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3 **Identifying maternal deaths using hospital data vs.**
4 **death certificates: population-based study**
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6 Kayvan Aflaki, HBSc
7 Institute of Medical Science
8 University of Toronto
9 Toronto, Canada
10

11
12 Alison L. Park, MSc
13 ICES
14 Toronto, Canada
15

16
17 Chantal Nelson, PhD
18 Maternal, Child and Youth Health Division, Centre for Surveillance and Applied Research
19 Public Health Agency of Canada
20 Ottawa, Canada
21

22
23 Wei Luo, MBBS, MSc
24 Maternal, Child and Youth Health Division, Centre for Surveillance and Applied Research
25 Public Health Agency of Canada
26 Ottawa, Canada
27

28
29 Joel G. Ray MD, MSc
30 Departments of Medicine and Obstetrics and Gynaecology
31 St. Michael's Hospital
32 Toronto, Canada
33

34 **Corresponding Author**

35 Dr. Joel G. Ray, MD MSc
36 Joel.Ray@unityhealth.to
37 (416) 864-6060 ext. 77442
38 St. Michael's Hospital
39 30 Bond St.
40 Toronto, Canada
41 M5B 18W
42

43 **Declaration of Interest**

44 The authors confirm that there are no known conflicts of interest associated with this work.
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Abstract

Background: Accurate identification of maternal deaths is paramount for audit and policy purposes. Agreement between pregnancy deaths recorded in hospital vs. those on a death certificate is unknown.

Methods: This population-based retrospective study was completed in all of Ontario, Canada, April 1, 2002-December 31, 2014. The Canadian Institute of Health Information (CIHI) databases were used to identify deaths during inpatient, emergency department and same-day-surgery encounters. Vital Statistics deaths were captured in the Ontario Office of the Registrar General Deaths (ORGD) database. Deaths were considered ≤ 42 days and ≤ 365 days following ending of a pregnancy, including recognized pregnancies resulting in a livebirth, stillbirth, miscarriage, ectopic pregnancy, or induced abortion.

Results: Of the 1,679,455 livebirths/stillbirths, 398 ORGD maternal deaths were mapped to a birth in CIHI, while 77 (16.2%) were not. Among 2,039,849 recognized pregnancies, 534 ORGD pregnancy-related deaths were linked to CIHI, and 68 (11.3%) were not. Among livebirths/stillbirths, upon removing unlinked ORGD pregnancy-related deaths, concordance measures between CIHI and ORGD for maternal death ≤ 42 days included a Kappa of 0.87 (95% CI 0.82-0.91) and positive percent agreement (PPA) of 0.88 (95% CI 0.83-0.94). For maternal deaths arising ≤ 42 days of a recognized pregnancy, the corresponding measures were similar. However, when unlinked ORGD deaths were retained, agreement measures declined for deaths ≤ 42 days of a livebirth/ stillbirth (Kappa 0.68, 95% CI 0.62-0.74; PPA 0.57, 95% CI 0.50-0.63).

Interpretation: Maternal mortality cannot be ascertained solely using hospital data, including beyond 42 days after pregnancy.

Introduction

While rare, maternal mortality is an often preventable event with devastating consequences for families and care providers. The World Health Organization (WHO) estimates that more than 300,000 women die each year from pregnancy or childbirth-related complications.¹ In 2010, the WHO noted a sharp increase in maternal mortality in Canada.² These findings prompted the Society of Obstetricians and Gynaecologists of Canada to work with federal and provincial partners to review maternal mortality surveillance.³ The investigating committee found that national maternal health surveillance faced serious barriers relating to data access, coverage, timeliness and completeness. Moreover, their report concluded that there was little standardization across jurisdictions with respect to definitions, data collection, and maternal mortality review processes.^{3,4} Although several provinces and territories have since established maternal death review committees, there is no national system to synthesize and report on maternal mortality, and thus, no accurate national picture of mortality prevalence and trends.^{3,4} This is especially so for maternal deaths occurring prior to the conventional birthing period, such as an ectopic pregnancy, induced abortion or miscarriage, or for deaths occurring after the conventional postpartum period of birth up to 42 days thereafter.

Since Ontario contributes about 35% of all births in Canada,^{5,6} there arises an opportunity to examine the systems responsible for monitoring and recording maternal mortality. Accordingly, the current study was undertaken to determine the accuracy, completeness, and level of agreement between pregnancy deaths in hospital and those recorded on a death certificate. This was done considering not only births, but also ectopic pregnancies, induced abortions, and miscarriages, as well as capturing maternal deaths up to 365 days after pregnancy.

Methods

Study design

This population-based retrospective study was completed in the entire province of Ontario, Canada, from April 1, 2002 to December 31, 2014. We used existing datasets linked using unique encoded identifiers and analyzed at ICES.

Data sources

The Ontario Office of the Registrar General Deaths (ORGD) database was used to identify deaths based on a Medical Certificate of Death (“Form 16”), completed by a physician.⁷ The ORGD shares Vital Statistics death data with Statistics Canada for national reporting. The ORGD includes date, location and International Statistical Classification of Diseases and Related Health Problems, Tenth Revision (ICD-10) codes for cause of death. Deaths occurring in a hospital setting were identified using the Canadian Institute of Health Information (CIHI) Discharge Abstract Database (DAD), the National Ambulatory Care Reporting System (NACRS) database, and the Same Day Surgery (SDS) database.⁸ The CIHI-DAD contains administrative, clinical, and demographic information pertaining to hospital discharges (i.e., deaths, sign-outs and transfers). Diagnostic codes are based on the ICD-10 Canada (ICD-10-CA), and procedural codes are based on the Canadian Classification of Health Interventions.⁹ The CIHI-NACRS contains hospital- and community-based emergency and ambulatory care visit information, and the CIHI-SDS contains patient-level data for day surgery institutions in Ontario.^{9,10}

Participants

Livebirths and stillbirths were identified in CIHI-DAD and NACRS. The CIHI-DAD, NACRS and SDS databases were used to capture all recognized pregnancies, namely a livebirth, a stillbirth \geq 20 weeks’ gestation, a miscarriage $<$ 20 weeks’ gestation, an ectopic pregnancy, or an induced abortion. The ORGD was used to identify the death of a woman any time within 365 days after the end of a recognized pregnancy. Therein, an ICD-10 cause of death code starting with “O” was further used to identify a pregnancy-related death.

Included were Ontario resident females aged 10 to 55 years at the time of a documented encounter for a recognized pregnancy outcome in CIHI and/or a registered death in ORGD – each between April 1, 2002 and December 31, 2015. Excluded were records possessing an invalid Ontario Health Insurance Plan (OHIP) number or hospitalization number, a non-Ontario postal code, as well as those records with non-unique patient or hospital record identifiers.

Statistical analysis

Agreement statistics (95% confidence intervals [CI]) were generated from 2 x 2 tables, describing the concordance between pregnancy deaths identified in CIHI and those in ORGD, first for deaths limited to women with a livebirth or stillbirth, and then among all recognized pregnancies, with consideration of deaths within 42 days and within 365 days of the pregnancy.

Agreement measures included Cohen's Kappa, sensitivity, specificity, positive predictive value, negative predictive value, overall percent agreement (OPA), positive percent agreement (PPA) and negative percent agreement (NPA). OPA, PPA and NPA, whose calculations are shown in Table S1, are generally used in the absence of a perfect reference standard, as might be the case with using ORGD, if a pregnancy is unrealized or the maternal death was beyond 42 days after birth.

Ethics approval

The use of data in this project was authorized under section 45 of Ontario's Personal Health Information Protection Act, which does not require review by a research ethics board.

Results

Number of maternal deaths

We identified 1,679,455 livebirth or stillbirth deliveries in CIHI-DAD or CIHI-NACRS (Figure 1, green). We matched these records to an identified maternal death in ORGD (Figure 1, blue). There were 398 ORGD birth-related deaths that could be mapped to a birth within the preceding 365 days in the CIHI-DAD or NACRS, while 77 pregnancy-related deaths (16.2%) in ORGD had no birth record in CIHI (Figure 1, red). Cause of death within 42 days of birth, classified by the 3-digit ICD-10 code, is shown in Table S2, and that for deaths between 43 and 365 after birth is shown in Table S3.

There were 2,039,849 recognized pregnancies in CIHI-DAD, NACRS or SDS (Figure 2, purple). 534 ORGD pregnancy-related deaths could be linked to these CIHI databases, while 68 (11.3%) could not (Figure 2, red).

Measures of concordance

Among livebirths and stillbirths, and upon removing unlinked ORGD pregnancy-related deaths, concordance measures for maternal deaths ≤ 42 days were high (Table 1a). For example, Cohen's Kappa was 0.87 (95% CI 0.82 to 0.91), PPA 0.88 (95% CI 0.83 to 0.94) and NPA 1.00 (95% CI 1.00 to 1.00). For maternal deaths arising ≤ 42 days of the ending of a recognized pregnancy, the corresponding measures were 0.82 (95% CI 0.78 to 0.87), 0.84 (95% CI 0.78 to 0.90) and 1.00 (95% CI 1.00 to 1.00) (Table 1b).

When unlinked ORGD were retained, however, agreement measures declined for maternal death ≤ 42 days of a livebirth or stillbirth, with Cohen's Kappa of 0.68 (95% CI 0.62 to 0.74) and PPA of 0.57 (95% CI 0.50 to 0.63) (Table 2a). The same pattern was seen for maternal deaths ≤ 42 days of a recognized pregnancy (Table 2b).

For maternal deaths ≤ 365 days of a livebirth or stillbirth (Table 3a), or ≤ 365 days after a recognized pregnancy (Table 3b), the concordance statistics were, again, generally favourable if unlinked ORGD pregnancy-related deaths were removed, but substantially declined when they were retained (Tables 4a and 4b).

Discussion

In this population-based study, about 16% of maternal deaths following a livebirth or stillbirth, and 11% of deaths after a recognized pregnancy (i.e., livebirth, stillbirth, ectopic pregnancy, miscarriage or induced abortion) were not captured during a CIHI hospital encounter when they were documented in the ORGD death record. When linkage between the CIHI and ORGD was possible, there was a high concordance for maternal deaths, which declined when non-linked cases were also considered.

Clinical and policy relevance

While Canada's maternal mortality rate is among the lowest in the world, a complete picture (the "universe") of maternal deaths is lacking.¹¹ Nearly 60% of all deaths in Ontario between 2001 and 2015 occurred in a hospital setting.¹² The current study further suggests that maternal mortality cannot be ascertained solely using hospital data, and highlights the need for

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3 improved methodology to effectively capture maternal mortality beyond 42 days after
4 pregnancy.
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7 It has been challenging to develop a national maternal mortality enquiry system, given
8 Canada's province-based approach to health care administration. Nevertheless, Canadian
9 provinces and territories can, and do, collaborate in the design, development, and collection of
10 national disease surveillance. Replication of the current study methods in other provinces and
11 territories is one step in achieving a better perspective about how maternal deaths can be
12 accurately and efficiently captured, including input from the chief coroner of each province.
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18 To ascertain more accurate and complete information on maternal mortality, and to enable
19 deterministic linkage between hospital and Vital Statistics data sources, we recommend
20 amending provincial and territorial death certificates to include a fillable field for an individual's
21 provincial health insurance plan number, such as the OHIP number in Ontario. We also
22 recommend that all pregnancies be captured – regardless of how the pregnancy ends – with
23 the inclusion of women who die while still pregnant.
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30 *Limitations*

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32 Our study has several limitations. First, not all miscarriages or induced abortions are captured
33 by the study datasets.^{13,14} In order to parallel those datasets currently available to the Canadian
34 Perinatal Surveillance System, we opted to use only the CIHI and Vital Statistics files. A broader
35 dataset might also include provincial billing information, for example, which might enhance
36 capture of induced abortion codes.^{13,14} Second, there were inherent problems in creating the
37 current data linkages. In Ontario, a Medical Certificate of Death (Form 16) does not include a
38 fillable field for an OHIP number, which serves as a unique identifier for all residents of Ontario.
39 Matching maternal deaths from the Vital Statistics registry to hospitalization information
40 depended on a probabilistic linkage method, which uses non-unique linkage keys, such as first
41 and last name combinations and date of birth. Such an approach is prone to false-positive and
42 false-negative linkages.¹⁵ For example, if a hospitalization record could not be linked to an
43 existing Vital Statistics record with certainty, then that record was deemed a non-match. Lastly,
44 deaths within CIHI are not linkable for individuals without a registered provincial health
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3 insurance plan number, which might miss maternal deaths among temporary visa holders,
4 recent refugees and undocumented residents – the majority who reside in larger urban centres,
5 including Toronto.^{16,17} Hence, the true scope of maternal mortality in Ontario may be higher
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7 than was reflected in the current study.
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10 11 12 *Conclusion*

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14 Vital Statistics death records likely capture the scope of maternal deaths in Ontario, more
15 accurately and completely than using CIHI hospital records alone. To improve the quality of
16 data linkage, we propose amending provincial and territorial medical death certificates to
17 include fields for health insurance numbers, and the capture of all deaths in, or after,
18 pregnancy.
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25 **Contributors:** Chantal Nelson, Alison Park and Joel Ray conceived of the study. Chantal Nelson,
26 Wei Luo, Alison Park, and Joel Ray contributed to the study design and data interpretation.
27 Alison Park analyzed the data. Kayvan Aflaki and Joel Ray drafted the manuscript. All the
28 authors revised the manuscript critically for important intellectual content, approved the final
29 version to be published and agreed to be account-able for all aspects of the work.
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44 **Data sharing:** The data set from this study is held securely in coded form at ICES. Although
45 data-sharing agreements prohibit ICES from making the data set publicly available, access may
46 be granted to those who meet prespecified criteria for confidential access, available at
47 www.ices.on.ca/DAS. The full data set creation plan and underlying analytic code are available
48 from the authors on request, with the understanding that the computer programs may rely on
49 coding templates or macros that are unique to ICES and are therefore inaccessible or may
50 require modification.
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3 **Disclaimer:** Parts of this material are based on data and information compiled and provided by
4 MOHLTC and CIHI. The analyses, conclusions, opinions, and statement expressed herein are
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9 Ministry of Government Services.
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Table 1. a. Maternal deaths \leq 42 days of a livebirth or stillbirth, comparing CIHI-DAD or CIHI-NACRS, vs. ORGD. Results exclude unlinked ORGD pregnancy-related deaths (Figure 1, **red**) in the numerator and denominator during percent agreement calculations. **b.** Maternal deaths \leq 42 days of the ending of a recognized pregnancy, comparing a recognized pregnancy in CIHI-DAD, CIHI-NACRS or CIHI-SDS, vs. ORGD. Results exclude unlinked ORGD pregnancy-related deaths (Figure 2, **red**) in the numerator and denominator during percent agreement calculations.

a.

CIHI death	ORGD death		Total
	Yes	No	
Yes	122	22	144
No	16	1,679,295	1,679,311
Agreement indicator	Value (95% CI)		
Total	138	1,679,317	1,679,455

Cohen's Kappa	0.87 (0.82 to 0.91)
Sensitivity	0.88 (0.83 to 0.94)
Specificity	1.00 (1.00 to 1.00)
Positive Predictive Value	0.85 (0.79 to 0.91)
Negative Predictive Value	1.00 (1.00 to 1.00)
Overall Percent Agreement	1.00 (1.00 to 1.00)
Positive Percent Agreement	0.88 (0.83 to 0.94)
Negative Percent Agreement	1.00 (1.00 to 1.00)

b.

CIHI death	ORGD death		Total
	Yes	No	
Yes	137	34	171
No	26	2,039,641	2,039,667
Agreement indicator	Value (95% CI)		
Total	163	2,039,675	2,039,838

Cohen's Kappa	0.82 (0.78 to 0.87)
Sensitivity	0.84 (0.78 to 0.90)
Specificity	1.00 (1.00 to 1.00)
Positive Predictive Value	0.80 (0.74 to 0.86)
Negative Predictive Value	1.00 (1.00 to 1.00)
Overall Percent Agreement	1.00 (1.00 to 1.00)
Positive Percent Agreement	0.84 (0.78 to 0.90)
Negative Percent Agreement	1.00 (1.00 to 1.00)

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Table 2. a. Maternal deaths ≤ 42 days of a livebirth or stillbirth, comparing CIHI-DAD or CIHI-NACRS, vs. ORGD. Results include unlinked ORGD pregnancy-related deaths (Figure 1, **red**) in the numerator and denominator during percent agreement calculations. **b.** Maternal deaths ≤ 42 days of the ending of a recognized pregnancy, comparing a recognized pregnancy in CIHI-DAD, CIHI-NACRS or CIHI-SDS, vs. ORGD. Results include unlinked ORGD pregnancy-related deaths (Figure 2, **red**) in the numerator and denominator during percent agreement calculations.

a.

CIHI death	ORGD death		Total
	Yes	No	
Yes	122	22	144
No	93	1,679,295	1,679,388
Total	215	1,679,317	1,679,532

b.

CIHI death	ORGD death		Total
	Yes	No	
Yes, n	137	34	171
No, n	94	2,039,652	2,039,746
Total	231	2,039,686	2,039,917

Agreement indicator	Value (95% CI)
Cohen's Kappa	0.68 (0.62 to 0.74)
Sensitivity	0.57 (0.50 to 0.63)
Specificity	1.00 (1.00 to 1.00)
Positive Predictive Value	0.85 (0.79 to 0.91)
Negative Predictive Value	1.00 (1.00 to 1.00)
Overall Percent Agreement	1.00 (1.00 to 1.00)
Positive Percent Agreement	0.57 (0.50 to 0.63)
Negative Percent Agreement	1.00 (1.00 to 1.00)

Agreement indicator	Value (95% CI)
Cohen's Kappa	0.68 (0.63 to 0.73)
Sensitivity	0.59 (0.53 to 0.66)
Specificity	1.00 (1.00 to 1.00)
Positive Predictive Value	0.80 (0.74 to 0.86)
Negative Predictive Value	1.00 (1.00 to 1.00)
Overall Percent Agreement	1.00 (1.00 to 1.00)
Positive Percent Agreement	0.59 (0.53 to 0.66)
Negative Percent Agreement	1.00 (1.00 to 1.00)

Table 3. a. Maternal deaths \leq 365 days of a livebirth or stillbirth, comparing CIHI-DAD or CIHI-NACRS, vs. ORGD. Results exclude unlinked ORGD pregnancy-related deaths (Figure 1, **red**) in the numerator and denominator during percent agreement calculations. **b.** Maternal deaths \leq 365 days of the ending of a recognized pregnancy, comparing a recognized pregnancy in CIHI-DAD, CIHI-NACRS or CIHI-SDS, vs. ORGD. Results exclude unlinked ORGD pregnancy-related deaths (Figure 2, **red**) in the numerator and denominator during percent agreement calculations.

a.

CIHI death	ORGD death		Total
	Yes	No	
Yes	278	34	312
No	120	1,679,023	1,679,143
Agreement indicator	Value (95% CI)		
Total	398	1,679,057	1,679,455

Cohen's Kappa	0.78 (0.75 to 0.82)
Sensitivity	0.70 (0.65 to 0.74)
Specificity	1.00 (1.00 to 1.00)
Positive Predictive Value	0.89 (0.86 to 0.93)
Negative Predictive Value	1.00 (1.00 to 1.00)
Overall Percent Agreement	1.00 (1.00 to 1.00)
Positive Percent Agreement	0.70 (0.65 to 0.74)
Negative Percent Agreement	1.00 (1.00 to 1.00)

b.

CIHI death	ORGD death		Total
	Yes	No	
Yes	346	34	171
No	188	2,039,652	2,039,746
Agreement indicator	Value (95% CI)		
Total	534	2,039,686	2,039,917

Cohen's Kappa	0.75 (0.72 to 0.78)
Sensitivity	0.65 (0.61 to 0.69)
Specificity	1.00 (1.00 to 1.00)
Positive Predictive Value	0.88 (0.85 to 0.91)
Negative Predictive Value	1.00 (1.00 to 1.00)
Overall Percent Agreement	1.00 (1.00 to 1.00)
Positive Percent Agreement	0.65 (0.61 to 0.69)
Negative Percent Agreement	1.00 (1.00 to 1.00)

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Table 4. a. Maternal deaths ≤ 365 days of a livebirth or stillbirth, comparing CIHI-DAD or CIHI-NACRS, vs. ORGD. Results include unlinked ORGD pregnancy-related deaths (Figure 1, **red**) in the numerator and denominator during percent agreement calculations. **b.** Maternal deaths ≤ 365 days of the ending of a recognized pregnancy, comparing a recognized pregnancy in CIHI-DAD, CIHI-NACRS or CIHI-SDS, vs. ORGD. Results include unlinked ORGD pregnancy-related deaths (Figure 2, **red**) in the numerator and denominator during percent agreement calculations.

a.

CIHI death	ORGD death		Total
	Yes	No	
Yes	278	34	312
No	197	1,679,023	1,679,220
Total	475	1,679,057	1,679,532

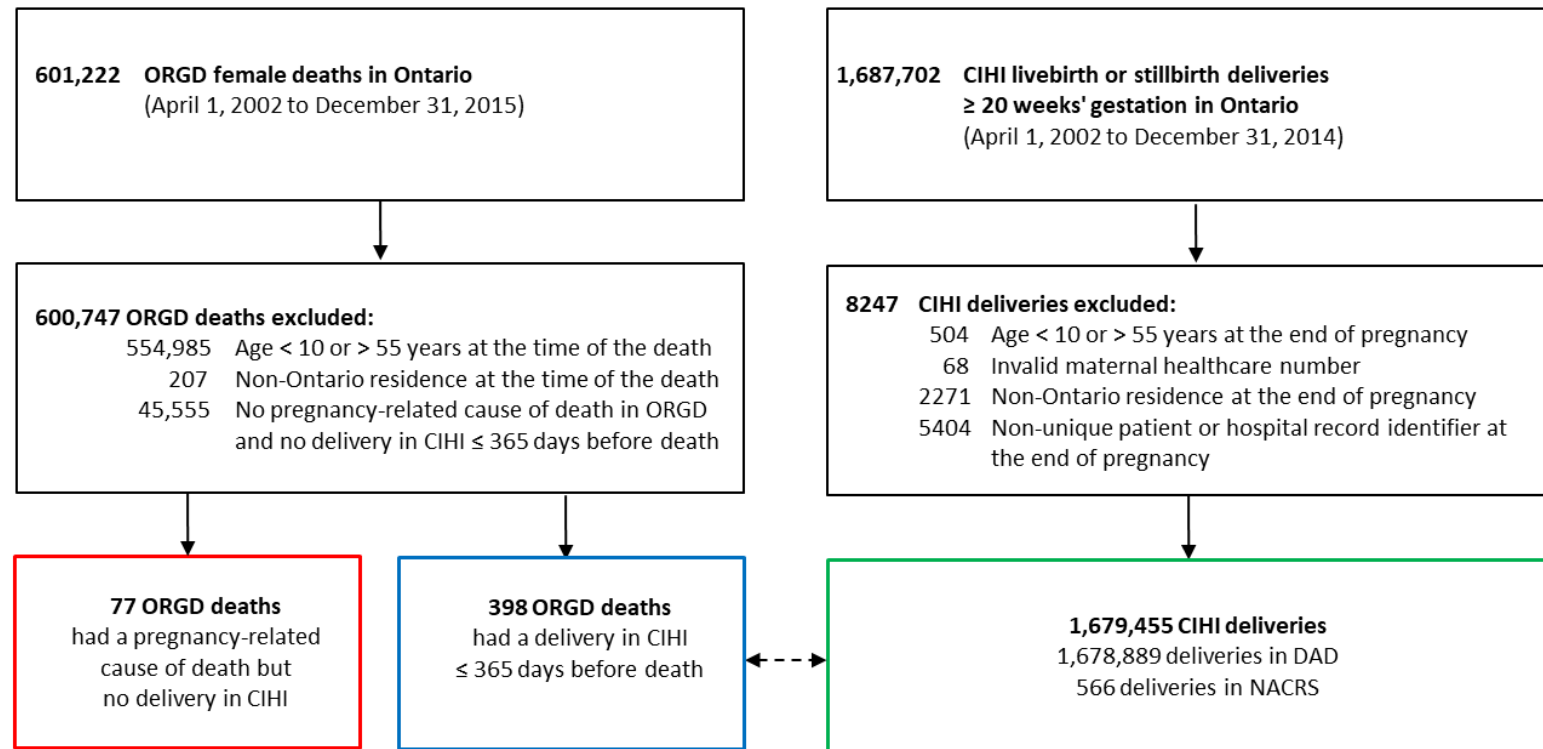
b.

CIHI death	ORGD death		Total
	Yes	No	
Yes	346	47	393
No	256	2,039,268	2,039,524
Total	602	2,039,315	2,039,917

Agreement indicator	Value (95% CI)
Cohen's Kappa	0.71 (0.82 to 0.91)
Sensitivity	0.59 (0.54 to 0.63)
Specificity	1.00 (1.00 to 1.00)
Positive Predictive Value	0.89 (0.86 to 0.93)
Negative Predictive Value	1.00 (1.00 to 1.00)
Overall Percent Agreement	1.00 (1.00 to 1.00)
Positive Percent Agreement	0.59 (0.54 to 0.63)
Negative Percent Agreement	1.00 (1.00 to 1.00)

Agreement indicator	Value (95% CI)
Cohen's Kappa	0.70 (0.66 to 0.73)
Sensitivity	0.57 (0.54 to 0.61)
Specificity	1.00 (1.00 to 1.00)
Positive Predictive Value	0.88 (0.85 to 0.91)
Negative Predictive Value	1.00 (1.00 to 1.00)
Overall Percent Agreement	1.00 (1.00 to 1.00)
Positive Percent Agreement	0.57 (0.54 to 0.61)
Negative Percent Agreement	1.00 (1.00 to 1.00)

Figure 1. Creation of a linked file that contains the deaths of women of reproductive age in the ORGD with records of obstetrical livebirths or stillbirths at ≥ 20 weeks' gestation in the CIHI-DAD or NACRS.



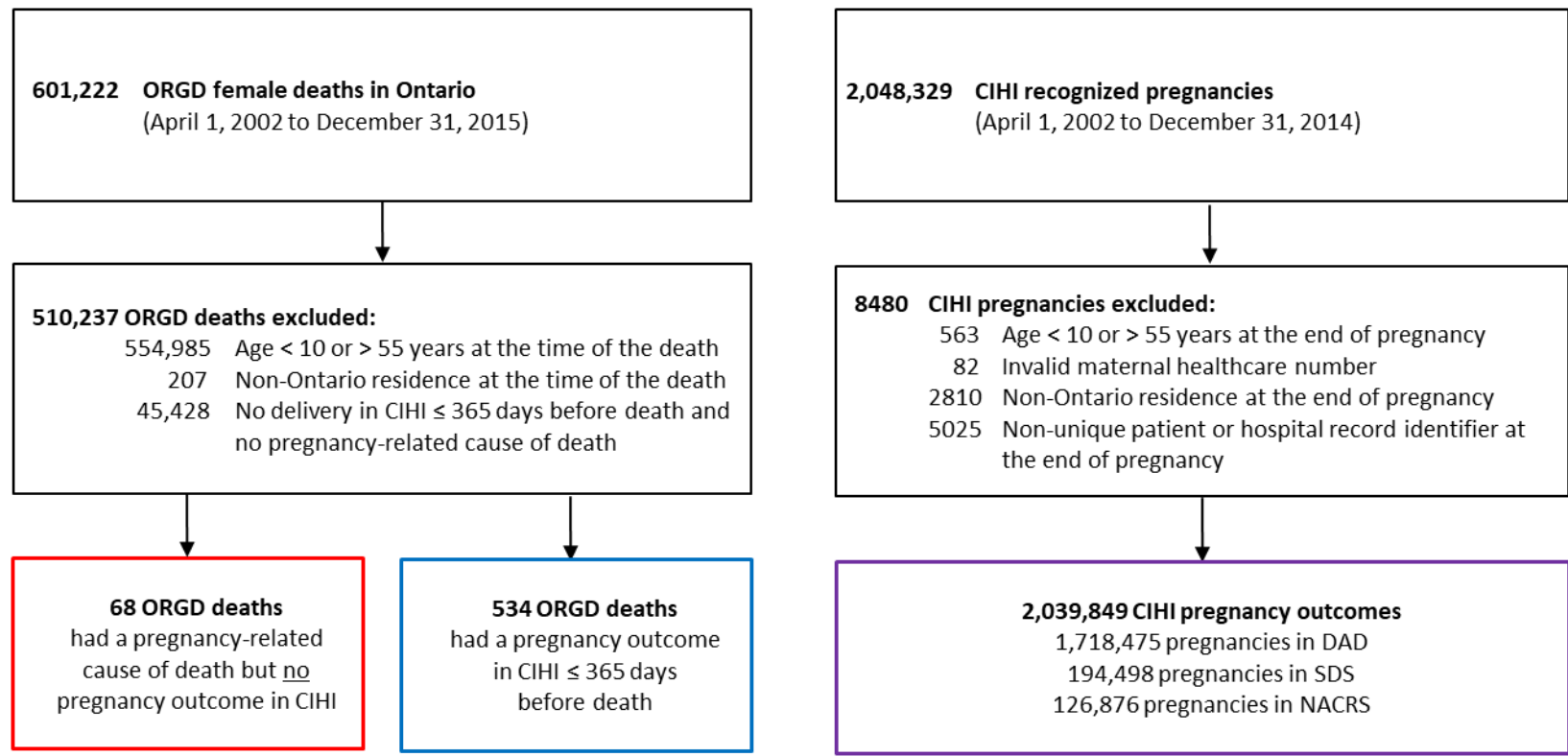
Abbreviations: ORGD: Office of the Registrar General - Deaths; CIHI: Canadian Institute for Health Information; DAD: Discharge Abstract Database; NACRS: National Ambulatory Care Reporting System; SDS: Same Day Surgery

* Includes livebirth or stillbirth deliveries ≥ 20 weeks' gestation.

** Pregnancy-related death in ORGD is defined as having a cause death (immediate, antecedent or other significant condition) ICD-10 code starting with an "O".

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Figure 2. Creation of a linked file that contains the deaths of women of reproductive age in the ORGD with women who have been identified with any recognized pregnancy outcome in the CIHI-DAD, SDS, and NACRS.



Abbreviations: ORGD: Office of the Registrar General - Deaths; CIHI: Canadian Institute for Health Information; DAD: Discharge Abstract Database; NACRS: National Ambulatory Care Reporting System; SDS: Same Day Surgery

* Includes livebirth or stillbirth deliveries ≥ 20 weeks' gestation.
** Pregnancy-related death in ORGD is defined as having a cause death (immediate, antecedent or other significant condition) ICD-10 code starting with an "O".

Table S1. Method to calculate positive and negative percent agreement.

Data source	ORGD	
CIHI	a	b
	c	d

Overall percent agreement = $(a + d)/(a + b + c + d)$.

However, the overall percent does not differentiate between the agreement on the positives and agreement on the negatives. Hence, it is often recommended that one report positive percent agreement (PPA) and negative percent agreement (NPA) when there is an imperfect reference standard (in this case, the ORGD).

$$\text{PPA} = a/(a + c)$$

$$\text{NPA} = d/(b + d)$$

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Table S2. Any cause of death \leq 42 days of delivery among women who had a livebirth or stillbirth in CIHI and a death record in ORGD. Cause of death is ranked according to the 3-digit ICD-10 code (4-digits for amniotic fluid embolism). Each case may have had more one cause of death, so the total count may exceed the number of cases. Suppression is required at 5 or fewer counts.

ICD-10 code	Label	Number	%
O99	Other maternal diseases classifiable elsewhere but complicating pregnancy, childbirth and the puerperium	74	15.4
O75	Other complications of labour and delivery, not elsewhere classified	66	13.7
O881	Amniotic fluid embolism	23	4.8
O14	Gestational [pregnancy-induced] hypertension with significant proteinuria	20	4.3
O26	Maternal care for other conditions predominantly related to pregnancy	20	4.3
O72	Postpartum haemorrhage	14	3.0
O90	Complications of the puerperium, not elsewhere classified	14	3.0
O96*	Death from any obstetric cause occurring more than 42 days but less than one year after delivery	14	3.0
O882	Obstetric blood-clot embolism	11	2.3
O16	Unspecified maternal hypertension	9	1.9
O85	Puerperal sepsis	9	1.9
O45	Premature separation of placenta [abruptio placentae]	8	1.7
O22	Venous complications in pregnancy	7	1.5
O95	Obstetric death of unspecified cause	7	1.5
O98	Maternal infectious and parasitic diseases classifiable elsewhere but complicating pregnancy, childbirth and the puerperium	7	1.5
C80	Malignant neoplasm without specification of site	6	1.3
I61	Intracerebral haemorrhage	6	1.3
I60	Subarachnoid haemorrhage	Suppressed	Suppressed
O46	Antepartum haemorrhage, not elsewhere classified	Suppressed	Suppressed
O86	Other puerperal infections	Suppressed	Suppressed
C50	Malignant neoplasm of breast	Suppressed	Suppressed
O36	Maternal care for other known or suspected fetal problems	Suppressed	Suppressed
T40	Poisoning by narcotics and psychodysleptics [hallucinogens]	Suppressed	Suppressed
T51	Toxic effect of alcohol	Suppressed	Suppressed
V89	Motor- or nonmotor-vehicle accident, type of vehicle unspecified	Suppressed	Suppressed
X45	Accidental poisoning by and exposure to alcohol	Suppressed	Suppressed
X70	Intentional self-harm by hanging, strangulation and suffocation	Suppressed	Suppressed
C16	Malignant neoplasm of stomach	Suppressed	Suppressed
I67	Other cerebrovascular diseases	Suppressed	Suppressed
O13	Gestational [pregnancy-induced] hypertension without significant proteinuria	Suppressed	Suppressed
O44	Placenta praevia	Suppressed	Suppressed
O68	Labour and delivery complicated by fetal stress [distress]	Suppressed	Suppressed
T71	Asphyxiation	Suppressed	Suppressed

ICD-10 code	Label	Number	%
X44	Accidental poisoning by and exposure to other and unspecified drugs, medicaments and biological substances	Suppressed	Suppressed
C22	Malignant neoplasm of liver and intrahepatic bile ducts	Suppressed	Suppressed
C25	Malignant neoplasm of pancreas	Suppressed	Suppressed
D68	Other coagulation defects	Suppressed	Suppressed
G00	Bacterial meningitis, not elsewhere classified	Suppressed	Suppressed
G93	Other disorders of brain	Suppressed	Suppressed
I27	Other pulmonary heart diseases	Suppressed	Suppressed
I40	Acute myocarditis	Suppressed	Suppressed
I64	Stroke, not specified as haemorrhage or infarction	Suppressed	Suppressed
N19	Unspecified renal failure	Suppressed	Suppressed
O10	Pre-existing hypertension complicating pregnancy, childbirth and the puerperium	Suppressed	Suppressed
O24	Diabetes mellitus in pregnancy	Suppressed	Suppressed
O30	Multiple gestation	Suppressed	Suppressed
O32	Maternal care for known or suspected malpresentation of fetus	Suppressed	Suppressed
O34	Maternal care for known or suspected abnormality of pelvic organs	Suppressed	Suppressed
O41	Other disorders of amniotic fluid and membranes	Suppressed	Suppressed
O42	Premature rupture of membranes	Suppressed	Suppressed
O69	Labour and delivery complicated by umbilical cord complications	Suppressed	Suppressed
O71	Other obstetric trauma	Suppressed	Suppressed
O87	Venous complications in the puerperium	Suppressed	Suppressed
Q23	Congenital malformations of aortic and mitral valves	Suppressed	Suppressed
R97	R97	Suppressed	Suppressed
S09	Other and unspecified injuries of head	Suppressed	Suppressed
S29	Other and unspecified injuries of thorax	Suppressed	Suppressed
T07	Unspecified multiple injuries	Suppressed	Suppressed
V48	Car occupant injured in noncollision transport accident	Suppressed	Suppressed
V87	Traffic accident of specified type but victim's mode of transport unknown	Suppressed	Suppressed
X42	Accidental poisoning by and exposure to narcotics and psychodysleptics [hallucinogens], not elsewhere classified	Suppressed	Suppressed
X99	Assault by sharp object	Suppressed	Suppressed
Y00	Assault by blunt object	Suppressed	Suppressed
Y12	Poisoning by and exposure to narcotics and psychodysleptics [hallucinogens], not elsewhere classified, undetermined intent	Suppressed	Suppressed
A41	Other septicaemia	Suppressed	Suppressed
B18	Chronic viral hepatitis	Suppressed	Suppressed
C18	Malignant neoplasm of colon	Suppressed	Suppressed
E66	Obesity	Suppressed	Suppressed
E86	Volume depletion	Suppressed	Suppressed
E87	Other disorders of fluid, electrolyte and acid-base balance	Suppressed	Suppressed
F32	Depressive episode	Suppressed	Suppressed

ICD-10 code	Label	Number	%
G08	Intracranial and intraspinal phlebitis and thrombophlebitis	Suppressed	Suppressed
I10	Essential (primary) hypertension	Suppressed	Suppressed
I46	Cardiac arrest	Suppressed	Suppressed
I74	Arterial embolism and thrombosis	Suppressed	Suppressed
J90	Pleural effusion, not elsewhere classified	Suppressed	Suppressed
J96	Respiratory failure, not elsewhere classified	Suppressed	Suppressed
K72	Hepatic failure, not elsewhere classified	Suppressed	Suppressed
O15	Eclampsia	Suppressed	Suppressed
Q28	Other congenital malformations of circulatory system	Suppressed	Suppressed
R56	Convulsions, not elsewhere classified	Suppressed	Suppressed
R68	Other general symptoms and signs	Suppressed	Suppressed
R99	Other ill-defined and unspecified causes of mortality	Suppressed	Suppressed
S31	Open wound of abdomen, lower back and pelvis	Suppressed	Suppressed
T43	Poisoning by psychotropic drugs, not elsewhere classified	Suppressed	Suppressed
T50	Poisoning by diuretics and other and unspecified drugs, medicaments and biological substances	Suppressed	Suppressed
T82	Complications of cardiac and vascular prosthetic devices, implants and grafts	Suppressed	Suppressed
X89	Assault by other specified chemicals and noxious substances	Suppressed	Suppressed
Y83	Surgical operation and other surgical procedures as the cause of abnormal reaction of the patient, or of later complication, without mention of misadventure at the time of the procedure	Suppressed	Suppressed
O883	Obstetric pyaemic and septic embolism	Suppressed	Suppressed
O880	Obstetric air embolism	Suppressed	Suppressed
	Total	482	100

Table S3. Any cause of death from 43 to 365 days of delivery among women who had a livebirth or stillbirth in CIHI and a death record in ORGD. Cause of death is ranked according to the 3-digit ICD-10 code (4-digits for amniotic fluid embolism). Each case may have had more one cause of death, so the total count may exceed the number of cases. Suppression is required at 5 or fewer counts.

ICD-10 code	Label	Number	%
T71	Asphyxiation	48	5.1
X70	Intentional self-harm by hanging, strangulation and suffocation	34	3.6
C79	Secondary malignant neoplasm of other sites	24	2.5
X42	Accidental poisoning by and exposure to narcotics and psychodysleptics [hallucinogens], not elsewhere classified	22	2.3
O96	Death from any obstetric cause occurring more than 42 days but less than one year after delivery	19	2.0
C50	Malignant neoplasm of breast	18	1.9
T40	Poisoning by narcotics and psychodysleptics [hallucinogens]	18	1.9
I49	Other cardiac arrhythmias	17	1.8
C92	Myeloid leukaemia	16	1.7
C34	Malignant neoplasm of bronchus and lung	14	1.5
V89	Motor- or nonmotor-vehicle accident, type of vehicle unspecified	14	1.5
A41	Other septicaemia	13	1.4
F19	Mental and behavioural disorders due to multiple drug use and use of other psychoactive substances	13	1.4
X00	Exposure to uncontrolled fire in building or structure	13	1.4
W76	Other accidental hanging and strangulation	12	1.3
C71	Malignant neoplasm of brain	10	1.1
E14	Unspecified diabetes mellitus	10	1.1
G93	Other disorders of brain	10	1.1
I26	Pulmonary embolism	10	1.1
I51	Complications and ill-defined descriptions of heart disease	10	1.1
I60	Subarachnoid haemorrhage	10	1.1
J18	Pneumonia, organism unspecified	10	1.1
T14	Injury of unspecified body region	10	1.1
T50	Poisoning by diuretics and other and unspecified drugs, medicaments and biological substances	10	1.1
S09	Other and unspecified injuries of head	9	1.0
F53	Mental and behavioural disorders associated with the puerperium, not elsewhere classified	8	0.9
I46	Cardiac arrest	8	0.9
T07	Unspecified multiple injuries	8	0.9
C78	Secondary malignant neoplasm of respiratory and digestive organs	7	0.7
C80	Malignant neoplasm without specification of site	7	0.7
M32	Systemic lupus erythematosus	7	0.7
Y83	Surgical operation and other surgical procedures as the cause of abnormal reaction of the patient, or of later complication, without mention of misadventure at the time of the procedure	7	0.7

ICD-10 code	Label	Number	%
C43	Malignant melanoma of skin	6	0.6
C53	Malignant neoplasm of cervix uteri	6	0.6
D43	Neoplasm of uncertain or unknown behaviour of brain and central nervous system	6	0.6
I21	Acute myocardial infarction	6	0.6
I25	Chronic ischaemic heart disease	6	0.6
K85	Acute pancreatitis	6	0.6
R97	R97	6	0.6
R99	Other ill-defined and unspecified causes of mortality	6	0.6
T51	Toxic effect of alcohol	6	0.6
T59	Toxic effect of other gases, fumes and vapours	6	0.6
V43	Car occupant injured in collision with car, pick-up truck or van	6	0.6
V87	Traffic accident of specified type but victim's mode of transport unknown	6	0.6
X41	Accidental poisoning by and exposure to antiepileptic, sedative-hypnotic, antiparkinsonism and psychotropic drugs, not elsewhere classified	6	0.6
X44	Accidental poisoning by and exposure to other and unspecified drugs, medicaments and biological substances	6	0.6
X45	Accidental poisoning by and exposure to alcohol	6	0.6
Y00	Assault by blunt object	6	0.6
C16	Malignant neoplasm of stomach	Suppressed	Suppressed
C85	Other and unspecified types of non-Hodgkin's lymphoma	Suppressed	Suppressed
I33	Acute and subacute endocarditis	Suppressed	Suppressed
I42	Cardiomyopathy	Suppressed	Suppressed
I63	Cerebral infarction	Suppressed	Suppressed
J96	Respiratory failure, not elsewhere classified	Suppressed	Suppressed
K55	Vascular disorders of intestine	Suppressed	Suppressed
R57	Shock, not elsewhere classified	Suppressed	Suppressed
T75	Effects of other external causes	Suppressed	Suppressed
C84	Peripheral and cutaneous T-cell lymphomas	Suppressed	Suppressed
E78	Disorders of lipoprotein metabolism and other lipidaemias	Suppressed	Suppressed
F10	Mental and behavioural disorders due to use of alcohol	Suppressed	Suppressed
F32	Depressive episode	Suppressed	Suppressed
I34	Nonrheumatic mitral valve disorders	Suppressed	Suppressed
I72	Other aneurysm	Suppressed	Suppressed
K72	Hepatic failure, not elsewhere classified	Suppressed	Suppressed
O88	Obstetric embolism	Suppressed	Suppressed
O90	Complications of the puerperium, not elsewhere classified	Suppressed	Suppressed
R09	Other symptoms and signs involving the circulatory and respiratory systems	Suppressed	Suppressed
R58	Haemorrhage, not elsewhere classified	Suppressed	Suppressed
R68	Other general symptoms and signs	Suppressed	Suppressed
S06	Intracranial injury	Suppressed	Suppressed

ICD-10 code	Label	Number	%
S11	Open wound of neck	Suppressed	Suppressed
S29	Other and unspecified injuries of thorax	Suppressed	Suppressed
T17	Foreign body in respiratory tract	Suppressed	Suppressed
T81	Complications of procedures, not elsewhere classified	Suppressed	Suppressed
T86	Failure and rejection of transplanted organs and tissues	Suppressed	Suppressed
V03	Pedestrian injured in collision with car, pick-up truck or van	Suppressed	Suppressed
V86	Occupant of special all-terrain or other motor vehicle designed primarily for off-road use, injured in transport accident	Suppressed	Suppressed
X74	Intentional self-harm by other and unspecified firearm discharge	Suppressed	Suppressed
X80	Intentional self-harm by jumping from a high place	Suppressed	Suppressed
X91	Assault by hanging, strangulation and suffocation	Suppressed	Suppressed
X99	Assault by sharp object	Suppressed	Suppressed
Y21	Drowning and submersion, undetermined intent	Suppressed	Suppressed
C26	Malignant neoplasm of other and ill-defined digestive organs	Suppressed	Suppressed
C56	Malignant neoplasm of ovary	Suppressed	Suppressed
C95	Leukaemia of unspecified cell type	Suppressed	Suppressed
D57	Sickle-cell disorders	Suppressed	Suppressed
D68	Other coagulation defects	Suppressed	Suppressed
E66	Obesity	Suppressed	Suppressed
E87	Other disorders of fluid, electrolyte and acid-base balance	Suppressed	Suppressed
F14	Mental and behavioural disorders due to use of cocaine	Suppressed	Suppressed
G00	Bacterial meningitis, not elsewhere classified	Suppressed	Suppressed
G40	Epilepsy	Suppressed	Suppressed
I61	Intracerebral haemorrhage	Suppressed	Suppressed
I67	Other cerebrovascular diseases	Suppressed	Suppressed
J45	Asthma	Suppressed	Suppressed
J80	Adult respiratory distress syndrome	Suppressed	Suppressed
M06	Other rheumatoid arthritis	Suppressed	Suppressed
M72	Fibroblastic disorders	Suppressed	Suppressed
O99	Other maternal diseases classifiable elsewhere but complicating pregnancy, childbirth and the puerperium	Suppressed	Suppressed
Q05	Spina bifida	Suppressed	Suppressed
Q21	Congenital malformations of cardiac septa	Suppressed	Suppressed
Q24	Other congenital malformations of heart	Suppressed	Suppressed
T42	Poisoning by antiepileptic, sedative-hypnotic and antiparkinsonism drugs	Suppressed	Suppressed
T43	Poisoning by psychotropic drugs, not elsewhere classified	Suppressed	Suppressed
T58	Toxic effect of carbon monoxide	Suppressed	Suppressed
V49	Car occupant injured in other and unspecified transport accidents	Suppressed	Suppressed
X59	Exposure to unspecified factor	Suppressed	Suppressed
Y84	Other medical procedures as the cause of abnormal reaction of the patient, or of later complication, without mention of misadventure at the time of the procedure	Suppressed	Suppressed
A87	Viral meningitis	Suppressed	Suppressed

ICD-10 code	Label	Number	%
B01	Varicella [chickenpox]	Suppressed	Suppressed
C18	Malignant neoplasm of colon	Suppressed	Suppressed
C25	Malignant neoplasm of pancreas	Suppressed	Suppressed
C49	Malignant neoplasm of other connective and soft tissue	Suppressed	Suppressed
C64	Malignant neoplasm of kidney, except renal pelvis	Suppressed	Suppressed
C67	Malignant neoplasm of bladder	Suppressed	Suppressed
C81	Hodgkin's disease	Suppressed	Suppressed
C91	Lymphoid leukaemia	Suppressed	Suppressed
D70	Agranulocytosis	Suppressed	Suppressed
D76	Certain diseases involving lymphoreticular tissue and reticulohistiocytic system	Suppressed	Suppressed
E10	Type 1 Diabetes mellitus	Suppressed	Suppressed
F31	Bipolar affective disorder	Suppressed	Suppressed
G04	Encephalitis, myelitis and encephalomyelitis	Suppressed	Suppressed
G91	Hydrocephalus	Suppressed	Suppressed
I11	Hypertensive heart disease	Suppressed	Suppressed
I27	Other pulmonary heart diseases	Suppressed	Suppressed
I50	Heart failure	Suppressed	Suppressed
I71	Aortic aneurysm and dissection	Suppressed	Suppressed
I74	Arterial embolism and thrombosis	Suppressed	Suppressed
J46	J46	Suppressed	Suppressed
K46	Unspecified abdominal hernia	Suppressed	Suppressed
K65	Peritonitis	Suppressed	Suppressed
K80	Cholelithiasis	Suppressed	Suppressed
L03	Cellulitis	Suppressed	Suppressed
N13	Obstructive and reflux uropathy	Suppressed	Suppressed
N19	Unspecified renal failure	Suppressed	Suppressed
N39	Other disorders of urinary system	Suppressed	Suppressed
O03	Spontaneous abortion	Suppressed	Suppressed
O08	Complications following abortion and ectopic and molar pregnancy	Suppressed	Suppressed
O26	Maternal care for other conditions predominantly related to pregnancy	Suppressed	Suppressed
Q03	Congenital hydrocephalus	Suppressed	Suppressed
Q85	Phakomatoses, not elsewhere classified	Suppressed	Suppressed
R04	Haemorrhage from respiratory passages	Suppressed	Suppressed
S01	Open wound of head	Suppressed	Suppressed
S02	Fracture of skull and facial bones	Suppressed	Suppressed
S12	Fracture of neck	Suppressed	Suppressed
S19	Other and unspecified injuries of neck	Suppressed	Suppressed
S36	Injury of intra-abdominal organs	Suppressed	Suppressed
S39	Other and unspecified injuries of abdomen, lower back and pelvis	Suppressed	Suppressed
T09	Other injuries of spine and trunk, level unspecified	Suppressed	Suppressed
T68	Hypothermia	Suppressed	Suppressed

ICD-10 code	Label	Number	%
T79	Certain early complications of trauma, not elsewhere classified	Suppressed	Suppressed
V13	Pedal cyclist injured in collision with car, pick-up truck or van	Suppressed	Suppressed
V19	Pedal cyclist injured in other and unspecified transport accidents	Suppressed	Suppressed
V47	Car occupant injured in collision with fixed or stationary object	Suppressed	Suppressed
V48	Car occupant injured in noncollision transport accident	Suppressed	Suppressed
W19	Unspecified fall	Suppressed	Suppressed
W80	Inhalation and ingestion of other objects causing obstruction of respiratory tract	Suppressed	Suppressed
X64	Intentional self-poisoning by and exposure to other and unspecified drugs, medicaments and biological substances	Suppressed	Suppressed
X67	Intentional self-poisoning by and exposure to other gases and vapours	Suppressed	Suppressed
X78	Intentional self-harm by sharp object	Suppressed	Suppressed
X81	Intentional self-harm by jumping or lying before moving object	Suppressed	Suppressed
X84	Intentional self-harm by unspecified means	Suppressed	Suppressed
X95	Assault by other and unspecified firearm discharge	Suppressed	Suppressed
Y03	Assault by crashing of motor vehicle	Suppressed	Suppressed
Y14	Poisoning by and exposure to other and unspecified drugs, medicaments and biological substances, undetermined intent	Suppressed	Suppressed
Y85	Sequelae of transport accidents	Suppressed	Suppressed
A48	Other bacterial diseases, not elsewhere classified	Suppressed	Suppressed
B59	Pneumocystosis	Suppressed	Suppressed
C22	Malignant neoplasm of liver and intrahepatic bile ducts	Suppressed	Suppressed
C47	Malignant neoplasm of peripheral nerves and autonomic nervous system	Suppressed	Suppressed
D32	Benign neoplasm of meninges	Suppressed	Suppressed
D33	Benign neoplasm of brain and other parts of central nervous system	Suppressed	Suppressed
D36	Benign neoplasm of other and unspecified sites	Suppressed	Suppressed
D61	Other aplastic anaemias	Suppressed	Suppressed
D65	Disseminated intravascular coagulation [defibrination syndrome]	Suppressed	Suppressed
E03	Other hypothyroidism	Suppressed	Suppressed
F11	Mental and behavioural disorders due to use of opioids	Suppressed	Suppressed
F17	Mental and behavioural disorders due to use of tobacco	Suppressed	Suppressed
F23	Acute and transient psychotic disorders	Suppressed	Suppressed
F29	Unspecified nonorganic psychosis	Suppressed	Suppressed
G41	Status epilepticus	Suppressed	Suppressed
I05	Rheumatic mitral valve diseases	Suppressed	Suppressed
I07	Rheumatic tricuspid valve diseases	Suppressed	Suppressed
I10	Essential (primary) hypertension	Suppressed	Suppressed
I20	Angina pectoris	Suppressed	Suppressed
I31	Other diseases of pericardium	Suppressed	Suppressed
I38	Endocarditis, valve unspecified	Suppressed	Suppressed
I40	Acute myocarditis	Suppressed	Suppressed

ICD-10 code	Label	Number	%
I47	Paroxysmal tachycardia	Suppressed	Suppressed
I62	Other nontraumatic intracranial haemorrhage	Suppressed	Suppressed
I64	Stroke, not specified as haemorrhage or infarction	Suppressed	Suppressed
I80	Phlebitis and thrombophlebitis	Suppressed	Suppressed
J15	Bacterial pneumonia, not elsewhere classified	Suppressed	Suppressed
J69	Pneumonitis due to solids and liquids	Suppressed	Suppressed
J81	Pulmonary oedema	Suppressed	Suppressed
J94	Other pleural conditions	Suppressed	Suppressed
K29	Gastritis and duodenitis	Suppressed	Suppressed
K74	Fibrosis and cirrhosis of liver	Suppressed	Suppressed
L89	Decubitus ulcer	Suppressed	Suppressed
L93	Lupus erythematosus	Suppressed	Suppressed
N17	Acute renal failure	Suppressed	Suppressed
N26	Unspecified contracted kidney	Suppressed	Suppressed
O75	Other complications of labour and delivery, not elsewhere classified	Suppressed	Suppressed
Q86	Congenital malformation syndromes due to known exogenous causes, not elsewhere classified	Suppressed	Suppressed
R00	Abnormalities of heart beat	Suppressed	Suppressed
R10	Abdominal and pelvic pain	Suppressed	Suppressed
R11	Nausea and vomiting	Suppressed	Suppressed
R18	Ascites	Suppressed	Suppressed
R40	Somnolence, stupor and coma	Suppressed	Suppressed
R50	Fever of unknown origin	Suppressed	Suppressed
R52	Pain, not elsewhere classified	Suppressed	Suppressed
R59	Enlarged lymph nodes	Suppressed	Suppressed
R94	Abnormal results of function studies	Suppressed	Suppressed
S18	Traumatic amputation at neck level	Suppressed	Suppressed
S21	Open wound of thorax	Suppressed	Suppressed
S22	Fracture of rib(s), sternum and thoracic spine	Suppressed	Suppressed
S26	Injury of heart	Suppressed	Suppressed
S27	Injury of other and unspecified intrathoracic organs	Suppressed	Suppressed
S32	Fracture of lumbar spine and pelvis	Suppressed	Suppressed
T02	Fractures involving multiple body regions	Suppressed	Suppressed
T45	Poisoning by primarily systemic and haematological agents, not elsewhere classified	Suppressed	Suppressed
T82	Complications of cardiac and vascular prosthetic devices, implants and grafts	Suppressed	Suppressed
T84	Complications of internal orthopaedic prosthetic devices, implants and grafts	Suppressed	Suppressed
T90	Sequelae of injuries of head	Suppressed	Suppressed
W18	Other fall on same level	Suppressed	Suppressed
W49	Exposure to other and unspecified inanimate mechanical forces	Suppressed	Suppressed
W65	Drowning and submersion while in bath-tub	Suppressed	Suppressed

ICD-10 code	Label	Number	%
X31	Exposure to excessive natural cold	Suppressed	Suppressed
Y42	Hormones and their synthetic substitutes and antagonists, not elsewhere classified	Suppressed	Suppressed
Y60	Unintentional cut, puncture, perforation or haemorrhage during surgical and medical care	Suppressed	Suppressed
Total		945	100

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