

Maternal Deaths Using Coroner's Data: A Latent Class Analysis

Kayvan Aflaki, MSc;¹ Simone N. Vigod, MD, MSc;² Ann E. Sprague, RN, PhD;³ Jocelynn Cook, PhD;⁴ Howard Berger, MD;⁵ Kazuyoshi Aoyama, MD, PhD;⁶ Reuven Jhirad, MD, MPH;⁷ Joel G. Ray, MD, MSc⁸

¹Institute of Medical Science, University of Toronto, Toronto, Canada

²Department of Psychiatry, Women's College Hospital, Toronto, Canada

³Better Outcomes Registry and Network – Ontario, Ottawa, Canada

⁴Society of Obstetricians and Gynecologists of Canada, Ottawa, Canada

⁵Departments of Obstetrics and Gynaecology, St. Michael's Hospital, Toronto, Canada

⁶Department of Anesthesia and Pain Medicine, The Hospital for Sick Children, Toronto, Canada

⁷Office of the Chief Coroner for Ontario/Ontario Forensic Pathology Service, Toronto, Canada

⁸Departments of Medicine and Obstetrics and Gynaecology, St. Michael's Hospital, Toronto, Canada

ABSTRACT

Objective: Knowledge regarding the antecedent clinical and social factors associated with maternal death around the time of pregnancy is limited. This study identified distinct subgroups of maternal deaths using population-based coroner's data, and that may inform ongoing preventative initiatives.

Methods: A detailed review of coroner's death files was performed for all of Ontario, Canada, where there is a single reporting mechanism for maternal deaths. Deaths in pregnancy, or within 365 days thereafter, were identified within the Office of the Chief Coroner for Ontario database, 2004–2020. Variables related to the social and clinical circumstances surrounding the deaths were abstracted in a standardized manner from each death file, including demographics, forensic information, nature and cause of death, and antecedent health and health care factors. These variables were then entered into a latent class analysis (LCA) to identify distinct types of deaths.

Results: Among 273 deaths identified in the study period, LCA optimally identified three distinct subgroups, namely, (1) in-hospital deaths arising during birth or soon thereafter (52.7% of the sample); (2) accidents and unforeseen obstetric complications also resulting in infant demise (26.3%); and (3) out-of-hospital suicides occurring postpartum (21.0%). Physical injury (22.0%) was the leading cause of death, followed by hemorrhage (16.8%) and overdose (13.3%).

Conclusion: Peri-pregnancy maternal deaths can be classified into three distinct sub-types, with somewhat differing causes. These

findings may enhance clinical and policy development aimed at reducing pregnancy mortality.

RÉSUMÉ

Objectif : Les connaissances sur les facteurs sociaux et cliniques antécédents associés aux décès maternels pendant ou après la grossesse sont limitées. Cette étude a permis de relever des sous-groupes distincts de décès maternels à l'aide des données du coroner fondées sur la population et susceptibles d'étayer les mesures préventives et continues.

Méthodes : La revue détaillée des dossiers de décès du coroner a été effectuée pour l'ensemble de l'Ontario, Canada, où il existe un seul mécanisme de déclaration des décès maternels. Les décès qui ont lieu pendant la grossesse ou dans les 365 jours la suivant entre 2004 et 2020 ont été relevés dans la base de données du Bureau du coroner en chef de l'Ontario. Les variables relatives aux circonstances sociales et cliniques des décès ont été extraites de manière normalisée de chaque dossier de décès, y compris les données démographiques, les renseignements médico-légaux, la nature et la cause du décès ainsi que les facteurs antécédents en matière de santé et de soins de santé. Ces variables ont ensuite été saisies dans une analyse de classes latentes afin de trouver des types de décès distincts.

Résultats : Parmi les 273 décès relevés dans la période d'étude, l'analyse de classes latentes a permis de déterminer de manière optimale trois sous-groupes distincts : (1) les décès en milieu hospitalier qui se sont produits pendant l'accouchement ou peu après (52,7 % de l'échantillon); (2) les accidents et les complications obstétricales imprévues entraînant également le décès du nourrisson (26,3 %); (3) les suicides en dehors du milieu hospitalier qui ont lieu pendant la période post-partum (21,0 %). Les blessures physiques (22,0 %) sont la principale cause de décès, suivies par les hémorragies (16,8 %) et les surdoses (13,3 %).

Conclusion : Les décès maternels liés à la grossesse peuvent être classés en trois sous-types distincts, dont les causes diffèrent quelque peu. Ces conclusions peuvent améliorer l'élaboration des

Keywords: maternal mortality; pregnancy; coroner; suicide; overdose; cause of death

Corresponding author: Joel G. Ray, MD, MSc,
Joel.ray@unityhealth.to

Disclosures: This project is supported by a grant provided by the PSI Foundation.

Received on September 19, 2023

Accepted on December 5, 2023

Available online on ■■■■

politiques et les connaissances cliniques visant à réduire la mortalité liée à la grossesse.

© 2024 The Author. Published by Elsevier Inc. on behalf of The Society of Obstetricians and Gynaecologists of Canada/La Société des obstétriciens et gynécologues du Canada. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

J Obstet Gynaecol Can 2024;■(■):102349

<https://doi.org/10.1016/j.jogc.2024.102349>

INTRODUCTION

Maternal mortality (i.e., peri-pregnancy death) is an often-preventable event that can have devastating consequences for families and health care providers. Globally, approximately 810 women die each day related to pregnancy and childbirth.¹ Between 1995 and 2015, maternal mortality rose in Canada from 5.1 to 11.9 per 100 000 livebirths.¹ This finding was noted by the World Health Organization,² and prompted the Society of Obstetricians and Gynaecologists of Canada to work with federal and provincial partners to review maternal mortality surveillance.³ The Public Health Agency of Canada now publishes updates on maternal mortality prevalence and time trends using hospital-based administrative data routinely submitted by provinces. However, these reports lack granular details about the nature of peri-pregnancy maternal deaths, especially those that arise outside of a hospital, that are most important for prevention initiatives.³ For example, it is now recognized that mental health and substance use issues significantly contribute to maternal deaths occurring within the community, yet, these are rarely recorded in hospital-based administrative data as maternal deaths.⁴

As Canada's most populous province, Ontario contributes about 38% of all births in Canada, equivalent to over 140 000 births annually.⁵ The Ontario Coroner's Act legislates that a coroner must be a physician, and the Office of the Chief Coroner (OCC) for Ontario has a standardized and mandated mechanism to capture pregnancy and post-pregnancy deaths (Figure S1), making Ontario an ideal place to study peri-pregnancy mortality. With such detailed data, there is also an opportunity to typify dissimilar death phenotypes, and thus, enable more specific approaches to mortality prevention. Accordingly, the current study extracted details regarding all maternal deaths reported to the OCC, and then characterized different groups of peri-pregnancy maternal deaths using latent class analysis (LCA), a statistical procedure that can aid in identifying

different subgroups (i.e., classes) within a heterogeneous population.^{6,7}

METHODS

Study Design and Data Sources

This retrospective study used coroner's data for the entire province of Ontario. All data files were held at the OCC for Ontario, authorized under Subsection 52.1 of the Coroner's Act, R.S.O. 1990.⁸ The OCC and Ontario Forensic Pathology Service operate within the Ministry of the Solicitor General. The OCC conducts investigations and inquests to ensure that no death is overlooked, concealed or ignored, and establishes death review committees that have specialized expertise in certain types of deaths to support death investigations (Figure S1).⁸ OCC investigation records include medical examiner and coroner reports, as well as autopsy and toxicology filings from the Ontario Forensic Pathology Service. Death investigation records may also include police reports, interview transcripts, emergency services (e.g., paramedic logs), patient charts, and the coroner's Maternal Perinatal Death Review Committee review reports when relevant.

Participants

To identify a maternal death, a two-part search of the OCC database was performed. First, the primary investigator (Author 1) searched for cases of "maternal perinatal deaths". Second, a keyword search of the OCC database was completed using "pregnancy" and other terms related to pregnancy, such as "birth", "ectopic", "postpartum", "delivery" and "stillbirth". All OCC database search results were screened for duplicates.

The current study considered all OCC-documented maternal deaths occurring during pregnancy, or up to 365 days after a recognized pregnancy, the latter defined as a livebirth, stillbirth at 20+ weeks' gestation, miscarriage before 20 weeks, ectopic pregnancy, or induced abortion. Included were individuals whose biological sex was female, and who were aged 16–50 years at the time of the death, occurring between 1 January 2004 and 31 December 2020, which is the available period of the OCC reports. Any uncertainty about an eligible case was resolved in discussion with a second investigator (Author 8).

Variables

Decedent data were abstracted through open-text documents in the coroner death records. Data abstraction was performed by Author 1, using a standardized data abstraction template (Table S1). The abstraction template

included sociodemographic variables, such as neighbourhood-level income quintile, community size, number of previous livebirths, immigrant status,⁹ and social vulnerability indicators (e.g., violence-related hospital care, homelessness, or involvement in the criminal justice system). Each pregnancy was classified as a livebirth, stillbirth, miscarriage, ectopic pregnancy or induced abortion. Manner of death was categorized as “natural”, suicide, accident, homicide, or undetermined. Deaths categorized as “natural” are those where an antecedent disease initiated the chain of events resulting in death.

Statistical Analysis

LCA was performed using RStudio (version 4.0.5) and the poLCA software package. LCA attempts to uncover unobserved or unrealized groups (i.e., “latent classes”) that exist within a heterogeneous population⁶—in this case, all OCC-documented maternal deaths. For each maternal death, how the pregnancy ended, manner of death, location of death, timing of death, gravidity, and residential income quintile (derived from postal code information) (Table S2), were considered in the derivation of the LCA model. All included variables were selected based on the existing literature, as well as an iterative discussion between Authors 1,2,5 and 8. Only variables with $\geq 80\%$ completeness are reported in this study.

A total of 2 to 9 class models were run, with group membership determined using a modal approach, which assigns the most likely group according to the highest membership probability.¹⁰ Model fit was evaluated based on statistical fit—using Akaike Information Criterion, Bayesian Information Criterion, likelihood-ratio chi-square test (G2), Entropy, and the Lo-Mendell-Rubin test — as well as by theoretical interpretability. Groups were then thematically labelled according to key defining characteristics therein.

RESULTS

From 1513 deaths identified through a keyword search in the OCC database, 1240 were excluded following screening, resulting in an analytical sample of 273 peripregnancy maternal deaths (Figure 1). The mean (SD) age of the women at the time of death was 32.5 (6.2) years, and about 29.7% of women resided in a low-income area (Table 1). A total of 163 deaths (59.7%) occurred outside of hospital. There were 127 deaths (46.5%) during pregnancy, and 125 (45.8%) following pregnancy. About 63% of the deaths were categorized as “natural”. There were 66 deaths (24.2%) due to suicide, including 31 from a hanging, 25 from an intentional overdose, eight from a fall, and the remainder due to drowning or inhalation (Table 1). There were 11 unintentional overdoses (4.0%). Physical injury ($n = 60$ [22.0%]) was the leading cause of death, followed by haemorrhage ($n = 46$ [16.8%]) and overdose ($n = 36$ [13.3%]). Preeclampsia ($n = 30$ [11.0%]), pregnancy-related sepsis ($n = 27$ [9.9%]) and thromboembolism ($n = 27$ [9.9%]) were the next most common causes, followed by amniotic fluid embolism ($n = 22$ [8.1%]).

LCA Findings

We evaluated LCA for 2 to 9 groups, with fit statistics and model interpretability suggesting that a 3-group model was most optimal, above either a 4-class or 5-class model (Table S3). The results of the 4- and 5-class models are shown in Tables S4 and S5, respectively.

Class 1 (“In-hospital deaths arising during or following delivery”) comprised 144 deaths (52.7% of all deaths) (Table 2). Most women assigned by the LCA to this subgroup were “natural” deaths (96.0%), and most of the deaths occurred during delivery (10.7%) or up to 1 year thereafter pregnancy (87.7%). Class 1 had the

Figure 1. Flow diagram of cohort derivation from Office of the Chief Coroner for Ontario (OCC) database.

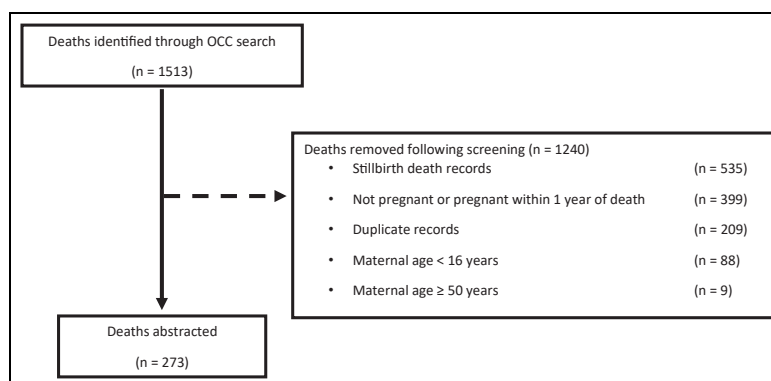


Table 1. Characteristics of 273 women in Ontario who died during pregnancy, or up to 365 days after a pregnancy, from 2004 to 2020

Characteristic	Measure
Death details	
Manner of maternal death	
“Natural” ^a	171 (62.6)
Suicide	66 (24.2)
Unintentional overdose ^b	11 (4.0)
Other accidents	19 (7.0)
Homicide	1 (0.4)
Undetermined	5 (1.8)
Cause of death	
Physical injury	60 (22.0)
Haemorrhage	46 (16.8)
Overdose	36 (13.2)
Preeclampsia	30 (11.0)
Sepsis	27 (9.9)
Thromboembolism	27 (9.9)
Cardiovascular	22 (8.1)
Amniotic fluid embolism	10 (3.7)
Neurological	5 (1.8)
Malignancy	2 (0.7)
Metabolic and endocrine	2 (0.7)
Undetermined	6 (2.2)
Mechanism of suicide (n = 66)	
Hanging	31 (47.0)
Overdose	25 (37.9)
Fall	8 (12.1)
Drowning	1 (1.5)
Inhalation	1 (1.5)
Location of maternal death	
Out-of-hospital	163 (59.7)
In-hospital	110 (40.3)
Timing of maternal death	
While pregnant	127 (46.5)
During delivery	21 (7.7)
After pregnancy	125 (45.8)
Obstetric details	
Gravidity	
1	103 (37.7)
2+	170 (62.2)
Pregnancy outcome	
Livebirth	149 (54.6)
Stillbirth	69 (25.3)
Miscarriage	49 (17.9)
Ectopic pregnancy	2 (0.7)
Induced abortion	4 (1.5)
Mode of delivery	
Vaginal	115 (42.1)
Caesarean	90 (33.0)
No delivery	68 (24.9)

(continued)

Table 1. (Continued)

Characteristic	Measure
Body mass index at time of death, kg/m²	
Underweight (<18.5)	11 (4.0)
Normal (18.5 to 24.9)	60 (22.0)
Overweight (25.0 to 29.9)	110 (40.3)
Obese (≥30.0)	92 (33.7)
Demographics	
Maternal age at death, years	
≤19	30 (10.9)
20–29	90 (33.0)
30–39	114 (41.8)
≥40	39 (14.3)
Community size	
<10 000	21 (7.7)
10 000 to 99 999	29 (10.6)
100 000 to 499 999	32 (11.7)
500 000 to 1 499 999	60 (22.0)
≥1 500 000	124 (45.4)
Information missing	7 (2.6)
Marital status	
Married or common-law	212 (77.7)
Single, divorced, or widowed	61 (22.3)
Residential income quintile (Q)	
Lowest income (Q1 or unknown)	81 (29.7)
Middle-and-highest income (Q2–Q5)	192 (70.3)
Highest education attained^c	
University or college	89 (32.6)
High school	20 (7.3)
Less than high school	2 (0.7)
Information missing	162 (59.3)
World region of origin^c	
North America	132 (48.4)
East Asia and Pacific	23 (8.4)
South Asia	20 (7.3)
Africa	19 (7.0)
West Asia	11 (4.0)
South and Central America	8 (2.9)
Southeast Asia	7 (2.6)
Caribbean	4 (1.5)
Europe	4 (1.5)
Unknown	55 (20.1)
Social vulnerabilities within 2 years preceding death^c	
Children discharged to social services	20 (7.3)
Criminal justice system involvement	25 (9.2)
Homelessness	11 (4.0)
Welfare or social support	38 (13.9)

All data are presented as a number (%).

^aDeaths categorized as “natural” are those where a disease initiated the chain of events resulting in death.^bUnintentional overdoses are those deaths attributed to drug toxicity that could not be readily classified as a suicide due to an absence of corroborating evidence.^cAs noted in health care records or police reports, which vary in detail and may not be comprehensive.

Table 2. Characteristics of 273 women who died during pregnancy, or up to 365 days after a pregnancy, 2004 to 2020, stratified by the 3-group solution identified by latent class analysis

Model variable	Group 1: In-hospital deaths arising during or following delivery (52.7%)	Group 2: Accidents and unforeseen obstetric complications also resulting in infant demise (26.3%)	Group 3: Out-of-hospital suicides in the postpartum period (21.0%)
Maternal age at death, years			
≤19	0.0	2.5	6.1
20–29	30.6	29.5	18.8
30–39	57.8	59.1	45.4
≥40	11.6	45.4	29.6
Manner of maternal death			
“Natural” ^a	96.0	71.6	15.8
Suicide	0.0	0.0	76.6
Unintentional overdose ^b	4.0	17.3	0.0
Other accidents	0.0	4.9	3.1
Undetermined	0.0	6.2	4.6
Location of maternal death			
Out-of-hospital	0.0	39.0	92.7
In-hospital	100.0	61.0	7.3
Timing of maternal death			
During pregnancy	1.7	51.3	0.0
During delivery	10.7	0.0	0.0
After delivery	87.7	48.7	100.0
Gravidity			
1	52.1	44.0	49.5
2+	47.9	56.0	50.5
Pregnancy outcome			
Livebirth	80.9	0.0	83.7
Stillbirth	19.1	40.7	3.9
Other	0.0	59.3	12.4
Income quintile (Q)			
Lowest income (Q1)	34.9	31.1	16.1
Middle-and-highest income (Q2–Q5)	65.1	68.9	83.4

All table values are in percentages.

^aDeaths categorized as “natural” are those where a disease initiated the chain of events resulting in death.

^bUnintentional overdoses are those deaths attributed to drug toxicity that could not be readily classified as a suicide due to an absence of corroborating evidence.

highest probability of containing women residing in the lowest area income quintile (34.9%). Moreover, all deaths included in this subgroup occurred in a hospital (100%).

Class 2 (“Accidents and unforeseen obstetric complications during pregnancy also resulting in infant demise”) comprised 75 deaths (26.3% of the cohort) (Table 2). Most deaths assigned by the LCA to this subgroup were also “natural” deaths (71.6%), but some were non-overdose accidental deaths (17.3%). Class 2 deaths almost always occurred during pregnancy (83.8%) and ended in stillbirth (57.3%) or miscarriage (39.7%). Class 2 was characterized by the second-highest membership probability of economic disadvantage (31.1%). Most deaths in this subgroup

occurred in hospital (61.0%). Class 3 (“Out-of-hospital suicides in the postpartum period”) comprised 57 deaths (21.0% of the cohort) (Table 2). Most deaths assigned by the LCA to this subgroup were suicide-related (76.6%), all occurred postnatally (100.0%), and 92.7% occurred outside of the hospital.

DISCUSSION

Principal Findings

This retrospective study, completed within a universal healthcare system that has a standardized approach for recording details about maternal deaths through a central coroner's office, observed three distinct groupings of deaths arising during, or up to 1 year after, pregnancy. This

appears to be the first study to apply a person-centred approach to identify distinct groups of women who died during or following pregnancy and using LCA methodology.

Results in Relation to Other Studies

In the current era, opioid use in pregnancy has become a dominant public health concern, with 5% of pregnancies exposed to opioids.¹¹ Previous studies reported associations between opioid use disorder during pregnancy and economic disadvantage, social vulnerability, higher psychiatric comorbidities, polysubstance use, and chronic medical conditions.¹¹ In the current study, Class 2 was characterized by the second highest membership probability of economic disadvantage, and the highest probability of a non-viable pregnancy (i.e., stillbirth, miscarriage or induced abortion). To better elucidate the relation between socioeconomic disadvantage and the risk of perinatal death, it might be better to apply an LCA approach more like that in the 4-class (Table S4) or 5-class solutions (Table S5). Certainly, a future LCA study, using population-based administrative datasets that contain disease diagnostic codes, prescription and opioid use data,¹² alongside sociodemographic measures, may enhance class sample sizes, with greater interpretability about accidental overdose, other physical injury-related deaths,⁴ and “natural” deaths from other causes.

Suicide accounted for nearly one-quarter of all study deaths herein. In the US, suicide has been previously reported to account for up to 20% of postpartum deaths.¹³ In the current study, the most lethal means of suicide among women in Class 3 (“Out-of-hospital suicides in the postpartum period”) was by hanging or overdose, which is consistent with other US data.¹³ A 15-year population-based study completed in Ontario calculated a perinatal suicide rate of 2.6 per 100 000 livebirths, which is between those rates reported in the US and UK.¹⁴

Clinical Implications

Identifying somewhat distinct classes of maternal deaths can inform targeted preventive and intervention strategies in Canada and elsewhere.¹ For example, specific characteristics may help to identify at-risk perinatal women, and inform suicide and substance use interventions that can be applied within family practice, obstetric and paediatric settings. These study findings may also assist provincial coroners in improving their detailed audits of the clinical and social circumstances surrounding maternal deaths, and the policy recommendations that they generate, *vis-à-vis* coroner inquests. Furthermore, the abstraction framework and findings from this study can support efforts to create a

comprehensive and reliable national system for maternal mortality and severe maternal morbidity data collection, review, and surveillance.¹

Strengths and Limitations

As a study strength, the OCC captures all coroner-investigated deaths in Ontario, including those arising outside of a traditional health care setting. The availability of non-clinical data in the OCC datafiles, including interviews and police reports, offers another great advantage over conventional population-based statistics. However, a 2018 report from the Ontario Ministry of the Solicitor General found that pregnancy deaths, fractures, or other trauma were underreported to the coroner.¹⁵ Not all maternal deaths in Ontario require a coroner investigation. For example, deaths occurring between 42-365 days post-delivery undergo review if the cause of death is believed to be directly related to the pregnancy, or as a complication of the pregnancy.¹⁵ Hence, the true scope of maternal mortality in Ontario, including natural deaths, maternal suicides and homicides, is likely higher than that described in the current study. Certain elements were also likely underreported, such as intimate partner violence, homelessness, or criminal justice system involvement.

Research Implications

We suggest amending death certificates to include a fillable field for a provincial or territorial health insurance plan number, such as the Ontario Health Insurance Plan number.^{1,16} We also advise mandating a status of pregnancy checkbox in the Coroner Investigation Statements, which effectively identifies whether the deceased woman was pregnant within the year preceding death.^{17,18} Finally, implementing a nationwide confidential enquiry system is another important step toward detailing pregnancy and post-pregnancy maternal mortality.³

CONCLUSIONS

These study findings highlight the differing nature of maternal mortality, and the potential added utility of applying LCA methods to coroner's data. Distinguishing the clinical and social circumstances associated with any maternal death is key to informing ongoing targeted preventative efforts within Canada and elsewhere.^{1,5}

DATA SHARING STATEMENT

The data from this study is held securely at the Office of the Chief Coroner for Ontario. Although data-sharing agreements prohibit the Office of the Chief Coroner for Ontario from making the data set publicly available, access may be

granted to those who meet prespecified criteria, available at <https://www.ipc.on.ca/decisions/three-year-reviews-and-approvals/faqs/>, for confidential access authorized under Subsection 52.1 of the Coroner's Act, R.S.O. 1990. The full data set creation plan and underlying analytic documents are available from the authors on request.

SUPPLEMENTARY DATA

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.jogc.2024.102349>.

REFERENCES

1. Aflaki K, Ray JG. How other countries can improve Canada's maternal mortality statistics. *Obstet Med* 2023;16:211–6.
2. The World Health Organization, United Nations Children's Fund, United Nations Population Fund, et al. Trends in maternal mortality: 1990 to 2010: estimates by the WHO, UNICEF: united nations population fund, and The World Bank; 2012. Available at: https://apps.who.int/iris/bitstream/handle/10665/44874/9789241503631_eng.pdf;jsessionid=63F82B9506FD887EE5064810723604C5?sequence=1. Accessed on July 15, 2023.
3. Cook JL, Sprague AE. Measuring maternal mortality in Canada: an update on the establishment of a confidential enquiry system for preventing maternal deaths #savingmoms #savingbabies. *J Obstet Gynaecol Can* 2019;41:1768–71.
4. Ray JG, Zipursky J, Park AL. Injury-related maternal mortality. *Am J Obstet Gynecol* 2018;219:307–8.
5. Estimates of the comparisons of economic growth, annual: Statistics Canada. Updated on February 2020. Available at: <https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1710000801>. Accessed on July 15, 2023.
6. Aflaki K, Vigod S, Ray JG. Part I: a friendly introduction to latent class analysis. *J Clin Epidemiol* 2022;147:168–70.
7. Aflaki K, Vigod S, Ray JG. Part II: a step-by-step guide to latent class analysis. *J Clin Epidemiol* 2023;159:348–51.
8. Ontario. Coroners act, R.S.O. 1990, c. C.37. Updated on June 8, 2023. <https://www.ontario.ca/laws/statute/90c37>. Accessed on July 15, 2023.
9. Urquia ML, Wanigaratne S, Ray JG, et al. Severe maternal morbidity associated with maternal birthplace: a population-based register study. *J Obstet Gynaecol Can* 2017;39:978–87.
10. Nylund KL, Asparouhov T, Muthen BO. Deciding on the number of classes in latent class analysis and growth mixture modeling: a Monte Carlo simulation study. *Structural Equation Modeling: A Multidisciplinary Journal* 2007;14:535–69.
11. Camden A, Ray JG, To T, et al. Prevalence of prenatal opioid exposure in Ontario, Canada, 2014–2019. *JAMA Netw Open* 2021;4:e2037388.
12. Camden A, To T, Ray JG, et al. Categorization of opioid use among pregnant people and association with overdose or death. *JAMA Netw Open* 2022;5:e2214688.
13. Chin K, Wendt A, Bennett IM, et al. Suicide and maternal mortality. *Curr Psychiatry Rep* 2022;24:239–75.
14. Grigoriadis S, Wilton AS, Kurdyak PA, et al. Perinatal suicide in Ontario, Canada: a 15-year population-based study. *CMAJ* 2017;189:E1085–92.
15. Office of the Chief Coroner, Ontario Forensic Pathology Service. Annual report of the office of the auditor general of Ontario. In Queen's Printer Ont 2019. Available at: https://www.auditor.on.ca/en/content/annualreports/arreports/en19/v1_308en19.pdf. Accessed on July 15, 2023.
16. Aflaki K, Park AL, Nelson C, et al. Identifying maternal deaths with the use of hospital data versus death certificates: a retrospective population-based study. *CMAJ Open* 2021;9:E539–47.
17. Horon IL, Cheng D. Effectiveness of pregnancy check boxes on death certificates in identifying pregnancy-associated mortality. *Public Health Rep* 2011;126:195–200.
18. Catalano A, Davis NL, Petersen EE, et al. Pregnant? Validity of the pregnancy checkbox on death certificates in four states, and characteristics associated with pregnancy checkbox errors. *Am J Obstet Gynecol* 2020;222:269.e1–8.