonly found to be significant predictors of PTB risk (Staneva et al., 2015) and the hypothesized model is testing for the effects of general psychological distress as a mediating pathway, rather than as standalone predictors. Furthermore, EPDS and PROMIS Anxiety were highly correlated (r = .80) and inclusion of both scales within the same model may introduce the issue of multicollinearity and increase the risk of type II error. Depression and anxiety are also highly co-occurring clinical symptoms within the pregnant population and that the use of a composite score is a common practice (e.g., Thomas-Argyriou et al., 2021).

Pandemic-Objective Hardship Index (POHI)

The Pandemic-Objective Hardship Index (POHI) (Giesbrecht et al., 2023) was developed to assess the impact of COVID-19 on individuals. It includes four components: Scope, Loss, Threats, and Change. Scope measures the duration and intensity of hardship, while Loss assesses financial, social, and physical losses. Threats captures health-related consequences, and Changes examines adjustments in daily life. The scale considers experiences over the previous month. It provides a comprehensive assessment of the objective challenges faced during the COVID-19 pandemic. Each subdomain has a maximum score of 50 and POHI Total is an aggregation of the four subdomains with a maximum of 200, with higher score representing greater impact of COVID-19. However, as explained by the authors of the measure in Giesbrecht et al., 2023, due to raw mean differences between the domains and lack of prior theoretical rationale for differential weighting of the domain scores, the total score is created by taking the equally weighted mean of the subdomain z scores.

Gestational Age

After giving birth, participants received a questionnaire regarding their delivery experience. The gestational age at birth was assessed by asking the question, "*How many weeks pregnant were you when your baby (or babies) was delivered?*" Participants responded by indicating the number of weeks.

Preterm Birth

PTB (preterm birth) was determined based on the gestational age at birth. Participants with a gestational age of less than 37 weeks were classified as preterm (1), while those with a gestational age of 37 weeks or more were classified as full-term births (0).

Sample Characteristics

Sample characteristic was analyzed using the following sociodemographic variables: annual household income (Snelgrove & Murphy, 2015), maternal age (Fuchs et al., 2018), maternal ethnicity (Heaman et al., 2013; Tucker et al., 2015), marital status (Shah et al., 2021; Zeitlin et al., 2002), and maternal education (Luo et al., 2006). Annual household income is comprised of nine categories: <$20,000 (1); $20,000-$39,999 (2); $40,000-$69,999 (3); $70,000-$99,999 (4); $100,000-$124,999 (5); $125,000-$149,999 (6); $150,000-$174,999 (7); $175,000-$199,999 (8); >$200,000 (9). All other sociodemographic variables except for maternal age were transformed into dichotomous variables based on their established association with PTB risk within the literature: ethnicity (White, minority); maternal education (high school and below, above high school); and marital status (married, single/cohabiting/separated/divorced).

Covariates

The path analysis was adjusted for time since onset of the pandemic since previous evaluation of POHI revealed a significant effect of time since onset of the pandemic on both total and subscale scores (Giesbrecht et al., 2023). Similar effect of time was observed in a study by Calvert et al (2023) where PTB rates were found to have reduced for the first three month into lockdown in high-income countries (Calvert et al., 2023), further warranting adjustment based on time into the pandemic. Time since onset of the pandemic was calculated by counting the number of months passed since January 25th, 2020. Additionally, maternal age, household income, maternal education, and marital status were included in the model as well-established predictors of PTB. Covariates were fitted into the model via an iterative fashion where all covariates were added to all pathways in the initial model, then removed one by one based on theoretical relevance and improvements in model fit indices.

Statistical Analysis

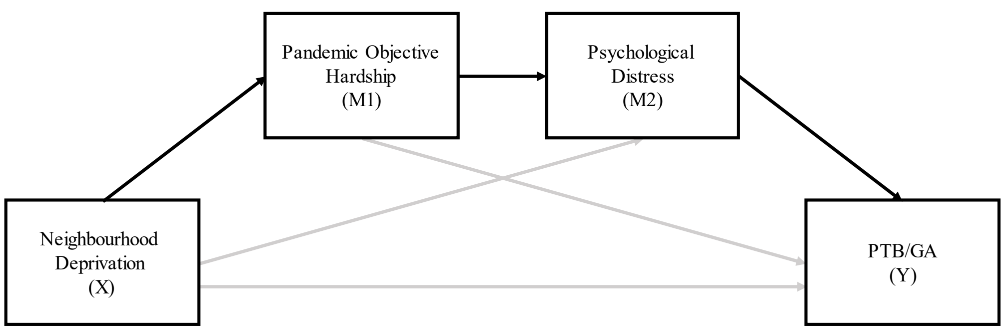
Frequencies and proportions were observed for aforementioned demographic characteristics (ethnicity, maternal education, multiples, household income, marital status) and PTB. Means and standard deviations (SD) were examined for maternal age, VANDIX, EPDS, PROMIS Anxiety, POHI Total, and GA. Correlation between the continuous measures were using Pearson's correlation coefficients.

Path Analysis

Path analysis is an extended form of regression analysis that allows for the examination of direct, indirect, and total effects of variables, along with evaluation of mediation between variables. Furthermore, availability of fit indices, such as chi-square, comparative fit index (CFI), Tucker-Lewis Index (TLI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR) makes path analysis an appropriate tool for investigating the interplay between the variables of interest and their representation of the data. The "lavaan" package (Rosseel, 2012) in the statistical software, R Version 4.3.1 (R Core Team, 2022), was used to test the path model. Two path models were created to examine the mechanism by which neighbourhood deprivation influences PTB and GA, through indirect unstandardized effects. The primary indirect effect of interest within the path models was the sequential mediation path through objective hardship and psychological distress (see Figure 2). This describes the stress response mechanism-based pathway where the hypothesized increase in exposure to objective pandemic hardship due to neighbourhood deprivation heightens psychological distress and subsequent PTB risk and/or shortens gestations.

Figure 2

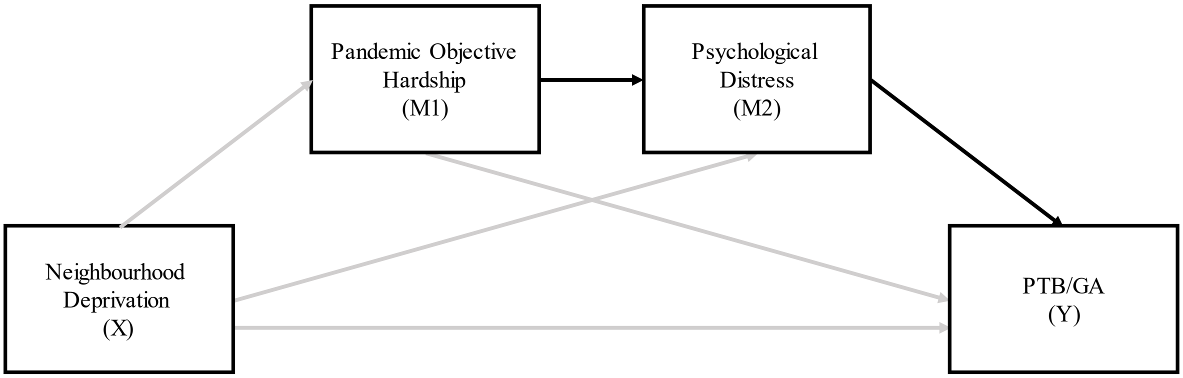
Path diagram highlighting the primary indirect effect via hardship and psychological distress



Second indirect effect of interest was the indirect pathway between pandemic objective hardship and PTB/GA, mediated by psychological distress. This pathway replicates the previous finding on the association between POHI and psychological distress (Giesbrecht et al., 2023), and tested whether this relationship predicts PTB/GA (Figure 3).

Figure 3

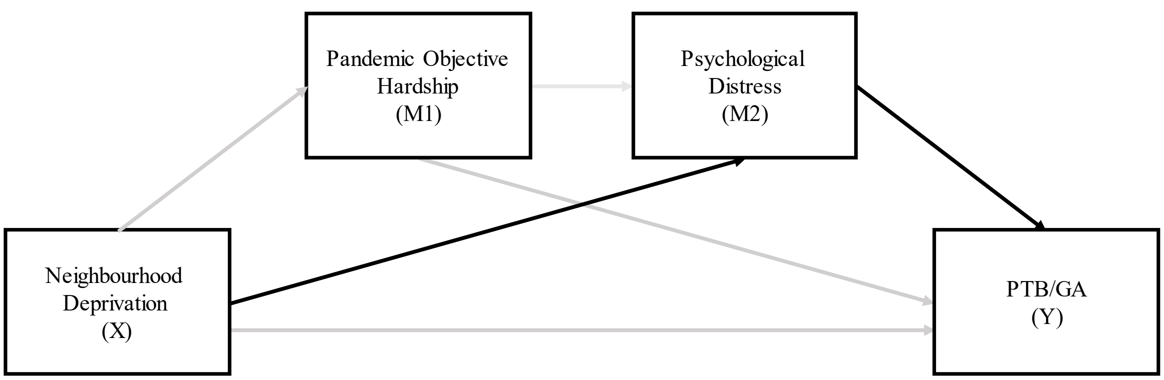
Path diagram highlighting psychological distress as a mediator between hardship and PTB/GA



Third indirect effect of interest was the indirect pathway between neighbourhood deprivation and PTB/GA, mediated by psychological distress. This pathway aimed to replicate the aforementioned and well-established indirect effects of neighbourhood SES on PTB risk through individual-level factors such as psychological distress (Figure 4).

Figure 4

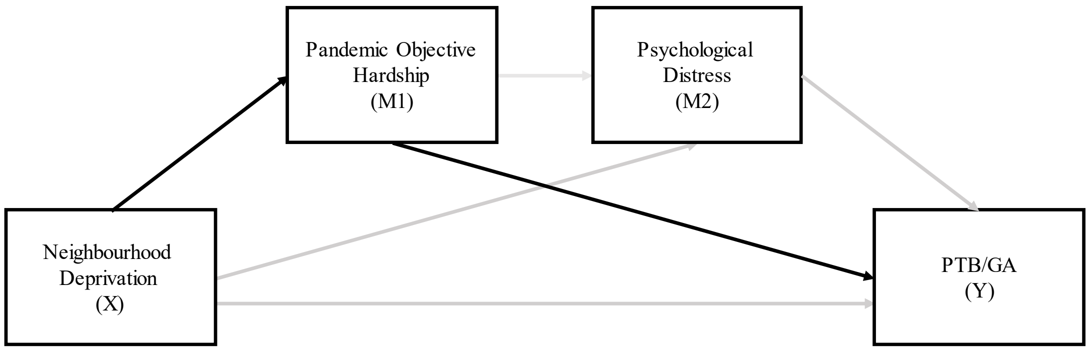
Path diagram highlighting psychological distress as a mediator between nSES and PTB/GA



Fourth indirect effect of interest was the indirect pathway between neighbourhood deprivation and PTB/GA, mediated by pandemic objective hardship. This pathway captures any effects of hardships experienced due to neighbourhood deprivation on PTB risk that are not mediated by psychological distress (Figure 5).

Figure 5

Path diagram highlighting hardship as a mediator between nSES and PTB/GA



Missing Data and Parameter Estimation

Missing data were handled differently for the PTB and the GA model due to models with categorical or continuous outcome variable requiring different estimators. For the PTB model, missing data were handled using multiple imputation. Multiple imputation is a technique for handling missing data through creation of multiple plausible values for each of the missing entries based on the observed data. For the present study, multiple imputation was conducted using the multiple imputation by chained equation ('mice') package from R. Within the mice package, predictive mean matching method was selected due to its versatility and robustness to violation of assumptions otherwise relevant for fully parametric procedures (Kleinke, 2017). Furthermore, predictive mean matching avoids imputation of impossible values (e.g., imputing a value of 31 when the variable's maximum value is 30) and can be flexibly applied for both categorical and continuous data. 20 values were imputed for each missing data, creating 20 multiply imputed datasets (*m*=20). The proposed PTB path model was fitted to the data using weighted least squares mean and variance adjusted (WLSMV) estimator. WLSMV estimator is used for structural equation modelling when the outcome variable is categorical or ordinal (Brown & Moore, 2012). Outputs from the path analyses were then pooled using Rubin's Rules (Little & Rubin, 2019;

Rubin, 1976) generating robust parameter estimates including unstandardized regression coefficients, standard errors, and p-values.

For the GA model, Full Information Maximum Likelihood (FIML) method was used to incorporate cases with missing variables. FIML is an estimator provided by lavaan package and it is a commonly used technique for handling missing data in the context of complex statistical models such as structural equation modelling and path analysis. FIML estimates parameters by utilizing all information available in the observed dataset, including those from cases with missing values. As such, it is more efficient and provides better estimates than other methods such as listwise or pairwise deletion, especially when the data is not missing completely at random. In terms of performance, simulation studies have found FIML to be on par with the multiple imputation method (T. Lee & Shi, 2021). In addition to the FIML method for handling missing data and parameter estimation, standard errors and test statistics were estimated using bootstrapping with 1000 iterations.

Results

Missing Data

At the time of the analysis, the total sample size of the PdP cohort was 10,752, of which 6850 participants provided birth outcome data. From the 6850 participants, 116 were removed due to multiple birth. 995 were further removed due to being unable to identify their corresponding DA from the postal code, or census data being unavailable for the identified DA. Then, 176 were then removed due to incomplete baseline demographic survey. The remaining 5563 analytical sample included 307 participants missing one or more predictor variables (i.e., EPDS, PROMIS Anxiety, POHI).

Sample Description

Overall, the final analytic sample consisted mostly of pregnant individuals who were White (87.4%), had attained some form of post-secondary education (93.8%), and had an annual household earning over $70,000 per year (82.6%). Majority of the sample were married (65.4%). Consistent with higher-than-average household income and education level, PTB was observed in only 5.0% of the analytical sample, which is significantly lower than Canadian national prevalence of 8% (Bartholomew et al., 2013). The mean GA at birth was 39.08 (*SD* = 1.66). Refer to Table 1 for detailed sample demographic.

Table 1

Demographic data for the final analytical sample

Variable	**Final Analytical Sample (n=5563)**	
	M	**SD**
Participant Age (years)	32.48	4.18
Gestational Age (weeks)	39.08	1.67
	n	**%**
Marital Status		
Married	3639	65.4
Common-Law/Cohabitating	1735	31.2
Single/separated/Divorced/Widowed	189	3.4
Education		
Completed High School or below	345	6.2
Above High School	5218	93.8
Ethnicity		
White	4861	87.4
Other	702	12.6
Annual Household Income		
$200,000+	602	10.8
$175,000-$199,999	391	7.0
$150,000-$174,999	675	12.1
$125,000-$149,999	790	14.2
$100,000-$124,999	1096	19.7
$70,000-$99,999	1046	18.8
$40,000-$69,999	657	11.8
$20,000-$39,999	234	4.2

Less Than $20,000	72	1.3
Preterm Status		
37 or more weeks GA at birth	5284	95.0
36 or less weeks GA at birth	279	5.0

Note. GA, gestational age

Descriptive Statistics

Descriptive statistics for the key variables included in the model are shown in Table 2. VANDIX, which represents neighbourhood deprivation, had a mean of 0 suggesting a range of neighbourhoods with either high or low deprivation scores. POHI Total is the mean of subscale z scores thus the mean is set close to 0 and SD is at 0.60. In terms of depressive symptoms, participants in the sample scored relatively high with a mean of 9.76. Considering that the cut-off for clinically significant depression using EPDS ranges between 8-12 depending on the population (Bhusal et al., 2016; Husain et al., 2014; Matijasevich et al., 2014), the average score of 9.76 indicates an elevated depressive symptom within the analytical sample. Using EPDS score of 10 as a cut-off, close to half of the analytical sample had an elevated score (*n*=2605, 46.8%). Lastly, PROMIS Anxiety T-score had a mean of 58.18 which is within the average range of 40 to 60. However, similar to the EPDS, 40.9% of the analytical sample (*n*=2273) had an elevated anxiety score (i.e., T-score above 60), suggesting a higher presence of anxiety symptom than expected in the general population.

Table 2

Descriptive statistics of model variables

Variables	**Mean**	***SD***	**Range**
VANDIX	-0.06	0.63	-2.83-4.47
POHI Total	0.00	0.60	-1.50-2.89
EPDS	9.76	5.34	0-28
PROMIS Anxiety Total	18.44	5.95	7-35
PROMIS Anxiety T-Score	57.82	8.17	36.3-82.7
Psychological Distress	0.00	1.90	-3.75-5.86

Note: VANDIX is a weighted summation of z scores; POHI Total is the mean of subscale z scores; Psychological Distress is a raw summation of EPDS and PROMIS Anxiety z scores

Bivariate Correlations

Pearson correlation coefficients were estimated between the continuous measures included in the path model. Bonferroni adjustment was applied to the α critical where the α value of .05 was divided by the number of comparisons conducted (10; adjusted α critical = .005). Except for EPDS and PROMIS Anxiety, measures showed a significant but weak positive correlation with each other. As expected, EPDS and PROMIS Anxiety displayed a strong correlation with a coefficient of 0.80. This exceeds the cut off of 0.70 traditionally used to indicate a potential concern for multicollinearity. Upon further examination using variable inflation factor (VIF), both EPDS and PROMIS Anxiety displayed a VIF of 3.16, suggesting that the variance of the two variables are 3.2 times greater than due to collinearity. While the literature is mixed on the acceptable cut off for VIF with the answer varying for each research question and methodology, a recent paper (Johnston et al., 2018) suggests a VIF $\geq$ 2.5 requires caution. Considering the aforementioned issue of comorbidity and the importance of examining overall psychological distress as a mediator, the use of a composite score is thus well-supported.

Table 3

Pearson's correlation coefficients between neighbourhood deprivation, depression, anxiety, and objective pandemic hardships

	Psychological Distress	EPDS	PROMIS Anxiety Total	POHI Total
VANDIX	0.07***	0.07***	0.06***	0.05***
POHI Total	0.26***	0.27***	0.24***	-
PROMIS Anxiety Total	0.95***	0.80***	-	
EPDS	0.95***	-		

***. Correlation is significant at the .001 level (two-tailed)

Model Fit

The effects of differential exposure to objective hardship and its impact on PTB risk via psychological distress was tested using the proposed path models. The proposed models demonstrated great model fit (Table 4). Absolute model fit measures such as the comparative fit index (CFI) and Tucker-Lewis index (TLI) met the ideal threshold of 0.95 for the PTB model (0.97 and 0.98, respectively), while the GA model met the ideal threshold for CFI (0.99) and met the acceptable threshold of 0.90 for TLI (0.93). Standardized root mean square residual (SRMR) fell below the threshold of 0.08 for both models (0.02 for both models), indicating good model fit. Similarly, both PTB and GA models' root mean square error of approximation (RMSEA) met the threshold of 0.05 (0.001 and 0.01, respectively). Although the significance of the chi-square test indicates misfit of both models with the data and a difference in the model implied and the actual observed variance covariance matrix, chi-square is considered a highly conservative test, especially for a model with large sample size as is the case here (Hooper et al., 2008). Considering that the selection of fit measures follows closely with what is suggested in the literature (Kline, 2023) and the outputs fall within the range recommended by previous structural equation modelling literature (Hooper et al., 2008), both models were interpreted to be valid representations of the dataset.

Table 4

Model fit indices

Fit indices	Fit statistics	
	PTB model	**GA model**
χ^2	$\chi^2(4) = 10.95$ (p=.027)*	$\chi^2(4) = 12.05$ (p=.007)**
CFI	0.97	0.99
TLI	0.98	0.93
RMSEA	0.02	0.02
SRMR	0.001	0.01

Note. * Indicates significance at the .05 level; ** indicates significance at the .01 level

Path Analysis

PTB Model Path Coefficients, Indirect Effects, and Direct Effect

All pathway coefficients, indirect effects, standard errors, and p-values for the PTB model are presented in Table 5. Presented parameter estimates account for the effects of covariates including time since onset of the pandemic, household income, maternal age, maternal education, and marital status. Notably, in the final PTB model, months into the pandemic at birth was significantly and inversely associated with baseline POHI Total (*B*=-0.009; *SE*=0.002; 95% CI: -0.014 to -0.004; *p*<.001), suggesting that those who were further into the pandemic at birth reported less objective pandemic hardship at baseline. Similarly, the further the participants were into the pandemic at the time of birth, odds of having PTB decreased (*B*=-0.031; *SE*=0.009; 95% CI: -0.049 to -0.013; *p*<.001).

Figure 6 illustrates the path coefficients and significance of the direct and indirect effects of interest within the PTB model. The primary indirect effect of interest involving serial mediation between neighbourhood deprivation and PTB via pandemic objective hardship and psychological distress was not supported (*B*=0.001; *SE*=0.001; 95% CI: 0.001 to 0.003; *p*=.236). Upon closer inspection of the path coefficients contributing to the indirect effects, while objective pandemic hardship was associated with an increase in baseline psychological distress (*B*=0.779; *SE*=0.055; 95% CI: 0.672 to 0.886; *p*<.001) which was then associated with an increased odds of having PTB (*B*=0.039; *SE*=0.020; 95% CI: 0.000 to 0.078; *p*=.05) as hypothesized, VANDIX was not predictive of reporting higher levels of objective pandemic hardship (*B*=0.025; *SE*=0.017; 95% CI: -0.008 to 0.058; *p*=.134) within the PTB model. Among secondary indirect effects of interest, only the mediation between objective pandemic hardship and PTB by psychological distress was revealed to be significant (*B*=0.030; *SE*=0.015; 95% CI: 0.001 to 0.059; *p*=.047). The direct effect of objective pandemic hardship on PTB was not significant (*B*=-0.096; *SE*=0.063; 95% CI: -0.221 to 0.028; *p*=.131). Lastly, the direct effect of neighbourhood deprivation on PTB risk was non-significant (*B*=0.052; *SE*=0.060; 95% CI: -0.066 to 0.170); *p*=.391.

Table 5

Paths, path coefficients, standard errors, p-values for the PTB model

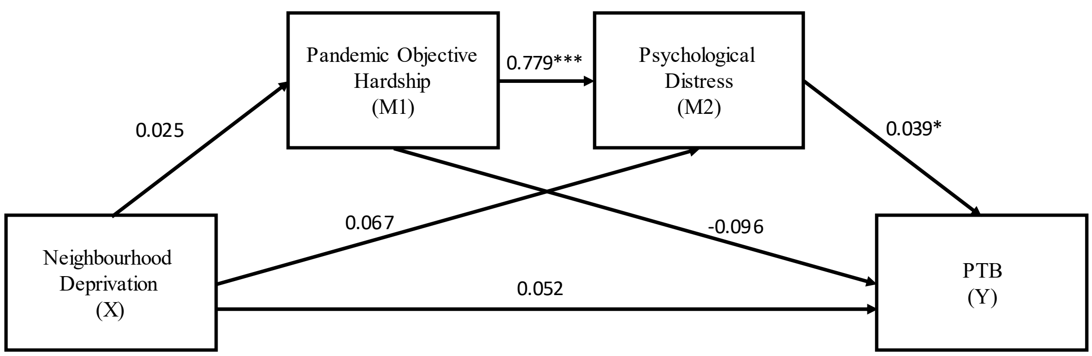
Path	Path label	Unstandardized Coefficients	Standard Error	*p* value
PTB Model				
Path Coefficients				
VANDIX → POHI Total	a1	0.025	0.017	.134
VANIDX → Psychological Distress	a2	0.067	0.053	.099
POHI Total → Psychological Distress	d21	0.779	0.055	.000***
POHI Total → PTB	b1	-0.096	0.063	.131
Psychological Distress → PTB	b2	0.039	0.020	.050*
VANDIX → PTB	cp	0.052	0.060	.391
Indirect Effects				
Indirect Effect 1: VANDIX → POHI Total → Psychological Distress → PTB	-	0.001	0.001	.236
Indirect Effect 2: POHI Total → Psychological Distress → PTB	-	0.030	0.015	.047*
Indirect Effect 3: VANDIX → Psychological Distress → PTB	-	0.003	0.003	.309
Indirect Effect 4: VANDIX → POHI Total → PTB	-	-0.002	0.002	.306
Covariates				

Months into the pandemic → POHI Total	-	-0.009	0.002	.000***
Household income → POHI Total	-	-0.041	0.006	.000***
Maternal age → POHI Total	-	0.019	0.002	.000***
Household income → Psychological Distress	-	-0.086	0.018	.000***
Maternal education → Psychological Distress	-	-0.321	0.133	.017*
Maternal age → Psychological Distress	-	-0.021	0.008	.007**
Months into the pandemic → PTB	-	-0.031	0.009	.000***
Maternal age → PTB	-	0.005	0.009	.548
Household income → PTB	-	0.012	0.019	.521
Maternal education → PTB	-	-0.042	0.155	.784
Marital status → PTB	-	0.117	0.078	.133

Note. * Indicates significance at the .05 level; *** indicates significance at the .001 level.

Figure 6

Path coefficients and their significance for the full PTB model



Note. * Indicates significance at the .05 level; *** indicates significance at the .001 level. All path coefficients are unstandardized values. Demographic and months into the pandemic variables were included as covariates.

GA Model Path Coefficients, Indirect Effects, and Direct Effect

All pathway coefficients, indirect effects, standard errors, and p-values for the GA model are presented in Table 6. Presented parameter estimates account for the effects of covariates including time since onset of the pandemic, household income, maternal age, maternal education, and marital status. Similar to the final PTB model, in the final GA model, months into the pandemic at birth was significantly and inversely associated with baseline POHI Total (*B*=-0.008; *SE*=0.002; 95% CI: -0.012 to -0.004; *p*<.001), suggesting that those who were further into the pandemic at birth reported less objective pandemic hardship at baseline. Similarly, the further the participants were into the pandemic at the time of birth, the longer they gestated before giving birth (*B*=0.019; *SE*=0.005; 95% CI: 0.009 to 0.028; *p*<.001). GA model also found months into the pandemic to be negatively predictive of psychological distress (*B*=-0.027; *SE*=0.006; 95% CI: -0.037 to -0.015; *p*<.001).

Figure 7 illustrates the path coefficients and significance of the direct and indirect effects of interest within the GA model. The primary indirect effect of interest involving serial mediation between neighbourhood deprivation and GA via pandemic objective hardship and psychological distress was not supported (*B*=-0.001; *SE*=0.001; 95% CI: -0.003 to 0.000; *p*=.069). Further inspection of the path coefficients revealed significance in all paths contributing to the indirect effect. Neighbourhood deprivation was associated with higher levels of objective pandemic hardship (*B*=0.028; *SE*=0.014; 95% CI: 0.000 to 0.055; *p*=.040) which then increased psychological distress (*B*=0.795; *SE*=0.042; 95% CI: 0.705 to 0.876; *p*<.001) and subsequently shortened the duration of gestation before giving birth (*B*=-0.054; *SE*=0.013; 95% CI: -0.079 to -0.029; *p*<.001). Among secondary indirect effects of interest, similar to the PTB model, only the mediation between objective pandemic hardship and GA by psychological distress was revealed to be significant (*B*=-0.043; *SE*=0.010; 95% CI: -0.064 to -0.023; *p*<.001). The direct effect of objective pandemic hardship on PTB was not significant (*B*=-0.044; *SE*=0.038; 95% CI: -0.118 to 0.033; *p*=.249), suggesting full mediation by psychological distress.

Direct effect of neighbourhood deprivation on GA was also significant, indicating that residing in more deprived neighbourhood at baseline led to shorter gestation before giving birth (*B*=-0.084; *SE*=0.035; 95% CI: -0.157 to -0.018; *p*=.016).

Table 6

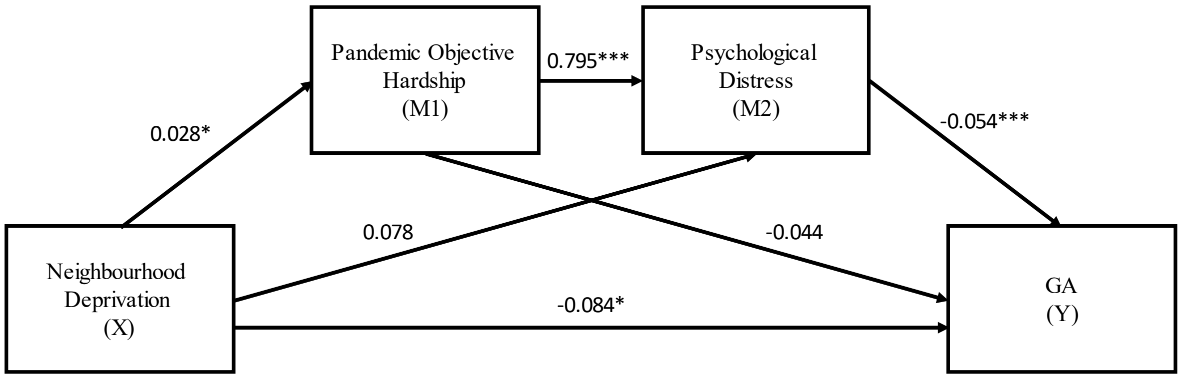
Paths, path coefficients, standard errors, p-values for the GA model

Path	Path label	Unstandardized Coefficients	Standard Error	*p* value
GA Model				
VANDIX → POHI Total	a1	0.028	0.014	.040*
VANIDX → Psychological Distress	a2	0.078	0.041	.056
POHI Total → Psychological Distress	d21	0.795	0.042	.000***
POHI Total → GA	b1	-0.044	0.039	.257
Psychological Distress → GA	b2	-0.054	0.013	.000***
VANDIX → GA	cp	-0.084	0.035	.016*
Indirect Effects				
Indirect Effect 1: VANDIX → POHI Total → Psychological Distress → GA	-	-0.001	0.001	.069
Indirect Effect 2: POHI Total → Psychological Distress → GA	-	-0.043	0.010	.000***
Indirect Effect 3: VANDIX → Psychological Distress → GA	-	-0.004	0.002	.093
Indirect Effect 4: VANDIX → POHI Total → GA	-	-0.001	0.001	.366
Covariates				
Months into the pandemic → POHI Total	-	-0.008	0.002	.000***
Household income → POHI Total	-	-0.045	0.004	.000***
Maternal age → POHI Total	-	0.019	0.002	.000***
Months into the pandemic → Psychological Distress	-	-0.027	0.006	.000***
Household income → Psychological Distress	-	-0.088	0.014	.000***
Maternal education → Psychological Distress	-	-0.268	0.116	.021*
Maternal age → Psychological Distress	-	-0.023	0.007	.001***
Marital status → Psychological Distress	-	-0.149	0.054	.006**
Months into the pandemic → GA	-	0.019	0.005	.000***
Maternal age → GA	-	-0.028	0.005	.000***

Note. * Indicates significance at the .05 level; ** indicates significance at the .01 level; *** indicates significance at the .001 level

Figure 7

Path coefficients and their significance for the full GA model



Note. * indicates significance at the .05 level; *** indicates significance at the .001 level. All path coefficients are unstandardized. Demographic and months into the pandemic variables were included as covariates.

Discussion

Primary Indirect Effect

The primary indirect effect hypothesized in the present study where neighbourhood deprivation increases exposure to pandemic objective hardship which then elevates psychological distress and leads to higher risk for PTB, was not supported. Specifically, VANDIX as neighbourhood deprivation index did not significantly predict pandemic objective hardship at baseline. As such, the primary indirect pathway displayed minimal effect and was non-significant. Similar findings were observed in the model with GA as the primary outcome. While individual path coefficients from neighbourhood deprivation to pandemic objective hardship, then to psychological distress and GA were significant, the overall indirect effect was also minimal and non-significant.

Such findings are surprising as previous studies have repeatedly demonstrated socioeconomic and geographical inequalities in the preparedness for a pandemic (Bouye et al., 2009) and disproportionate effects of the pandemic are observed among those with lower SES and residing in poorer neighbourhoods (e.g., Chen & Krieger, 2021; Dorn et al., 2020; Kontopantelis et al., 2021). Consistently, racial minority groups that have historically experienced health inequality have observed the disparity carry over into the pandemic as well, with Blacks and Hispanics experiencing higher prevalence, hospitalization, and mortality compared to White counterparts (Mude et al., 2021). People of colour are disproportionately represented within deprived neighbourhoods with fewer resources and investments (Bailey et al., 2017; Williams & Collins, 2001). As such they are more likely to have crowded housing with higher proportion of essential workers (D. Phuong Do & Reanne Frank, 2021) and use of public transportation for commute (Figueroa et al., 2021), which contributes to geographical and neighbourhood-level elevation in exposure to pandemic-related hardships (Berkowitz et al., 2020). Additionally, considering that a previous study on the POHI found significant association between all components of the measure across geographic locations (Giesbrecht et al., 2023), it was postulated for the VANDIX to display a strong, positive association with the POHI, which was not supported by the present model. Based on the fact that individual demographic covariates such as income and age were significantly predictive of pandemic objective hardship and psychological distress, it may be the case that the hardships assessed by the POHI are better predicted by individual SES instead. Indeed, in the aforementioned study using the POHI (Giesbrecht et al., 2023), the authors found that the subscales Threat, Loss, and Change were more predictive of the odds of meeting the clinical cut-off for depression and anxiety than the subscale Scope. It was suggested that the difference may be due to the former three domains assessing individual-level exposures while latter reflects regional-level exposures (e.g., infection rates, restrictions). Thus, VANDIX as an area-based measure may differentially predict the subscales based on how much they reflect regional-level exposures. If true, the use of the composite score in the present study that equally weighs the contributing subscales may suppress any significant association that exists between a subscale and the VANDIX.

It should also be noted that the census data contributing to the calculation of the VANDIX are mostly assessing financial affluence of those residing within the DA, rather than the neighbourhood's access to healthcare, social welfare, chaos/crime rate, food/housing security, or dependency within households (Bell & Hayes, 2012). There are other types of neighbourhood characteristics, such as neighbourhood disorder (Ross & Mirowsky, 1999), which may better predict exposure to hardship during the pandemic. In fact, in a recent study, neighbourhood disorder index composed of community crime reports was found to be a better predictor of infant sleep compared to neighbourhood deprivation measured via VANDIX (Li et al., 2022). Additionally, while the authors of the VANDIX have demonstrated its association with the health status of regions within British Columbia, it is unclear whether this relationship holds true for the rest of Canada and other regions. Therefore, a replication of the model using other area-based socioeconomic indicators such as the Canadian Marginalization Index (Matheson et al., 2012), may show different results.

Secondary Indirect Effect

In addition to the primary indirect pathway, three secondary indirect paths within the model were also tested. Among the three secondary paths explored, only the path observing the mediating role of psychological distress between pandemic objective hardship and PTB risk was found to be significant in both the PTB and the GA model. Specifically, pandemic objective hardship displayed a significant, positive association with psychological distress, which then increased the odds of having PTB and shorter gestation before giving birth. Furthermore, pandemic objective hardship was not directly predictive of PTB risk or GA, suggesting that psychological distress fully mediates the relationship between pandemic objective hardship and PTB risk. This is consistent with a recent finding reporting lack of association between objective hardship experience during the pandemic and gestational age (Gladstone et al., 2023), indicating the importance of accounting for prenatal psychological distress when assessing the effects of hardship during the pandemic on birth outcome. A study on the influence of the pandemic on placental morphometry and texture also found significant difference between the pandemic and non-pandemic cohort for placental volume and thickness when prenatal psychological distress was accounted for as a mediator (Saeed et al., 2023). Current literature is mixed on the effects of the pandemic on birth outcome, particularly PTB, and the present finding sheds much needed light on the potential mechanism via which the unique hardships experienced during the course of the pandemic influences birth outcomes. In particular, the use of an explicit measure of pandemic-related hardships to establish an association with psychological distress and PTB risk is novel. Previous studies mostly compared pre- and post-pandemic cohorts and lacked the ability to delineate which changes brought on by the pandemic influences PTB rates (e.g., Berghella et al., 2020; Pasternak et al., 2021; Wood et al., 2021). While the present model failed to establish nSES as a precursor to hardship and psychological distress during the pandemic, the observed indirect effect of the pandemic hardship on PTB risk via psychological distress highlights the significance of hardship experienced on birth outcomes and the importance of mental health variables when assessing for risk.

Biologically, changes in the vascular functions observed following psychological distress may underlie the present findings. Elevated experience of psychological distress is associated with increase in the risk of hypertensive disorders of pregnancy (Klonoff-Cohen et al., 1996; Leeners et al., 2007). Consistently, corticotrophin releasing hormone (CRH), which is a precursor for the secretion of cortisol within the HPA axis, has been found to be associated with hypertensive disorders of pregnancy as well (Perkins et al., 1995; Teixeira et al., 1999). Studies have also found reduction in uterine, fetal, and umbilical blood flow within highly anxious pregnant individuals indicative of fetal hypoxia, along with changes in the blood flow towards fetal brain in a compensatory manner (Hüneke & Ude, 2002; Sjöström et al., 2002; Vythilingum et al., 2010). Considering that hypertensive disorders of pregnancy such as pre-eclampsia are well-established risk factors for PTB (Hang An et al., 2022; Huang et al., 2022), it is suggested that the identification of psychological distress as a significant mediator for PTB risk in the present study is in part due to the associated cardiovascular changes.

Importantly, the findings provide a point of mitigation against the risk of adverse pregnancy outcomes for those who were most impacted by the pandemic or similar hardships. As suggested in an expert review (Traylor et al., 2020), nonpharmacologic approaches for reducing prenatal distress are available and there is a pressing need to investigate methods to increase the access and uptake of said approaches.

Effects of Months of into the Pandemic

Within the models, covariates were included to account for the effects of individual demographic factors with well-established association with PTB risk, such as educational attainment by the birthing individual and their age, household income, and marital status. Additionally, months into the pandemic at the time of giving birth was included due to the prolonged duration of the pandemic and changes in the hardship experienced during its course. Months into the pandemic as a covariate was significantly predictive of both pandemic objective hardship, PTB risk, and GA. The number of months into the pandemic at birth was associated with lower levels of pandemic objective hardship. Consistently, those who were further into the pandemic when giving birth had lower odds of having PTB and gestated for longer. Similar reduction in PTB rates over the course of several months into the pandemic was observed in a previous study (Gemmill et al., 2022). However, Calvert et al in 2023 found the opposite where PTB rates were decreased for the first three months of the pandemic (Calvert et al., 2023). Such findings suggest that while a significant time effect of the pandemic is present, the direction of the effect and the contributing factors are yet to be clarified.

Strengths and Limitations

Present study possesses a number of notable strengths. Methodologically, the use of a large, Canada-wide sample allows for generalizable findings across different regions and contexts. Additionally, the use of well-established and robust methods of handling missing data such as FIML and multiple imputation within the models allowed for a full utilization of the collected information and reduced the risk of completer biased results. In terms of novelty, the study is the first to test a model connecting nSES, pandemic objective hardship, and psychological distress during pregnancy to PTB risk. While individual findings are available from the previous literature, a comprehensive assessment of various mechanisms of effect based on stress response pathway is unique. The use of a self-report measure of pandemic-related hardship also contributes to the study's novelty, as most studies utilize cohort study design. The explicit connection established between the hardships experienced and psychological distress using the POHI further emphasizes the role mental health variables play when considering the effects of the pandemic on birth outcomes. However, the study also has a number of weaknesses to be considered when interpreting the findings. The higher-than-average household income and mostly White, highly educated sample reduces the generalizability despite the large sample size. Also, the PTB rate was significantly lower in the analytical sample than the national average, thus the representativeness of the sample is reduced. The study also did not differentiate between the different types of PTB such as spontaneous or induced which may fail to capture the changes in medical decision making (i.e., caesarian deliveries) during the pandemic and how that contributes to PTB rate. Lastly, the present study examined the symptom variables and hardship measures collected at baseline, without stratification based on trimesters. Considering that the stressors experienced at certain points of pregnancy (Zhu et al., 2010; Cole-Lewis et al., 2014; Hoffman et al., 2016) are thought to have a bigger effect on the risk of PTB, stratification based on the timing of stressor may find changes in the strength of association between hardship, psychological distress, and their effects on PTB risk. The narrow scope of PTB as birth outcome must also be considered when reviewing the present findings. PTB rate is calculated by dividing the number of preterm born by the total number of live births within the same geographical region. This fails to account for miscarriage or stillbirth that occurs within the same region. Combined with difficulties associated with measuring for miscarriage and reduction in health seeking behaviour during the pandemic, full effects of neighbourhood deprivation on birth outcome may be masked by the likely increase in miscarriage (Balachandren et al., 2022; Sacinti et al., 2021) during the pandemic.

Future Directions

Exploration of other area-based socioeconomic indices or predictors of inequal exposure to pandemic-related hardship, such as individual-level SES or ethnicity (Boserup et al., 2020), may yield different results. Also, a more detailed analysis of the effects of different subscales within the POHI is also warranted as many changes were introduced by the pandemic and the relationship with nSES and PTB risk may differ across subdomains. Having established psychological distress as a significant mediator between hardship and PTB risk, examining other associated factors such as sleep (Micheli et al., 2011; Okun et al., 2011), pregnancy-specific anxiety (Khalesi & Bokaie, 2018), or health behaviours such as exercise (Di Mascio et al., 2016) may reveal multiple pathway via which the increased experience of pandemic-specific hardship can impact PTB risk.

Conclusion

Findings from the present study informs a divided area of research, where studies with a similar aim of identifying the effects of the pandemic on PTB risk diverge on whether the pandemic has had negative, neutral, or even positive impact on adverse outcome of pregnancy. The comprehensive assessment of multiple pathways implicated by previous research is valuable when trying to understand if and how the different factors contribute towards PTB risk. Results suggest that the pandemic-related objective hardships lead to an elevation in psychological distress which then heightens the risk of giving PTB and shortens gestation. Findings highlight the need to explore other demographic and socioeconomic indices for identifying populations vulnerable to hardships such as the pandemic. Additionally, the importance of considering mental health consequences for assessing, and mitigating, the adverse effects of hardships on birth outcomes is further emphasized.

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