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RESEARCH HEALTH SERVICES

Clearing the surgical backlog caused by COVID-19 in Ontario: a time series modelling study

Jonathan Wang MASc, Saba Vahid PhD, Maria Eberg MSc, Shannon Milroy MSc, John Milkovich, Frances C. Wright MD MEd, Amber Hunter MBA, Ryan Kalladeen HBA, Claudia Zanchetta RN MN(ACNP), Harindra C. Wijeysundera MD PhD, Jonathan Irish MD MSc

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ABSTRACT

BACKGROUND: To mitigate the effects of coronavirus disease 2019 (COVID-19), jurisdictions worldwide ramped down nonemergent surgeries, creating a global surgical backlog. We sought to estimate the size of the nonemergent surgical backlog during COVID-19 in Ontario, Canada, and the time and resources required to clear the backlog.

METHODS: We used 6 Ontario or Canadian population administrative sources to obtain data covering part or all of the period between Jan. 1, 2017, and June 13, 2020, on historical volumes and operating room throughput distributions by surgery type and region, and lengths of stay in ward and intensive care unit (ICU) beds. We used time series forecasting, queuing models and probabilistic sensitivity analysis to estimate the size of the backlog and clearance time for a +10% (+1 day per week at 50% capacity) surge scenario.

RESULTS: Between Mar. 15 and June 13, 2020, the estimated backlog in Ontario was 148 364 surgeries (95% prediction interval 124 508–174 589), an average weekly increase of 11 413 surgeries. Estimated backlog clearance time is 84 weeks (95% confidence interval [CI] 46–145), with an estimated weekly throughput of 717 patients (95% CI 326–1367) requiring 719 operating room hours (95% CI 431–1038), 265 ward beds (95% CI 87–678) and 9 ICU beds (95% CI 4–20) per week.

INTERPRETATION: The magnitude of the surgical backlog from COVID-19 raises serious implications for the recovery phase in Ontario. Our framework for modelling surgical backlog recovery can be adapted to other jurisdictions, using local data to assist with planning.

On Mar. 11, 2020, the World Health Organization (WHO) declared a global pandemic of coronavirus disease 2019 (COVID-19), which has exacted a massive global impact on health, politics and the economy.[1] With some jurisdictions past the peak of the first wave, the strain on the health care system is becoming apparent — specifically, the impact on surgical care.[2] The CovidSurg Collaborative estimated that 28 404 603 surgeries would be cancelled or postponed across 190 countries in the initial 12 weeks of COVID-19, including 37.7% of cancer surgeries and 81.7% of other (benign) surgeries.[3] If countries increased normal surgical volume by 20%, it would take a median of 45 weeks to clear the backlog. Modelling post-pandemic recovery for elective orthopedic surgery in the United States suggested it would take 7–16 months to reach a steady state with a backlog of more than 1 million surgeries.[4]

On Mar. 15, 2020, Ontario's Ministry of Health directed hospitals to begin a measured "ramping down of elective surgeries and other nonemergent clinical activity" in anticipation of a COVID-19 surge.[5] On May 26, 2020, the Ministry of Health lifted the directive, allowing hospitals to gradually increase elective and time-sensitive surgeries.[6] The reduction in nonemergent surgeries in Ontario because of COVID-19 has created a substantial surgical backlog. Our objective was to estimate the size of the nonemergent surgical backlog owing to COVID-19 in Ontario, and the time and resources required to clear this backlog.

Methods

The framework for developing these estimates is outlined in Figure 1. At the recommendation of our regional and hospital partners for feasible surge scenarios, we considered a +10% (1 d per week at 50% capacity) surge scenario, adding 8 hours per day incremental to a 5-day operating week. We included surgeries performed in a fully equipped operating room and categorized

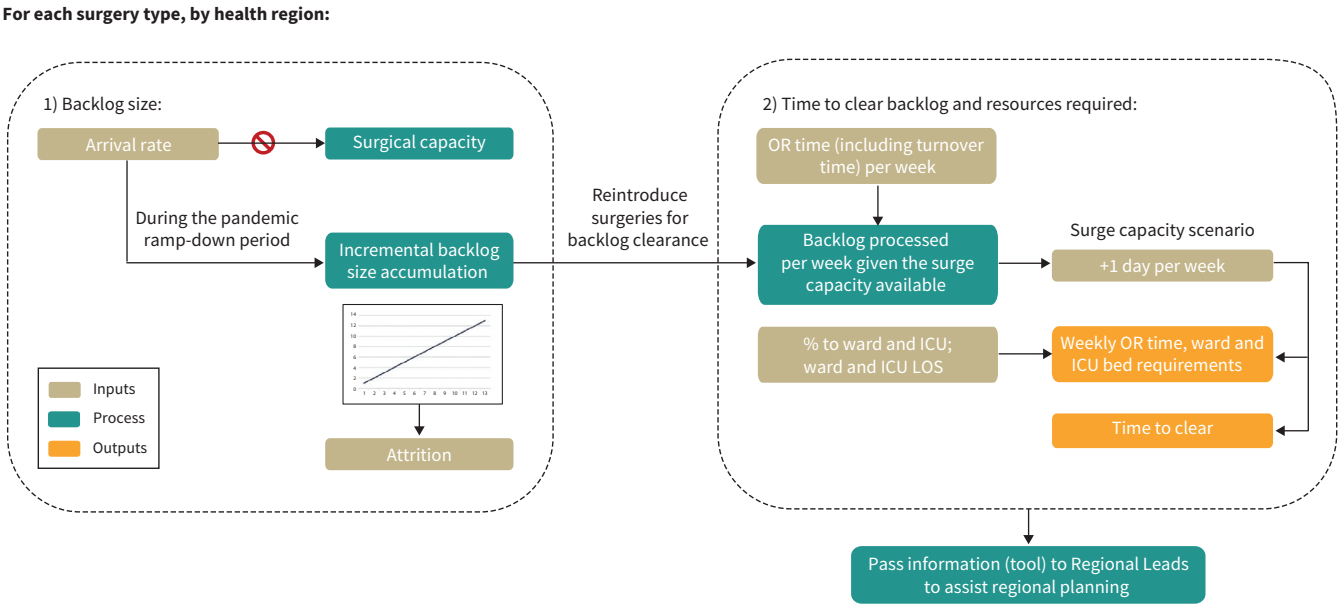

Figure 1: Schematic of the approach to model the surgical backlog. Note: ICU = intensive care unit, LOS = length of stay, OR = operating room.

them as cancer, cardiac (coronary artery bypass graft and valve procedures), vascular, transplant, pediatric and other surgeries (general, orthopedic, gynecologic, urologic, ophthalmic, etc.). A full breakdown of the procedure types included for pediatric, cancer and other surgeries is provided in Appendix 1 (available at www.cmaj.ca/lookup/doi/10.1503/cmaj.201521/tab-related-content). For cancer, vascular, pediatric and other surgeries, nonemergent surgeries are grouped by patient priority level (P2, P3 and P4).[7] Time-sensitive surgeries are categorized as cancer P2–P4, cardiac, transplant and vascular P2–P3.

Data sources

We used 6 administrative data sources to parameterize our model: the Province of Ontario Wait Times Information System, Canadian Institute for Health Information National Ambulatory Care Reporting System, Canadian Institute for Health Information Discharge Abstract Database, CorHealth Ontario Cardiac Registry, Trillium Gift of Life Network Organ and Tissue Allocation System and the Surgery Efficiency Target Program. Full descriptions of the Ontario-specific data sets can be found in Appendix 1. We used the Discharge Abstract Database and the National Ambulatory Care Reporting System for duration of operating room time and ward and intensive care unit (ICU) length of stay distributions, and proportions requiring ward and ICU stays. For cancer, vascular, pediatric and percentages of surgeries, we used the Wait Times Information System for volume and attrition estimates. For cardiac, we used the CorHealth Ontario Cardiac Registry for volume and attrition estimates, and for transplant, we used Trillium's Organ and Tissue Allocation System for volume and attrition estimates. We used the Surgery Efficiency Target Program to provide the number of operating rooms by region and turnover time distributions.

Key input parameters included distributions for operating room time, ward and ICU length of stay, and estimates of the number of operating rooms and historical percentages of surgeries requiring ward and ICU stays (Table 1). Regional inputs are included in Appendix 1.

Estimating the size of the incremental backlog

Ontario has a population of 14.7 million and is subdivided into 5 health regions (West, Central, Toronto, East and North).[8,9] In 2019/20, 90 facilities in Ontario reported 643 395 surgical procedures completed in fully equipped operating rooms.[10] These surgical procedures are classified into 4 priority levels (P1–P4) based on a patient's clinical condition, to standardize appropriate wait times across Ontario.[7] P1 cases are "life or limb" emergencies and the P2–P4 wait time categories have different maximum wait time targets, with more time-sensitive service areas such as cancer and cardiac surgeries having more aggressive time targets than those for other conditions. The targets associated with each priority level reflect the need to accelerate care to minimize impact on survival for patients with life-threatening disease (e.g., cancer, cardiac and vascular disease) and to accelerate care in the case of other surgical conditions (e.g., joint replacement, cataract surgery) to minimize the impact of disability on patients.

We estimated the size of the accumulated backlog from Mar. 15 to June 13, 2020, which includes gradual ramp-up activity from the Ministry of Health announcement to reopen nonemergent surgeries on May 26, 2020, up to June 13, 2020. We calculated the backlog size as the difference between the expected and the observed number of surgeries during the aforementioned time period. This backlog is incremental to the existing surgical backlog in Ontario and includes cancelled or postponed surgeries and patients unable to attend a surgical consult because of COVID-19.

Table 1: Provincial inputs by surgery type with data source specified*

Ontario summary: input table	Backlog size†	OR time, hr‡	% to ward	% to ICU	Ward LOS, d‡	ICU LOS, d‡	No. of ORs
Data source	WTIS, CORC, TOTAL	DAD/NACRS	DAD	DAD	DAD	DAD	SETP
Procedure type§							
Cancer P2–P3	1537 (486–3427)	2.0 (1.2–3.5)	54	10	3.0 (1.0–5.3)	1.8 (1.0–3.3)	818
Cancer P4	3615 (2440–4869)	1.5 (0.8–3.0)	50	5	2.0 (1.0–4.0)	1.6 (0.9–3.0)	818
Vascular P2–P3	940 (430–1,635)	2.1 (1.3–3.2)	63	18	3.0 (1.0–7.0)	1.8 (1.0–3.8)	463
Vascular P4	935 (412–1516)	1.7 (1.2–2.8)	42	13	2.3 (1.0–5.0)	1.3 (1.0–3.0)	463
Transplant	243 (22–577)	4.9 (3.8–7.9)	100	65	7.0 (6.0–11.5)	3.0 (1.3–6.5)	126
Cardiac CABG	295 (150–440)	4.3 (3.7–5.2)	100	99	4.1 (3.1–6.0)	1.2 (1.0–2.2)	131
Cardiac Valve	175 (89–261)	4.7 (3.9–5.8)	100	99	4.3 (3.1–6.2)	1.5 (1.0–3.0)	131
Other P2–P3	20 400 (15 752–25 098)	1.1 (0.6–1.7)	27	2	2.0 (1.0–3.0)	1.9 (1.0–4.6)	842
Other P4	107 873 (95 994–119 917)	0.8 (0.3–1.5)	21	1	2.0 (1.0–2.0)	1.1 (0.9–2.7)	842
Pediatric P2–P3	3151 (1431–5729)	1.2 (0.7–1.8)	19	5	2.0 (1.0–4.5)	2.1 (1.0–11.6)	623
Pediatric P4	9200 (7301–11 122)	0.8 (0.5–1.3)	14	1	1.0 (1.0–2.0)	1.0 (0.8–2.0)	623

Note: CABG = coronary artery bypass graft, CORC = CorHealth Ontario Cardiac Registry, DAD = Discharge Abstract Database, ICU = intensive care unit, IQR = interquartile range, LOS = length of stay, NACRS = National Ambulatory Care Reporting System, OR = operating room, P2–P4 indicates priority level 2 to 4, SETP = Surgical Efficiency Target Program, TOTAL = Trillium Gift of Life Organ and Tissue Allocation System, WTIS = Wait Times Information System.
*Regional breakdown can be found in Appendix 1. Percentage of available ORs was modelled as a normal distribution with a mean of 50% and standard deviation of 10%. Turnover time distributions were available from June 2020 from SETP by region. Provincial turnover time across all surgery types was a median of 22 (IQR 12–33) minutes.
†Backlog size estimates are reported as the mean (95% prediction interval).
‡OR time, ward LOS and ICU LOS are reported as median (IQR) for 2019 data.
§Provincial historical 2019 attrition rates were available for cancer P2–P3 (0.1%), cancer P4 (0.2%), vascular P2–P4 (0.3%) and transplant (6.1%).

Estimating the clearance time of the incremental backlog

We estimated the clearance time by dividing the backlog size by the throughput of an operating room, an adaptation of Little's Law from queuing theory.[11] To estimate the operating room throughput, we derived the operating room time distributions by surgery type and region from 2019 data. We derived the surgical turnover time distributions by region from June 2020 data, collected as part of the province's Surgery Efficiency Target Program. These data reflect an increase in historical turnover times arising from additional donning and doffing and cleaning protocols for COVID-19.[12] We used data from a few months into the pandemic because by that time, surgical staff would have been accustomed to the additional personal protective equipment (PPE) protocols required and these data would more accurately represent the turnover time during surge activities. We rounded down the throughput in an 8-hour day, to represent the number of full surgeries accomplished per day. To ensure that the 8-hour day is fully used, we added 1 extra patient per day per operating room whenever more than 1.5 hours remained in a day (excluding transplants).

We based the number of operating rooms on the historical number of rooms that performed each surgery type in 2019. To account for variation in ramp-up activity, we assumed the distribution of the percentage of available operating rooms participating in the surge to be normal, with a mean of 50% and standard deviation of 10%. For example, if a hospital had 4 operating rooms during a regular day and the percentage available was 50%, we assumed 2 operating rooms would be active per surge day.

We combined backlog estimates with operating room throughputs and available operating rooms to calculate the clearance time for each region, summing across all surgery types. We did not consider clinical prioritization of patients; we processed each surgery type serially, implying hospitals would allocate the surge time to only 1 type of surgery at a time. Although this may not reflect actual prioritization approaches taken by an individual hospital, this simplified modelling approach is valid for the primary intent of the study, which was to estimate total clearance time. The provincial clearance time is the volume-weighted average of the clearance time in each region. As a point of comparison, we also calculate the clearance time for time-sensitive surgeries only, assuming these surgeries are prioritized and assigned the surge time exclusively over elective procedures.

Estimating the resources required to clear the backlog

The key resources required to clear the backlog are operating room time, ward beds and ICU beds. We estimated weekly operating room time using the operating room throughput and the historical surgery duration distributions by surgery type and region in 2019. We estimated weekly ward and ICU bed requirements by surgery type and region using the operating room throughput, proportion to ward or ICU and the associated length of stay distributions. We calculated provincial estimates as a volume-weighted average among regions. For living donor transplant volumes, we considered ward beds for the donor and recipient. We did not cap the weekly ward and ICU bed requirements. These numbers are intended as additional information to be used with regional bed capacity reports to assess the feasibility of the surge scenario.

Statistical analysis

We forecasted the expected number of surgeries using time series forecasting models by region and by surgery type. We trained the forecasts on historical weekly data from January 2017 to October 2019 and validated them on data from October 2019 to Mar. 8, 2020. The modelling options included seasonal naïve for observed weekly volumes less than 50, seasonal and trend decomposition using locally estimated scatterplot smoothing (LOESS), dynamic harmonic regression with trigonometric terms for seasonality, and TBATS state space models.[13–16] For deceased and living donor–related transplants, we assumed that donor volumes were available to process the transplant backlog. For each surgical category (except for cardiac), we selected the model with the best performance during the validation period (minimum root

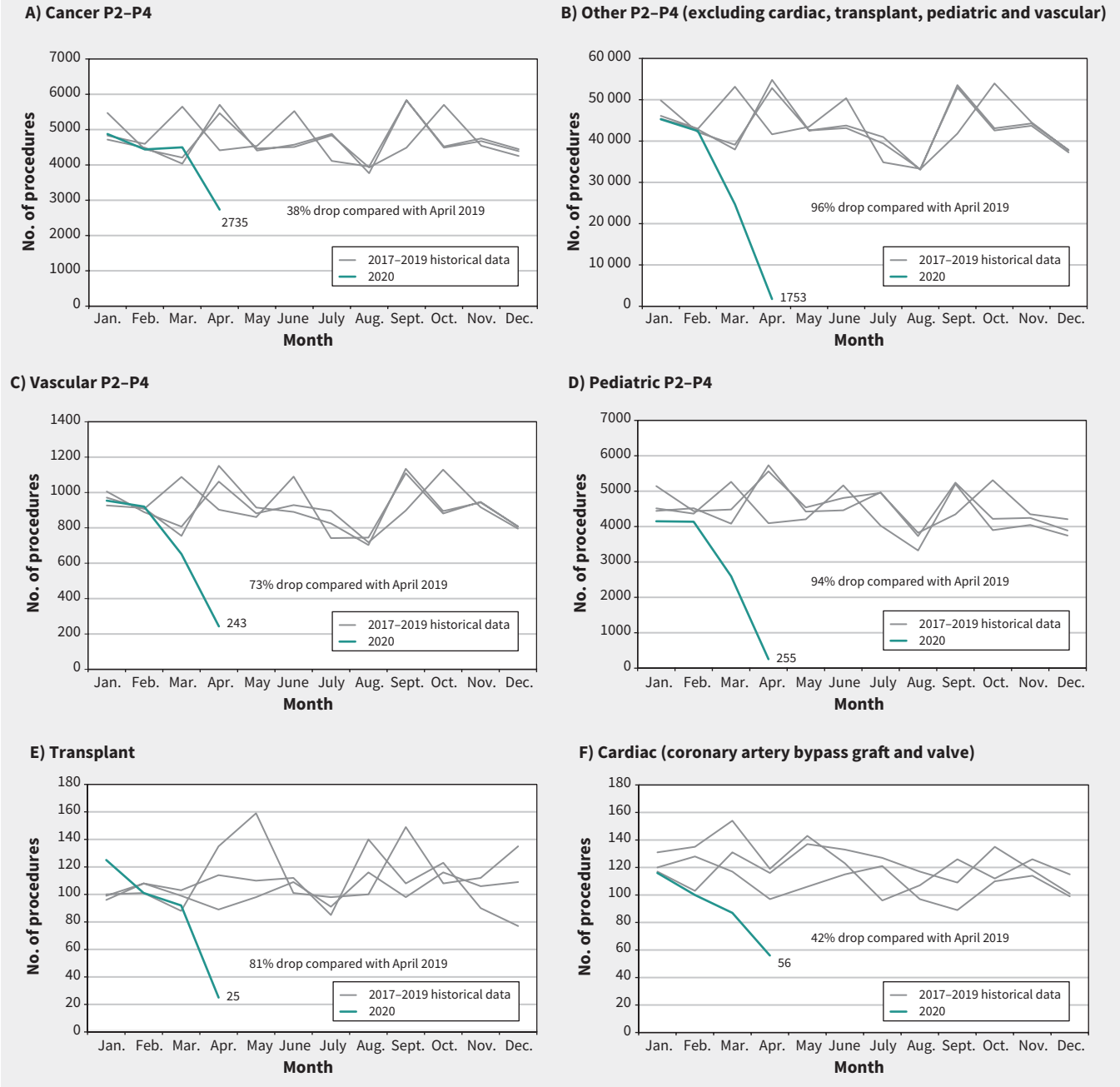

Figure 2: Monthly volume trends for surgical procedures in Ontario from 2017 to 2020 (up to and including April 2020) including oncology, vascular, cardiac, transplant and other surgeries. Report date: May 20, 2020. Data source: Wait Times Information System, Ontario Health (Cancer Care Ontario); Trillium Gift of Life Network Organ and Tissue Allocation System, Ontario Health — Trillium Gift of Life Network; CorHealth Ontario Cardiac Registry. Note: Data are from calendar years 2017 to 2020, inclusive of April 2020; P2–P4 indicates priority level 2 to 4. The grey lines represent monthly volume trends from 2017 to 2019 and the blue line represents the monthly trends for 2020 up to April 2020. CABG = coronary artery bypass graft.

mean squared error).[15] We used a similar method to calculate expected cardiac procedures based on historical trends in the CorHealth Ontario Registry.[17] To account for the variability and uncertainty in the inputs, we conducted probabilistic sensitivity analysis. The probabilistic sensitivity analysis used 1000 trials, and we calculated the mean for each output of the model along with 95% confidence intervals (CIs). Additional details (forecasting methods and model selection) are included in Appendix 1.

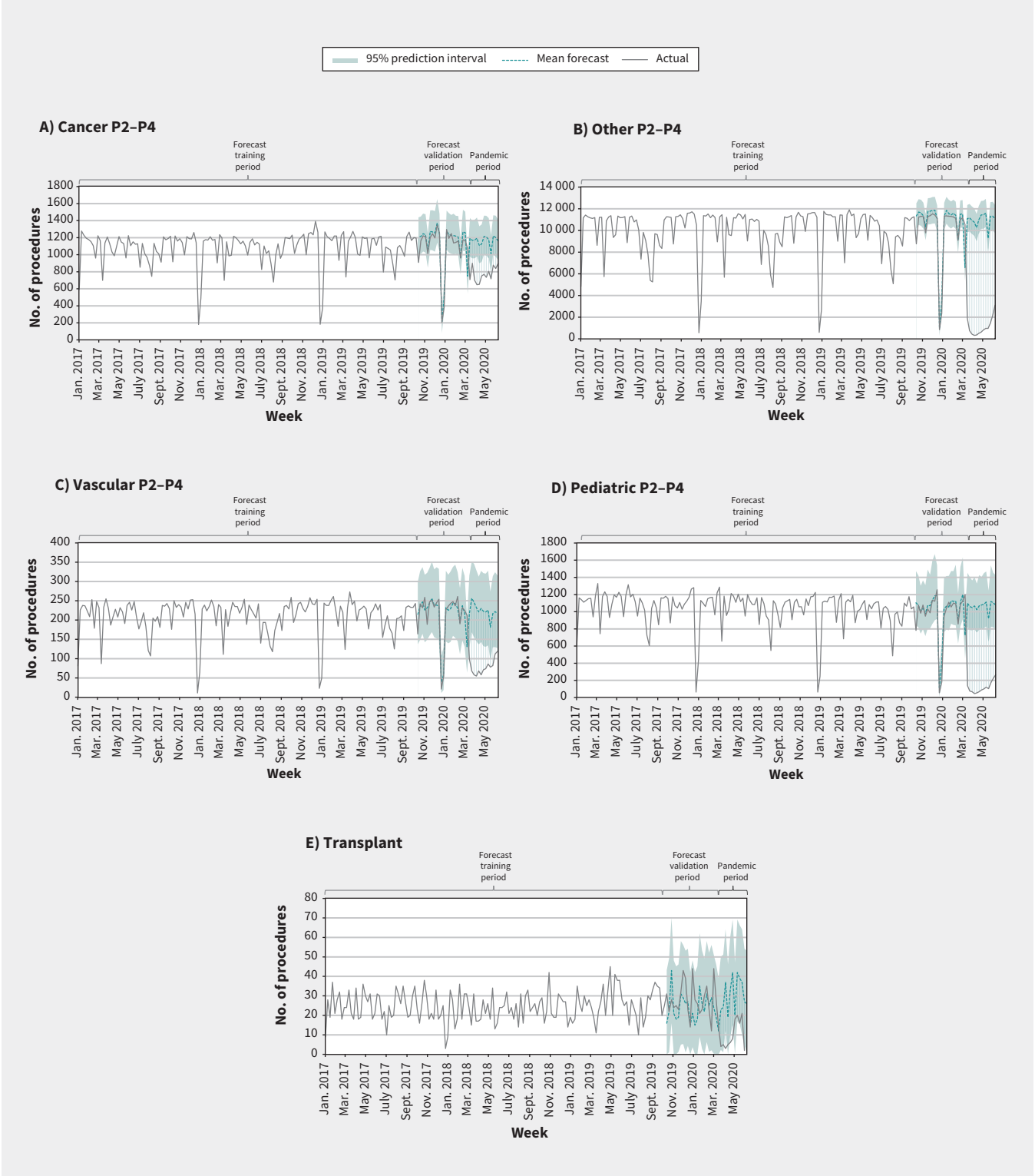

Figure 3: Weekly volumes versus forecasts for surgical procedures in Ontario from 2017 to 2020 (up to and including June 13, 2020) including cancer, vascular, pediatric, transplant and other surgeries. Report date: June 23, 2020. Data source: Wait Times Information System, Ontario Health (Cancer Care Ontario). Note: Data are from calendar year 2017 to 2020, inclusive of June 13, 2020; P2–P4 indicates priority level 2 to 4.

Ethics approval

Ontario Health (Cancer Care Ontario) is designated a "prescribed entity" for the purposes of section 45(1) of the *Personal Health Information Protection Act* of 2004. As a prescribed entity, Ontario Health (Cancer Care Ontario) is authorized to collect personal health information from health information custodians without the consent of the patient, and to use such personal health information for the purpose of analysis or compiling statistical information with respect to the management, evaluation or monitoring of the allocation of resources to or planning for all or part of the health system, including the delivery of services. Trillium Gift of Life Network is governed by the *Trillium Gift of Life Network Act* of 1990, where section 8.8 specifies that one of the objects of Trillium Gift of Life Network is to collect, analyze and publish information relating to the donation and use of tissue. The cardiac clinical registry data used in this publication are from participating hospitals through CorHealth Ontario, which serves as an advisory body to the Ontario Ministry of Health and Long-Term Care (MOHLTC), is funded by the MOHLTC and is dedicated to improving the quality, efficiency, access and equity in the delivery of the continuum of adult cardiovascular, vascular and stroke services in Ontario, Canada. Because this study is in compliance with privacy regulations, ethics review was not required.

Results

In April 2020, there were 38% fewer cancer surgeries, 42% fewer cardiac surgeries, 73% fewer vascular surgeries, 81% fewer transplant surgeries, 94% fewer pediatric surgeries and 96% fewer other adult surgeries compared with April 2019 (Figure 2). Between Mar. 15 and June 13, 2020, the incremental provincial backlog was 148 364 surgeries (95% prediction interval 124 508–174 589). Weekly time series forecasts are shown in Figure 3; weekly accumulation of the provincial mean backlog is illustrated in Figure 4, with an average provincial increase of 11 413 surgeries per week.

The provincial median turnover time across all surgery types from March to June 2020 was 21 minutes (interquartile range [IQR] 11–32), a 31% increase compared with March to June 2019 (p = 0.3, Mood's median test). The provincial median turnover times from April to June 2020 were April, 29 minutes (IQR 18–41); May, 25 minutes (IQR 15–37); and June, 22 minutes (IQR 12–33). The provincial operating room throughput during the clearance period was 717 patients per week (95% CI 326–1368). For all surgery types, it will take about 84 weeks (95% CI 46–145) to clear the backlog. For time-sensitive surgeries only, it will take about 14 weeks (95% CI 8–23) to clear the backlog, assuming all surge resources are dedicated to time-sensitive surgeries only.

The provincial average weekly resources required to clear all surgery types in the backlog are 719 operating room hours (95% CI 431–1038), 265 ward beds (95% CI 87–678) and 9 ICU beds (95% CI 4–20). The weekly resource requirements are crucial to ensure that hospitals select a sustainable surge scenario based on local resources available. Provincial and regional estimates of the backlog size by surgery type, clearance times and resources required to clear the backlog are shown in Table 2. Provincial results from the probabilistic sensitivity analysis showing the variability in the outputs are summarized in Figure 5.

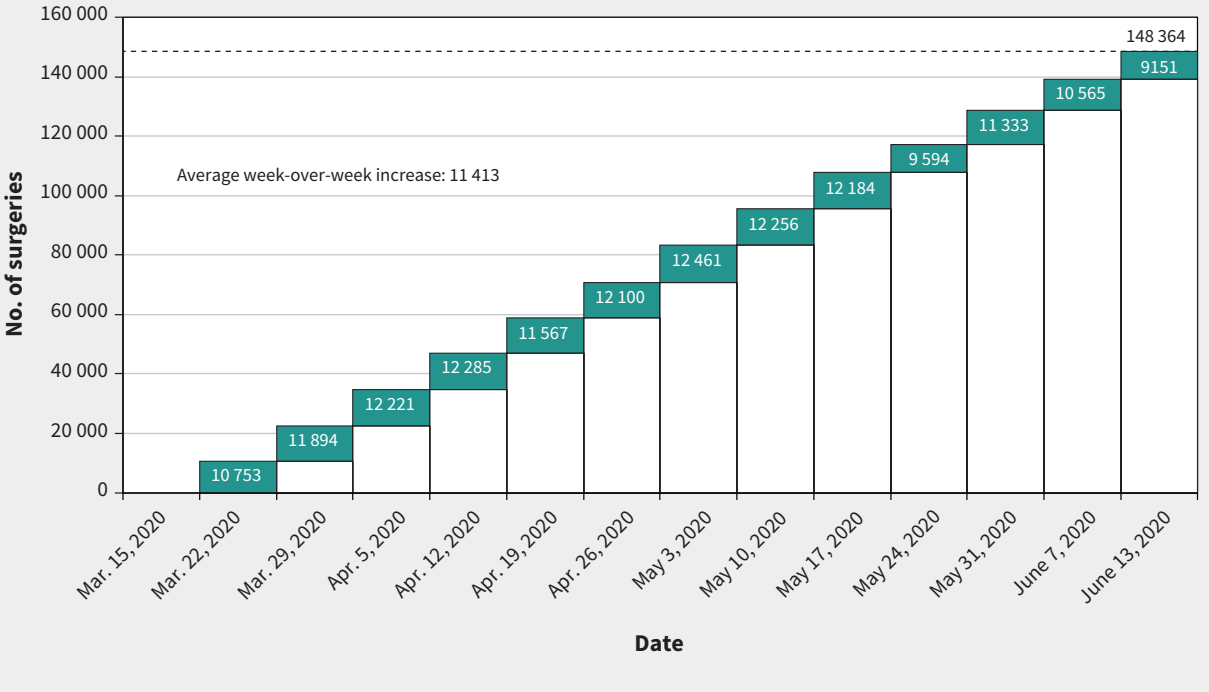

Figure 4: Week-over-week accumulation of the mean provincial backlog for all surgery types from Mar. 15, 2020, to June 13, 2020, for a total mean backlog size of 148 364 surgeries.

Interpretation

Our analyses quantify the impact of COVID-19 on surgeries in Ontario. The wide CIs (11 mo to 2.8 yr) on the clearance time estimates indicate the uncertainty and variation inherent in the analysis. Clearance times depend on the extent of surgical recovery and if a surge in surgical activity is undertaken. The results reflect a gradual recovery in surgical activity from the Ministry of Health announcement to reopen nonemergent surgeries on May 26, 2020, up to June 13, 2020. Without any increases in resources to support surge activity, incoming new cases will lead to a subsequent backlog.

Table 2: Provincial and regional results from the probabilistic sensitivity analysis showing the estimated backlog size and the time and resources required to clear the backlog

	Health region					
Category or outcome	**Ontario***	**West**	**Central**	**Toronto**	**East**	**North**
Estimated backlog size by surgical category†						
Cancer P2–P3	1537 (486–3427)	206 (75–552)	308 (130–588)	488 (126–1265)	376 (106–714)	159 (49–308)
Cancer P4	3615 (2440–4869)	927 (597–1259)	700 (450–952)	986 (698–1298)	911 (675–1148)	91 (19–212)
Vascular P2–P3	940 (430–1635)	202 (60–408)	296 (154–502)	97 (31–176)	284 (166–405)	61 (20–145)
Vascular P4	935 (412–1516)	369 (160–587)	314 (179–451)	128 (54–209)	111 (18–223)	13 (1–46)
Transplant	243 (22–577)	48 (4–113)	NA	124 (11–293)	72 (7–170)	NA
Cardiac CABG	295 (150–440)	77 (39–115)	71 (36–106)	86 (44–128)	37 (19–55)	23 (12–35)
Cardiac Valve	175 (89–261)	29 (15–43)	64 (33–95)	51 (26–76)	20 (10–30)	12 (6–17)
Other P2–P3	20 400 (15 752–25 098)	5361 (3418–7305)	5858 (5082–6633)	2098 (1458–2737)	5671 (4779–6613)	1412 (1013–1811)
Other P4	107 873 (95 994–119 917)	34 660 (31 117–38 203)	26 560 (23 580–29 705)	13 102 (11 674–14 530)	26 702 (24 097–29 307)	6849 (5526–8171)
Pediatric P2–P3	3151 (1431–5729)	858 (179–1537)	561 (401–750)	624 (379–870)	869 (431–2123)	239 (42–449)
Pediatric P4	9200 (7301–11 122)	3004 (2479–3501)	2513 (2128–2899)	1311 (1003–1618)	1831 (1375–2339)	540 (317–764)
Total estimated backlog size	148 364 (124 508–174 589)	45 742 (38 143–53 624)	37 245 (32 173–42 680)	19 093 (15 504–23 199)	36 885 (31 683–43 127)	9399 (7005–11 959)
Estimated time to clear the backlog‡						
Estimated throughput (patients per week)	717 (326–1367)	933 (328–2532)	809 (264–2250)	278 (108–642)	710 (240–1736)	278 (92–669)
Estimated clearance time, wk	84 (46–145)	79 (31–159)	74 (26–156)	120 (58–231)	87 (34–180)	53 (20–117)
Estimated resources required‡						
OR time (h) per week	719 (431–1038)	926 (552–1344)	735 (433–1057)	452 (260–658)	705 (420–1022)	271 (163–388)
Ward beds per week	265 (87–678)	352 (58–1483)	295 (48–1142)	99 (22–305)	258 (44–935)	110 (15–392)
ICU beds per week	9 (4–20)	14 (3–44)	5 (1–17)	9 (2–27)	7 (2–20)	3 (1–10)

Note: CABG = coronary artery bypass graft, ICU = intensive care unit, NA = no surgeries are performed in this health region, OR = operating room, P2–P4 indicates priority level 2 to 4.
*The Ontario results for estimated time and resources required to clear the backlog are volume-weighted averages of each regional outputs.
†Backlog size estimates are reported as the mean (95% prediction interval).
‡Results are reported as the mean (95% confidence interval) of the probabilistic sensitivity analysis.

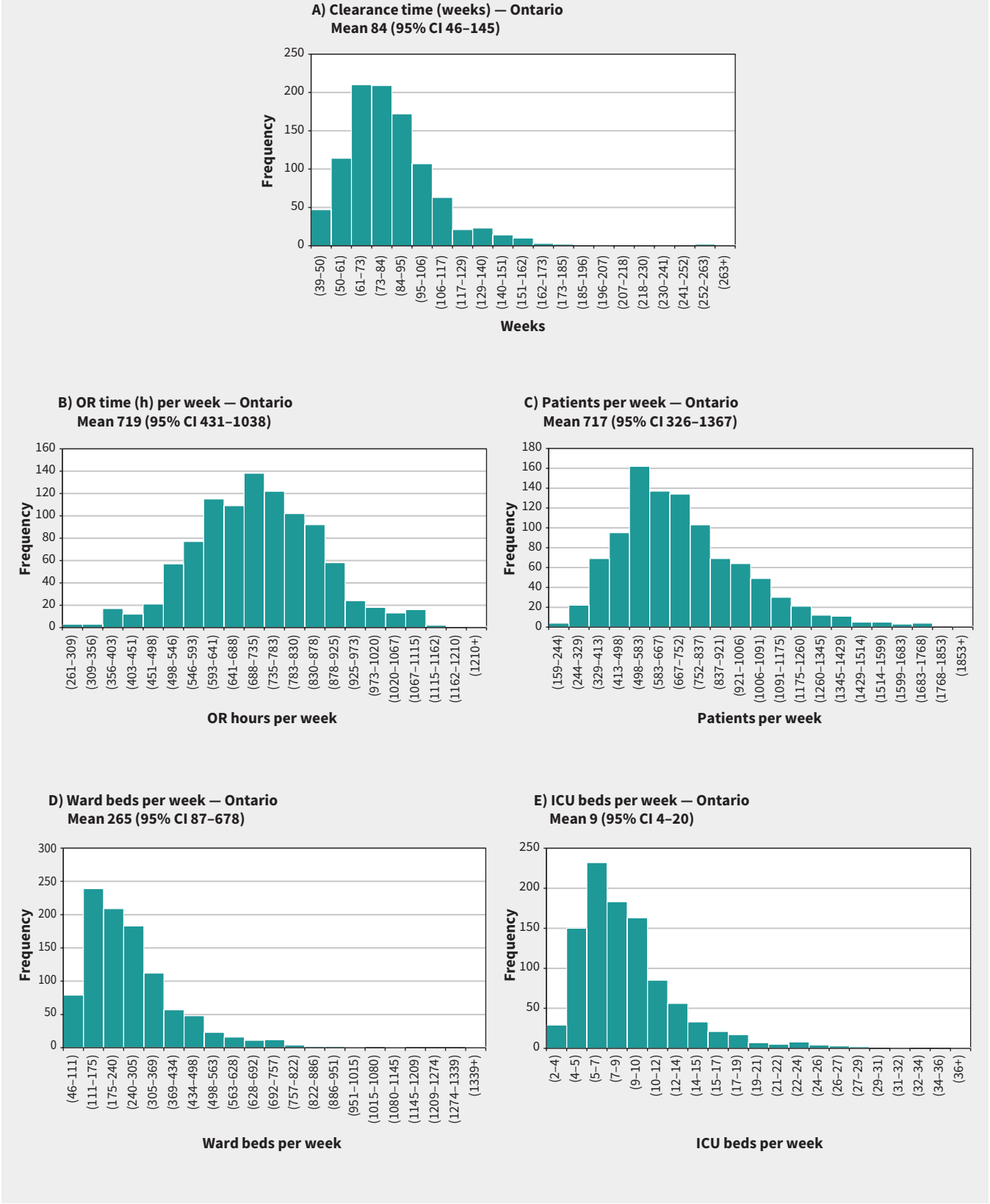

Figure 5: Provincial results from the probabilistic sensitivity analysis for (A) clearance time, (B) operating room (OR) time per week, (C) patients per week, (D) ward beds per week and (E) intensive care unit (ICU) beds per week. The analyses were run 1000 times, and the frequencies add up to 1000. Note: CI = confidence interval.

Our framework for modelling the surgical backlog can be adapted to other jurisdictions, using local data to assist with recovery planning. We have created a deterministic, Excel-based tool using average inputs to help regional partners plan for restarting surgeries (see the Excel tool, available at https://github.com/wangjona/surgicalbacklog). According to Ontario Health recommendations, hospitals must ensure they can achieve at least 10% acute bed occupancy within 48 hours and have a minimum of 15 days of PPE onsite, coupled with a 30-day alternative backstop in each region or subregion.[18] Hospital planners can use estimates of their upcoming surgery volumes in conjunction with the tool to assess the feasibility of the recommended criteria.

Limitations

Our analysis does not account for the potential occurrence of future waves of COVID-19 in Ontario. A delayed recovery or ramping down of nonemergent surgeries after a subsequent COVID-19 wave will continue to cause the backlog to grow, increasing the clearance time and resource estimates.

We considered clearance time estimates serially with operating room time distributions. Including multiple categories of surgeries in 1 operating room day (e.g., scheduling cancer and vascular surgeries within the same operating room day) with stochastic operating room times may reduce the clearance time and resources required. Further research on optimal priority scheduling of patients to improve operating room use in pandemic recovery should be a next step.

Modelling assumes availability of health human resources, beds, drugs and PPE. However, the pandemic has caused significant challenges related to health human resources in many jurisdictions, including Ontario, as operating room staff have been reallocated to other hospital departments and may be experiencing work fatigue.[19–25] Regions are also coping with a reduction in beds resulting from the movement of patients from long-term care into hospitals, coupled with a reduction of beds per room to accommodate physical distancing protocols.[26] Therefore, it may be difficult to ensure adequate staffing and beds to support ramp-up plans.[19] Similarly, drug and PPE shortages resulting from supply chain disruptions have been identified as a challenge in restarting surgeries.[27,28] Provincial supply chains must be robust to secure sufficient drugs and PPE. Modelling requirements and supply for health human resources, beds, critical medications and PPE would be beneficial future steps.

Finally, we used historical data to forecast the expected surgical volumes and to estimate resource utilization patterns. The expected surgical volumes are based on historical patterns, which may change in the pandemic recovery phase. There is a paucity of data informing assumptions on the demand for surgeries during the recovery phase and the potential ramp-down phase during subsequent COVID-19 waves. We also assumed that all forecasted surgical volumes are appropriately indicated for surgery, which may not be true in all cases.[29] For resource utilization patterns, patients waiting longer for treatment may have higher resource utilization than those receiving care before the pandemic, owing to disease progression as one might see in cancer or cardiac care, or may become ineligible for surgery as their condition progresses. In addition, patients waiting for transplants may lose opportunities for organ donation. Consequently, this analysis should be considered with other guidance tools, such as ethical frameworks and clinical prioritization guides.[30] Without significant increases in resources, prioritization of patients for surgery based on survival and quality-of-life outcomes is paramount.

Conclusion

We presented an approach to modelling the incremental provincial and regional surgical backlog in Ontario and the time and resources required to clear the backlog as a result of COVID-19. This work shows the unprecedented magnitude of the secondary impact of COVID-19 on surgical care in Ontario. Our framework for modelling the surgical backlog can be adapted to other jurisdictions using local data to assist with recovery planning. To effectively manage this impact on more than 140 000 patients, health systems and surgical leaders cannot get back to business as usual, but rather must employ innovative system-based solutions to provide patients with timely surgical care and prepare for future COVID-19 waves.[31–33]

References

1. WHO timeline — COVID-19 [statement]. Geneva: World Health Organization; updated 2020 July 30. Available: www.who.int/news-room/detail/27-04-2020-who-timeline—covid-19 (accessed 2020 June 14).
2. Rosenbaum L. The untold toll — the pandemic's effects on patients without COVID-19. *N Engl J Med* 2020;382:2368-71.
3. COVIDSurg Collaborative. Elective surgery cancellations due to the COVID-19 pandemic: global predictive modelling to inform surgical recovery plans. *Br J Surg* 2020 May 12 [Epub ahead of print]. doi: 10.1002/bjs.11746.
4. Jain A, Jain P, Aggarwal S. SARS-CoV-2 impact on elective orthopaedic surgery: implications for post-pandemic recovery. *J Bone Joint Surg Am* 2020 May 12. [Epub ahead of print]. doi: 10.2106/JBJS.20.00602.
5. Ramping down elective surgeries and other non-emergent activities [memorandum to Ontario Health and hospitals]. Toronto: Ministry of Health and Long-Term Care; 2020 Mar. 15. Available: www.health.gov.on.ca/en/pro/programs/publichealth/coronavirus/docs/memos/DM_OH_CMOH_memo_COVID19_elective_surgery_March_15_2020.pdf (accessed 2020 Aug. 24).
6. COVID-19 directive #2 for health care providers (regulated health professionals or persons who operate a group practice of regulated health professionals), issued under Section 77.7 of the *Health Protection and Promotion Act* (HPPA), R.S.O. 1990, c. H.7. Toronto: Ministry of Health and Long-Term Care; 2020. Available: www.health.gov.on.ca/en/pro/programs/publichealth/coronavirus/docs/directives/RHPA_professionals.pdf (accessed 2020 Aug. 24).
7. Measuring wait times for other surgeries and procedures. Toronto: Health Quality Ontario. Available: www.hqontario.ca/System-Performance/Measuring-System-Performance/Measuring-Wait-Times-for-Other-Surgeries-and-Procedures (accessed 2020 June 11).
8. Ontario taking next steps to integrate health care system: changes will protect uninterrupted access to patient care [news release]. Toronto: Ministry of Health and Long-Term Care; 2019 Nov. 13. Available: https://news.ontario.ca/mohltc/en/2019/11/ontario-taking-next-steps-to-integrate-health-care-system.html (accessed 2020 June 14).
9. *Population estimates, quarterly [Table: 17-10-0009-01 (formerly CANSIM 051-0005)]*. Ottawa: Statistics Canada; 2020. Available: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1710000901 (accessed 2020 June 17).
10. Cancer Care Ontario's data book — 2020–2021. Toronto: Ontario Health (Cancer Care Ontario); 2019. Available: https://ext.cancercare.on.ca/ext/databook/db2021/databook.htm (accessed 2020 Aug. 24).
11. Little JDC. A proof for the queuing formula: L = λ W. *Oper Res* 1961;9:383-7. doi: 10.1287/opre.9.3.383.

12. Coccolini F, Perrone G, Chiarugi M, et al. Surgery in COVID-19 patients: operational directives. *World J Emerg Surg* 2020;15:25.
13. Hyndman R, Athanasopoulos G, Bergmeir C, et al. Forecast: forecasting functions for time series and linear models. R package 8.12. 2020. Available: https://pkg.robjhyndman.com/forecast/ (accessed 2020 June 17).
14. de Livera AM, Hyndman RJ, Snyder RD. Forecasting time series with complex seasonal patterns using exponential smoothing. *J Am Stat Assoc* 2011;106:1513-27. doi: 10.1198/jasa.2011.tm09771.
15. Hyndman RJ, Athanasopoulos G. Forecasting: principles and practice. Melbourne (AU): OTexts; 2018. Available: https://otexts.com/fpp2/ (accessed 2020 June 22).
16. Cleveland RB, Cleveland WS, McRae JE, et al. STL: a seasonal-trend decomposition procedure based on loess. *J Off Stat* 1990;6:3-73. Available: www.nniiem.ru/file/news/2016/stl-statistical-model.pdf (accessed 2020 Aug. 24).
17. Tam DY, Naimark D, Natarajan MK, et al. The use of decision modelling to inform timely policy decisions on cardiac resource capacity during the COVID-19 pandemic. *Can J Cardiol* 2020;36:1308-12.
18. A measured approach to planning for surgeries and procedures during the COVID-19 pandemic. Toronto: Ontario Health; updated 2020 June 15. Available: www.ontariohealth.ca/sites/ontariohealth/files/2020-06/A Measured Approach to Planning for Surgeries and Procedures During the COVID-19 Pandemic.pdf (accessed 2020 Aug. 24).
19. Shoukat A, Wells CR, Langley JM, et al. Projecting demand for critical care beds during COVID-19 outbreaks in Canada. *CMAJ* 2020;192:E489-96.
20. Kim T. Improving preparedness for and response to coronavirus disease 19 (COVID-19) in long-term care hospitals in the Korea Tark Kim Seongnam, Korea. *Infect Chemother* 2020;52:133-41.
21. Chersich MF, Gray G, Fairlie L, et al. COVID-19 in Africa: care and protection for frontline healthcare workers. *Global Health* 2020;16:46.
22. Carenzo L, Costantini E, Greco M, et al. Hospital surge capacity in a tertiary emergency referral centre during the COVID-19 outbreak in Italy. *Anaesthesia* 2020;75:928-34.
23. Moghadas SM, Shoukat A, Fitzpatrick MC, et al. Projecting hospital utilization during the COVID-19 outbreaks in the United States. *Proc Natl Acad Sci U S A* 2020;117:9122-6.
24. Rubin R, Abbasi J, Voelker R. Latin America and its global partners toil to procure medical supplies as COVID-19 pushes the region to its limit. *JAMA* 2020 June 12. [Epub ahead of print]. doi: 10.1001/jama.2020.11182.
25. Sasangohar F, Jones SL, Masud FN, et al. Provider burnout and fatigue during the COVID-19 pandemic: lessons learned from a high-volume intensive care unit. *Anesth Analg* 2020;131:106-11.
26. *Utilization of multi-bed ward rooms and inpatient placement in hospitals during COVID-19*. Toronto: Ontario Health; 2020. Available: www.ontariohealth.ca/sites/ontariohealth/files/2020-06/Utilization%20of%20Multi-Bed%20Ward%20Rooms%20and%20Inpatient%20Placement%20in%20Hospitals%20During%20COVID-19.pdf (accessed 2020 June 22).
27. Badreldin HA, Atallah B. Global drug shortages due to COVID-19: impact on patient care and mitigation strategies. *Res Soc Adm Pharm* 2020 May 19 [Epub ahead of print]. doi: 10.1016/j.sapharm.2020.05.017.
28. Ranney ML, Griffeth V, Jha AK. Critical supply shortages — the need for ventilators and personal protective equipment during the COVID-19 pandemic. *N Engl J Med* 2020;382:e41.
29. Cooper Z, Sayal P, Abbett SK, et al. A conceptual framework for appropriateness in surgical care: reviewing past approaches and looking ahead to patient-centered shared decision making. *Anesthesiology* 2015;123:1450-4.
30. ASCCP interim guidance for timing of diagnostic and treatment procedures for patients with abnormal cervical screening tests. Rockville (MD): American Society for Colposcopy and Cervical Pathology (ASCCP); 2020. Available: www.asccp.org/covid-19 (accessed 2020 June 11).
31. Urbach DR, Martin D. Confronting the COVID-19 surgery crisis: time for transformational change. *CMAJ* 2020;192:E585-6.
32. Barron L, Kumar T. Surgical backlog must not be fixed at the expense of the healthcare system. *Healthy Debate.ca* 2020 Aug. 4. Available: https://healthydebate.ca/opinions/surgical-backlog-expense (accessed 2020 Aug. 5).
33. Butler C. How surgical smoothing could help ease the medical backlog created by COVID-19. *CBC News* 2020 July 13. Available: www.cbc.ca/news/canada/london/elective-surgery-wait-times-covid-surgical-smoothing-1.5641819 (accessed 2020 Aug. 5).

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Affiliations: Ontario Health (Cancer Care Ontario) (Wang, Vahid, Eberg, Milroy, Milkovich, Wright, Hunter, Zanchetta, Irish); Division of General Surgery (Wright), Sunnybrook Health Sciences Centre; Trillium Gift of Life Network (Kalladeen); Schulich Heart Centre (Wijeysundera), Sunnybrook Health Sciences Centre; Division of Cardiology (Wijeysundera), Department of Medicine and Department of Otolaryngology-Head and Neck Surgery/Surgical Oncology (Irish), Princess Margaret Cancer Centre/University Health Network, University of Toronto, Toronto, Ont.

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Data sharing: Aggregated data for the time series modelling of surgical volume data may be requested for research purposes through the Ontario Health (Cancer Care Ontario)'s data request process immediately after publication (no end date): https://www.ccohealth.ca/en/request-data-for-research. The data used as inputs to this modelling study (OR time, turnover time, ward and ICU length of stay, % to ward and ICU and the number of ORs) are summarized in Appendix 1.

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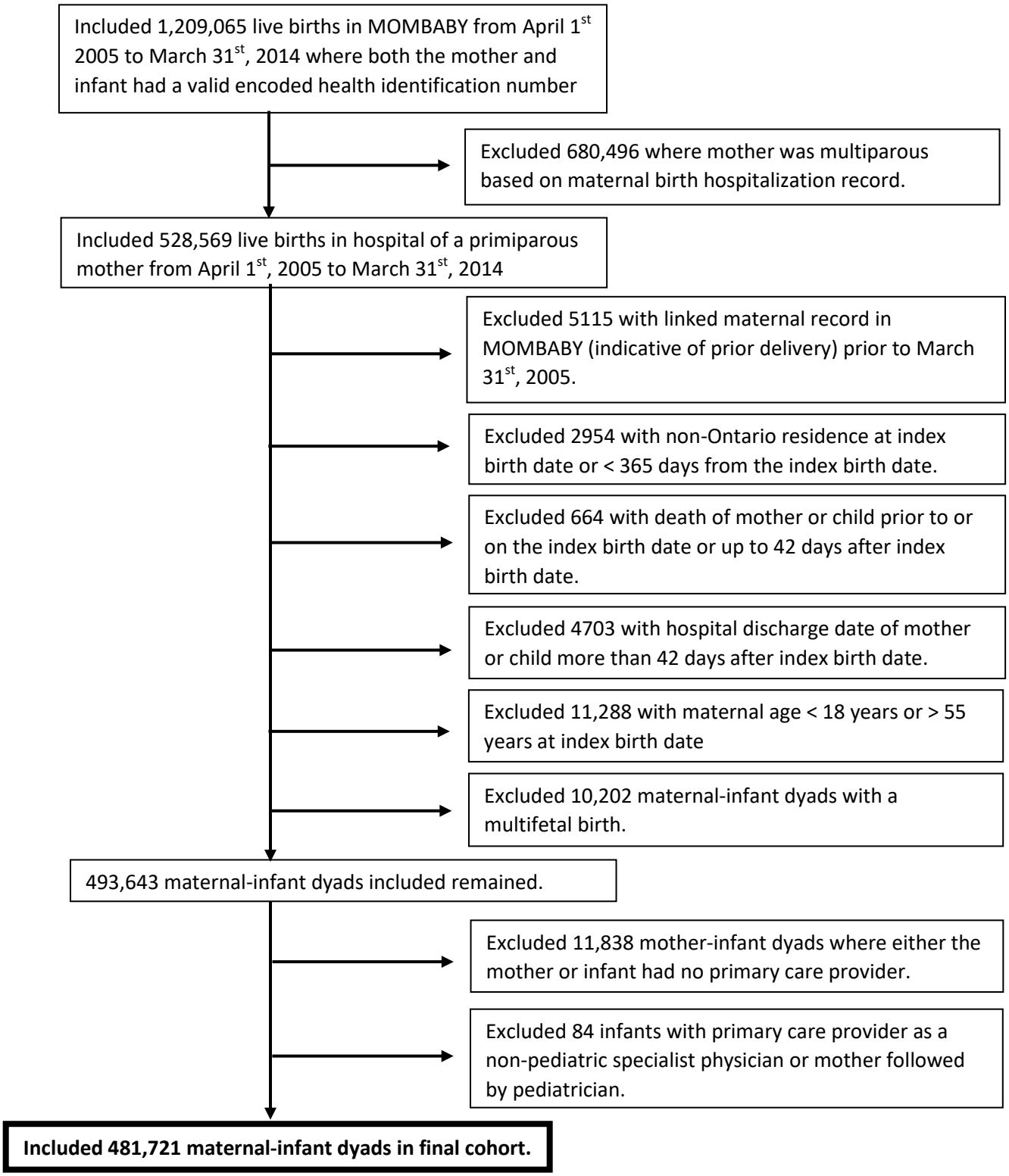
Correspondence to: Jonathan Irish, jonathan.irish@uhn.ca

Appendix 1 (as supplied by the authors): Supplementary information

Figure A1-1: Flowsheet of inclusion and exclusion criteria



Appendix to: Saunders NR, Ray JG, Diong C, et al. Primary care of mothers and infants by the same or different physicians: a population-based cohort study. *CMAJ* 2020. DOI:10.1503/cmaj.191038.

Box A1-1: Primary Care Codes from Ontario Health Insurance Plan (OHIP) Billings Database

Primary care provider who provided the majority care for mothers and their infant from 42 days to 365 days following the infant's birth date.

Maternal Primary Care Provider Assignment

All visits by general practitioners or family doctors in Ontario during observation window with the following fee codes:
A001, A003, A004, A005, A006, A007, A008, A901, A903, A905, G212, G271, G372, G373, G365, G538, G539, G590, G591, G842, G843, G844, G845, G846, G847, G848, K005, K013, K017 and a location code of office, home, or phone.

Physician who billed the greatest number of days of visits by the mother assigned as the primary care provider for the mother. Where there was a tie, the primary care provider who most recently saw the mother was assigned as the primary care provider. Pediatrics. 2006 Mar;117(3):595-602

Child Primary Care Provider Assignment

All visits by general practitioners, family doctors, or Pediatricians in Ontario during the observation window with the following fee codes:
A001, A002, A003, A004, A005, A006, A007, A008, A901, A903, A905, G212, G271, G372, G373, G365, G538, G539, G590, G591,G840, G841, G842, G843, G844, G845, G846, G847, G848, K005, K013, K017, A261, A262, A268, K267, K269, K119, K120 and a location code of office, home, or phone.

Physician who billed the greatest number of days of visits by the child assigned as the primary care provider for the child. Where there was a tie, the primary care provider who most recently saw the child was assigned as the primary care provider.

SPECIFIC DEFINTION OF PRIMARY CARE CONCORDANCE

1) Concordant care: Maternal and child provider was the same, using above codes.
2) Discordant care, 2 family physicians: Maternal provider was one family doctor and child's provider was another family doctor using above codes.
3) Discordant care, 1 family physician, 1 Pediatrician: Maternal provider was a family doctor and child's provider was a Pediatrician using above codes.

SENSITIVE DEFINITION OF PRIMARY CARE CONCORDANCE

Concordant care: Mother and child had ANY primary care code billed by the same family physician at least once in the 42 to 365 days following the index birth date.

Box A1-2: Codes used for mental health hospitalization or emergency department visit:

Any discharge diagnosis from the emergency department or hospital discharge record with the following diagnostic codes: ICD-10-CA: F04 to F99, X60-X84, Y10-Y19, Y28

Table A1-1: Codes used for the maternal composite cardiovascular disease outcome, defined as any hospitalization from 42 to 730 days following index birth date, with any of the following diagnostic codes:

Disease	ICD-10-CA diagnostic codes	ICD-10-CA procedural codes*
Coronary artery disease	I20, I21, I22, I24, I25.0, I25.1, I51.3, I51.6	1.IJ.76, 1IJ50, 1IJ57
Cerebrovascular disease	G46, I63.0-I66.9, I67	1JE57, 1JW57, 1JX57
Peripheral artery disease	I70.0, I70.2, I74	1JM76, 1JW76, 1JX76, 1KA76, 1KG57, 1KR76, 1KR87LA, 1KT76, 1ID76MU, 1KG76, 1KG87 1KE76
Cardiac dysrhythmia	I48, I47.2, I49.0, I47.2	--
Heart failure	I50	--

Table A1-2. Reasons for maternal hospitalization in 42 to 730 days following index birth date using "Most Responsible Diagnosis" from Canadian Institutes for Health Information Discharge Abstract Database.

		Frequency	Percent
Most responsible diagnoses for maternal hospitalization			
1	Factors influencing health status and contact with health services[a]	11 410	42.0
2	Diseases of the digestive system	5772	21.3
3	Diseases of the genitourinary system	1707	6.3
4	Neoplasms	1682	6.2
5	Injury, poisoning and certain other consequences of external causes	1328	4.9
6	Symptoms, signs and abnormal clinical and laboratory findings not elsewhere classified	1256	4.6
7	Diseases of the respiratory system	676	2.5
8	Endocrine, nutritional and metabolic diseases	622	2.3
9	Certain infectious and parasitic diseases	512	1.9
10	Diseases of the circulatory system	472	1.7
11	Diseases of the musculoskeletal system and connective tissue	470	1.7
12	Diseases of the nervous system	347	1.3
13	Mental and behavioural disorders	321	1.2
14	Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	233	0.9
15	Diseases of the skin and subcutaneous tissue	132	0.5
Most responsible diagnoses for child hospitalization			
1	Diseases of the respiratory system	14 346	31.3
2	Symptoms, signs and abnormal clinical and laboratory findings not elsewhere classified	5627	12.3
3	Certain infectious and parasitic diseases	5543	12.1
4	Congenital malformations, deformations, and chromosomal abnormalities	4025	8.8
5	Diseases of the digestive system	3333	7.3
6	Diseases of the genitourinary system	2931	6.4
7	Injury, poisoning and certain other consequences of external causes	2418	5.3
8	Factors influencing health status and contact with health services	1295	2.8
9	Diseases of the nervous system	1144	2.5
10	Diseases of the skin and subcutaneous tissue	1022	2.2
11	Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	777	1.7
12	Endocrine, nutritional and metabolic diseases	715	1.6
13	Diseases of the ear and mastoid process	635	1.4
14	Neoplasms	535	1.2
15	Diseases of the musculoskeletal system and connective tissue	429	0.9

[a] Factors influencing health status and contact with health services includes all International Classification of Diseases (ICD) 10-CA diagnostic codes from Chapter XXI. These codes are provided for occasions when circumstances other than a disease, injury or external cause classifiable to other categories are recorded as "diagnoses" or "problems". This can arise in two main ways: (a) when a person who may or may not be sick encounters the health services for some specific purpose, such as to receive limited care or service for a current condition, to donate an organ or tissue, to receive prophylactic vaccination (immunization), or to discuss a problem which is in itself not a disease or injury; (b) when some circumstance or problem is present which influences the person's health status but is not in itself a current illness or injury. Such factors include encountering health services for examination and investigation (Z00-Z13), for potential health hazards related to communicable diseases (Z20-Z29), in circumstances related to

reproduction (Z30-Z39), for specific procedures and health care (Z40-Z54), with potential health hazards related to socioeconomic and psychosocial circumstances (Z55-Z65), in other circumstances (Z70-Z76) and with potential health hazards related to family and personal history and certain conditions influencing health status (Z80-Z99).

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Table A1-3: Construct validity for primary care concordance.[a] All data are presented as a number (%) unless otherwise indicated.

		Concordant: Mother and infant have the same family physician (N = 239 033)	**Discordant: Mother and infant each have different family physicians (N = 114 006)**	**Pediatrician: Mother has a family physician and child has a Pediatrician (N = 128 682)**
Maternal Continuity of Care (proportion of visits to assigned PCP)	High COC (76%+)	153 834 (64.4)	14 730 (12.9)	43 377 (33.7)
	Low COC (<76%)	85 199 (35.6)	99 276 (87.1)	85 305 (66.3)
Child Continuity of care (proportion of visits to assigned PCP)	High COC (76%+)	151 720 (63.5)	51 085 (44.8)	80 740 (62.7)
	Low COC (<76%)	87 313 (36.5)	62 921 (55.2)	47 942 (37.3)
Any enhanced 18-month well-baby visit[b]		62 209 (58.5)	30 104 (51.5)	42 628 (60.3)
Enhanced 18-month well-baby visit by assigned PCP[b]		53 623 (86.3)	21 703 (72.3)	38 053 (89.3)

[a] Continuity of care measured between 42 and 730 days following index birth date.

[b] For infants born 2010 and later as this visit/fee code was not introduced until 2009

SD, standard deviation; IQR, interquartile range; PCP, primary care provider; COC, continuity of care

Table A1-4: Characteristics of the study cohort according to the primary care provider of the mother and of her infant child using the sensitive definition of the primary care provider. All data are presented and a number (%) unless otherwise indicated.

Characteristic		Concordant: Mother and infant have the same family physician (N = 300 012)	Discordant: Mother and infant each have different family physicians (N = 79 094)	Pediatrician: Mother has a family physician and child has a Pediatrician (N = 102 615)
Of the mother				
Mean (SD) age, y		28.8 (5.3)	28.5 (5.3)	30.7 (5.2)
Neighbourhood income quintile (Q)	*Q1 (low)*	63 149 (21.0)	16 666 (21.1)	20 330 (19.8)
	Q2	62 303 (20.8)	16 249 (20.5)	20 361 (19.8)
	Q3	64 229 (21.4)	16 335 (20.7)	19 388 (18.9)
	Q4	63 484 (21.2)	16 583 (21.0)	22 495 (21.9)
	Q5 (high)	45 941 (15.3)	12 855 (16.3)	19 622 (19.1)
	Missing	906 (0.3)	406 (0.5)	419 (0.4)
Rural residence		18 179 (6.1)	8027 (10.1)	821 (0.8)
Immigrant		73 896 (24.6)	13 682 (17.3)	36 313 (35.4)
Comorbidities in the preceding 3 years, according the Johns Hopkins Adjusted Diagnostic Groups	*0-5*	80 381 (26.8)	35 302 (44.6)	30 168 (29.4)
	6-9	142 647 (47.5)	34 051 (43.1)	48 896 (47.6)
	10+	76 984 (25.7)	9 741 (12.3)	23 551 (23.0)
Primary care model[a]	*Fee-for-service*	60 668 (20.2)	67 483 (85.3)	54 644 (53.3)
	Non-capitated	142 764 (47.6)	7047 (8.9)	34 955 (34.1)
	Capitated	96 164 (32.1)	4528 (5.7)	12 942 (12.6)
	Other	416 (0.1)	36 (0.0)	74 (0.1)
Of the child				
Gestational age at birth, weeks	*< 34*	2 602 (0.9)	960 (1.2)	1637 (1.6)
	34-36	15 142 (5.0)	3725 (4.7)	5992 (5.8)
	≥ 37	282 192 (94.1)	74 365 (94.0)	94 962 (92.5)
Birthweight, g	*< 1500*	483 (0.2)	390 (0.5)	365 (0.4)
	1500-2500	13 400 (4.5)	3256 (4.1)	6228 (6.1)
	2501-4000	256 132 (85.4)	67 223 (85.0)	87 453 (85.2)
	> 4000	29 959 (10.0)	8127 (10.3)	8555 (8.3)
Birth hospitalization length of stay	*≤ 24 hours*	14 139 (4.7)	4700 (5.9)	3249 (3.2)
	2-6 days	274 821 (91.6)	71 499 (90.4)	93 589 (91.2)
	≥ 7 days	11 052 (3.7)	2895 (3.7)	5777 (5.6)
Complex chronic condition		*11 993 (4.0)*	3423 (4.3)	6085 (5.9)

[a]In Ontario, several models of primary care practice and remuneration exist. A full description of the models is available elsewhere (http://cmajopen.ca/content/4/4/E679.full). Broadly, fee-for-service is a tradition model where physicians are paid for each service provided and typically work in solo practice with no requirements for after-hours care; non-capitated models include physicians paid largely through fee-for-service but they receive incentives and bonuses and a small fee for rostering patients. Practice is often in a group with after hours premiums; capitated models include payment for each rostered patient blended with fee-for-service and incentive and bonus components, practice is in a group with after hours-premiums.

Table A1-5: Maternal and child outcomes, univariate analysis and regression models by specific and sensitive definitions of primary care concordance.[a]

		Unadjusted Specific Definition	Multivariable Adjusted Specific Definition	Unadjusted Sensitive Definition	Multivariable Adjusted Sensitive Definition
Outcomes of the mother		**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Non-maternity Hospitalization	Concordant	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)
	Discordant (2 FP)	0.90 (0.87, 0.93)	1.00 (0.96, 1.04)	0.87 (0.83, 0.90)	0.95 (0.91, 1.00)
	Pediatrician (Peds + FP)	0.82 (0.79, 0.84)	0.99 (0.95, 1.02)	0.79 (0.76, 0.82)	0.96 (0.92, 0.99)
Death	Concordant	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)
	Discordant (2 FP)	1.21 (0.83, 1.76)	1.00 (0.62, 1.63)	1.13 (0.73, 1.73)	1.00 (0.61, 1.65)
	Pediatrician (Peds + FP)	0.69 (0.44, 1.07)	0.55 (0.34, 0.89)	0.77 (0.49, 1.21)	0.69 (0.43, 1.12)
Composite Cardiovascular Outcome[b]	Concordant	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)
	Discordant (2 FP)	0.71 (0.49, 1.03)	0.94 (0.59, 1.48)	0.60 (0.39, 0.95)	0.82 (0.49, 1.38)
	Pediatrician (Peds + FP)	0.73 (0.51, 1.04)	0.71 (0.49, 1.05)	0.41 (0.76, 0.92)	0.61 (0.40, 0.94)
Hospitalization for mental illness	Concordant	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)
	Discordant (2 FP)	1.16 (1.05, 1.29)	1.12 (0.98, 1.28)	1.01 (0.90, 1.14)	1.02 (0.89, 1.18)
	Pediatrician (Peds + FP)	0.75 (0.67, 0.84)	0.86 (0.76, 0.99)	0.66 (0.58, 0.75)	0.81 (0.71, 0.93)
Emergency department visit for mental illness	Concordant	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)
	Discordant (2 FP)	1.06 (1.00, 1.13)	1.11 (1.03, 1.20)	0.94 (0.88, 1.01)	1.00 (0.93, 1.09)
	Pediatrician (Peds + FP)	0.73 (0.69, 0.78)	1.02 (0.95, 1.09)	0.67 (0.63, 0.72)	0.97 (0.90, 1.04)
Health care utilization of the mother		**RR (95% CI)**	**RR (95% CI)**	**RR (95% CI)**	**RR (95% CI)**
Number of visits to any PCP	Concordant	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)
	Discordant (2 FP)	0.56 (0.55, 0.56)	0.68 (0.68, 0.69)	0.36 (0.36, 0.36)	0.45 (0.45, 0.45)
	Pediatrician (Peds + FP)	0.75 (0.74, 0.75)	0.75 (0.75, 0.76)	0.63 (0.63, 0.64)	0.65 (0.65, 0.65)
Number of emergency department visits	Concordant	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)
	Discordant (2 FP)	0.94 (0.92, 0.95)	1.06 (1.04, 1.08)	0.88 (0.86, 0.89)	1.06 (1.04, 1.09)
	Pediatrician (Peds + FP)	0.73 (0.72, 0.74)	0.87 (0.85, 0.88)	0.67 (0.66, 0.68)	0.84 (0.83, 0.86)
Number of low acuity emergency department visits	Concordant	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)
	Discordant (2 FP)	0.98 (0.97, 1.00)	1.07 (1.04, 1.10)	0.99 (0.97, 1.01)	1.17 (1.13, 1.20)
	Pediatrician (Peds + FP)	0.59 (0.58, 0.60)	0.69 (0.67, 0.71)	0.57 (0.56, 0.58)	0.71 (0.69, 0.73)

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		Unadjusted Specific Definition	Multivariable Adjusted Specific Definition	Unadjusted Sensitive Definition	Multivariable Adjusted Sensitive Definition
Outcomes of the child		**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Child hospitalization	Concordant	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)
	Discordant (2 FP)	0.90 (0.87, 0.92)	0.91 (0.89, 0.94)	0.76 (0.73, 0.78)	0.76 (0.73, 0.79)
	Pediatrician (Peds + FP)	1.19 (1.16, 1.22)	1.19 (1.16, 1.23)	1.01 (0.98, 1.03)	1.01 (0.98, 1.04)
Child death	Concordant	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)
	Discordant (2 FP)	1.55 (1.16, 2.06)	2.30 (1.64, 3.22)	1.69 (1.27, 2.24)	2.46 (1.76, 3.45)
	Pediatrician (Peds + FP)	1.57 (1.20, 2.07)	1.83 (1.35, 2.48)	1.26 (0.95, 1.68)	1.48 (1.09, 2.02)
Health care utilization of the child		**RR (95% CI)**	**RR (95% CI)**	**RR (95% CI)**	**RR (95% CI)**
Number of visits to any PCP	Concordant	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)
	Discordant (2 FP)	0.75 (0.74, 0.75)	0.80 (0.79, 0.80)	0.64 (0.64, 0.64)	0.69 (0.68, 0.69)
	Pediatrician (Peds + FP)	0.97 (0.97, 0.97)	0.93 (0.93, 0.94)	0.89 (0.89, 0.90)	0.86 (0.86, 0.86)
Number of emergency department visits	Concordant	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)
	Discordant (2 FP)	0.92 (0.91, 0.93)	1.00 (0.99, 1.02)	0.87 (0.86, 0.88)	0.98 (0.97, 1.00)
	Pediatrician (Peds + FP)	0.79 (0.78, 0.80)	0.85 (0.85, 0.86)	0.72 (0.72, 0.73)	0.80 (0.79, 0.81)
Number of low acuity emergency department visits	Concordant	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)
	Discordant (2 FP)	0.97 (0.95, 0.98)	1.00 (0.98, 1.03)	0.99 (0.97, 1.01)	1.16 (1.13, 1.19)
	Pediatrician (Peds + FP)	0.61 (0.60, 0.62)	0.65 (0.64, 0.66)	0.58 (0.57, 0.59)	0.69 (0.85, 0.70)
		OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
No enhanced 18-month well-baby visit[c]	Concordant	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)
	Discordant (2 FP)	1.33 (1.30, 1.36)	1.08 (1.05, 1.11)	1.47 (1.44, 1.51)	1.27 (1.24, 1.31)
	Pediatrician (Peds + FP)	0.54 (0.53, 0.56)	0.49 (0.48, 0.50)	0.54 (0.53, 0.55)	0.52 (0.51, 0.54)

[a] Outcomes measured between 42 and 730 days following index birth date.

[b] Composite CVD outcome: Any coronary artery, cerebrovascular, peripheral arterial disease, cardiac dysrhythmia or heart failure

[c] For infants born 2010 and later as this visit/fee code was not introduced until 2009

Multivariable models adjusted for: maternal age, neighbourhood income quintile, rurality, immigrant status, number of comorbidities, mental health hospitalization, primary care model, gestational age at birth, infant birth hospitalization length of stay, birth weight, presence of complex chronic condition

SD, standard deviation; IQR, interquartile range; OR, Odds Ratio; RR, Relative Risk; CI, Confidence Interval; PCP, primary care provider; Peds, Pediatrician; FP, family physician

Appendix to: Saunders NR, Ray JG, Diong C, et al. Primary care of mothers and infants by the same or different physicians: a population-based cohort study. *CMAJ* 2020. DOI:10.1503/cmaj.191038.

Table A1-6: Outcomes of the study cohort according to the primary care provider of the mother her child using a shorter outcome window of 42 to 365 days following index.[a] All data are presented as a number (%) unless otherwise indicated.

	Concordant: Mother and infant have the same family physician (N = 239 033)	Discordant: Mother and infant each have different family physicians (N = 114 006)	Pediatrician: Mother has a family physician and child has a Pediatrician (N = 128 682)
Outcomes of the mother			
Non-maternity hospitalization	4009 (1.7)	1438 (1.3)	1677 (1.3)
Death	17 (0.007)	13 (0.011)	8 (0.006)
Composite cardiovascular outcome[b]	50 (0.021)	13 (0.011)	22 (0.017)
Hospitalization for mental illness	528 (0.2)	303 (0.3)	231 (0.2)
Emergency department visit for mental illness	1688 (0.7)	894 (0.8)	722 (0.6)
Health care utilization of the mother			
Mean number of visits to any PCP (SD)	4.1 (3.3)	3.3 (3.6)	3.5 (3.0)
Mean number of mental health visits to PCP (SD)	2.0 (1.7)	2.5 (5.2)	1.9 (3.1)
Mean number of emergency department visits (SD)	1.7 (1.5)	1.7 (1.6)	1.6 (1.5)
Mean number of low acuity emergency department visits (SD)	1.4 (1.1)	1.5 (1.2)	1.3 (1.0)
Outcomes of the child			
Hospitalization	8847 (3.7)	3905 (3.4)	6349 (4.9)
Death	76 (0.032)	62 (0.054)	55 (0.043)
Health care utilization of the child			
Mean number of visits to any PCP (SD)	7.3 (3.5)	5.8 (3.1)	7.3 (3.6)
Mean number of emergency department visits (SD)	1.8 (1.4)	1.8 (1.3)	1.6 (1.2)
Mean number of low acuity emergency department visits (SD)	1.5 (1.1	1.5 (1.1)	1.3 (0.7)

[a] Outcomes measured between 42 and 365 days following index birth date.

[b] Composite CVD outcome: Any coronary artery, cerebrovascular, peripheral arterial disease, cardiac dysrhythmia or heart failure

SD, standard deviation; IQR, interquartile range; PCP, primary care provider

Appendix to: Saunders NR, Ray JG, Diong C, et al. Primary care of mothers and infants by the same or different physicians: a population-based cohort study. *CMAJ* 2020. DOI:10.1503/cmaj.191038.

Table A1-7: Outcomes of the study cohort according to the primary care provider remuneration and practice model of the mother.[a] All data are presented as a number (%) unless otherwise indicated.

	Concordant: Mother and infant have the same family physician (N = 239 033)				Discordant: Mother and infant each have different family physicians (N = 114 006)				Pediatrician: Mother has a family physician and child has a Pediatrician (N = 128 682)			
	Fee-for-Service	Non-Capitated Model	Capitated Model	Other	Fee-for-Service	Non-Capitated Model	Capitated Model	Other	Fee-for-Service	Non-Capitated Model	Capitated Model	Other
	n = 25 848	n = 124 212	n = 88 618	n = 355	n = 92 217	n = 13 132	n = 8578	n = 79	n = 64 730	n = 47 422	n = 16 438	n = 92
Outcomes of the mother												
Non-maternity hospitalization	1252 (4.8)	6172 (5.0)	4599 (5.2)	22 (6.2)	3985 (4.3)	718 (5.5)	486 (5.7)	-	2434 (3.8)	2145 (4.5)	755 (4.6)	-
Death	11 (0.043)	42 (0.034)	20 (0.023)	-	33 (0.036)	6 (0.046)	-	-	16 (0.026)	9 (0.019)	-	-
Composite cardiovascular outcome[b]	11 (0.043)	58 (0.047)	40 (0.045)	-	22 (0.024)	7 (0.053)	8 (0.093)	-	17 (0.03)	18 (0.04)	8 (0.05)	-
Hospitalization for mental illness	141 (0.6)	456 (0.4)	371 (0.4)	-	381 (0.4)	94 (0.7)	63 (0.7)	-	232 (0.4)	110 (0.2)	50 (0.3)	-
Emergency department visit for mental illness	450 (1.7)	1579 (1.3)	1449 (1.6)	-	1115 (1.4)	1035 (1.0)	4482 (1.5)	1115 (1.4)	741 (1.1)	447 (0.9)	192 (1.2)	-
Health care utilization of the mother												
Mean number of visits to any PCP (SD)	9.1 (7.2)	9.6 (6.6)	6.2 (4.5)	7.1 (5.4)	4.8 (6.0)	8.5 (6.7)	5.8 (4.6)	6.1 (4.5)	5.6 (5.8)	8.0 (5.7)	6.2 (4.5)	7.0 (8.1)
Mean number of mental health visits to PCP (SD)	2.7 (3.1)	2.7 (2.9)	2.5 (2.5)	3.4 (3.8)	3.0 (8.4)	2.7 (3.8)	2.5 (3.2)	3.0 (5.2)	2.5 (7.0)	2.3 (2.5)	2.2 (2.1)	5.0 (9.3)
Mean number of emergency department visits (SD)	2.3 (2.3)	2.1 (2.2)	2.3 (2.5)	3.0 (3.3)	2.2 (2.3)	2.4 (2.7)	2.6 (2.9)	2.1 (1.6)	2.0 (2.3)	1.9 (1.8)	2.1 (2.1)	2.0 (1.7)
Mean number of low acuity emergency department visits (SD)	1.8 (1.8)	1.7 (1.6)	1.8 (1.6)	2.1 (2.2)	1.8 (1.8)	1.8 (1.9)	1.9 (1.9)	1.6 (1.5)	1.5 (1.4)	1.4 (1.1)	1.5 (1.3)	1.3 (0.6)
Outcomes of the child												
Hospitalization	1824 (7.1)	8555 (6.9)	6004 (6.8)	23 (6.5)	5740 (6.2)	803 (6.1)	532 (6.2)	-	5048 (7.8)	3790 (8.0)	1544 (9.4)	-
Death	9 (0.035)	58 (0.047)	44 (0.050)	-	45 (0.049)	19 (0.145)	18 (0.210)	-	39 (0.060)	43 (0.091)	12 (0.073)	-
Health care utilization of the child												
Mean number of visits to any PCP (SD)	14.2 (7.6)	15.2 (6.8)	12.1 (5.3)	10.5 (5.0)	10.6 (5.6)	13.83 (7.3)	10.7 (5.8)	8.8 (3.6)	12.6 (6.2)	14.8 (6.8)	13.7 (6.4)	12.1 (5.6)
Mean number of emergency department visits (SD)	2.6 (2.4)	2.5 (2.2)	2.8 (2.5)	3.1 (2.7)	2.5 (2.3)	2.5 (2.3)	2.7 (2.4)	2.7 (2.1)	2.3 (2.0)	2.2 (1.8)	2.4 (2.1)	3.4 (3.5)
Mean number of low acuity emergency department visits (SD)	2.0 (2.0)	1.8 (1.7)	2.0 (1.9)	2.2 (2.)	2.0 (1.7)	1.9 (1.8)	2.0 (1.8)	1.9 (1.2)	1.6 (1.2)	1.5 (1.0)	1.6 (1.3)	2.9 (3.2)
No enhanced 18-month well-baby visit[c]	6366 (58.5)	22066 (51.5)	18749 (35.7)	53 (36.6)	22617 (47.4)	2965 (55.7)	2788 (51.4)	18 (46.1)	9081 (30.2)	4652 (25.2)	2692 (25.7)	14 (27.4)

[a] Outcomes measured between 42 and 730 days following index birth date.

[b] Composite CVD outcome: Any coronary artery, cerebrovascular, peripheral arterial disease, cardiac dysrhythmia or heart failure

[c] For infants born 2010 and later as this visit/fee code was not introduced until 2009

SD, standard deviation; IQR, interquartile range; PCP, primary care provider

Small cell sizes ≤5 merged with next smallest group to prevent back-calculation of small cell sizes, as per institutional policy.

Appendix to: Saunders NR, Ray JG, Diong C, et al. Primary care of mothers and infants by the same or different physicians: a population-based cohort study. *CMAJ* 2020. DOI:10.1503/cmaj.191038.

Table A1-8: Outcomes of the study cohort according to the primary care provider of the mother her child using sensitive definition of primary care provider.[a] All data are presented as a number (%) unless otherwise indicated

	Concordant: Mother and infant have the same family physician (N = 300 012)	Discordant: Mother and infant each have different family physicians (N = 79 094)	Pediatrician: Mother has a family physician and child has a Pediatrician (N = 102 615)
Outcomes of the mother			
Non-maternity hospitalization	15 015 (5.0)	3454 (4.4)	4106 (4.0)
Death	91 (0.030)	27 (0.034)	24 (0.023)
Composite cardiovascular outcome[b]	138 (0.046)	22 (0.028)	29 (0.028)
Hospitalization for mental illness	1274 (0.4)	339 (0.4)	288 (0.3)
Emergency department visit for mental illness	4482 (1.5)	1115 (1.4)	1035 (1.0)
Health care utilization of the mother			
Mean number of visits to any PCP (SD)	8.4 (6.4)	3.8 (4.4)	7.2 (6.2)
Mean number of mental health visits to PCP (SD)	2.7 (3.9)	2.5 (5.6)	2.6 (4.3)
Mean number of emergency department visits (SD)	2.2 (2.3)	2.2 (2.4)	1.9 (2.1)
Mean number of low acuity emergency department visits (SD)	1.7 (1.6)	1.8 (1.9)	1.5 (1.3)
Outcomes of the child			
Hospitalization	21 885 (7.3)	4458 (5.6)	7532 (7.3)
Death	153 (0.051)	68 (0.086)	66 (0.064)
Health care utilization of the child			
Mean number of visits to any PCP (SD)	14.2 (6.7)	9.8 (5.2)	12.3 (6.0)
Mean number of emergency department visits (SD)	2.6 (2.4)	2.5 (2.2)	2.2 (1.8)
Mean number of low acuity emergency department visits (SD)	1.9 (1.8)	2.0 (1.8)	1.5 (1.1)
No enhanced 18-month well-baby visit[c]	54 774 (40.9)	21 168 (50.5)	13 027 (27.2)

[a] Outcomes measured between 42 and 730 days following index birth date.

[b] Composite CVD outcome: Any coronary artery, cerebrovascular, peripheral arterial disease, cardiac dysrhythmia or heart failure

[c] For infants born 2010 and later as this visit/fee code was not introduced until 2009

SD, standard deviation; IQR, interquartile range; PCP, primary care provider

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Table A1-9: Child outcomes, univariate analysis and regression models by specific and sensitive definitions of primary care concordance stratified by healthy children and children with complex chronic conditions or prematurity. [a]

		Unadjusted Specific Definition	Multivariable Adjusted Specific Definition	Unadjusted Sensitive Definition	Multivariable Adjusted Sensitive Definition
Outcomes of healthy children					
		OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Child hospitalization	Concordant	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)
	Discordant (2 FP)	0.90 (0.87, 0.93)	0.92 (0.89, 0.96)	0.77 (0.74, 0.80)	0.78 (0.75, 0.81)
	Pediatrician (Peds + FP)	1.07 (1.04, 1.10)	1.14 (1.10, 1.18)	0.92 (0.89, 0.95)	0.98 (0.94, 1.01)
Child death	Concordant	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)
	Discordant (2 FP)	1.32 (0.91, 1.91)	1.98 (1.24, 3.15)	1.54 (1.04, 2.27)	2.32 (1.44, 3.74)
	Pediatrician (Peds + FP)	0.86 (0.57, 1.31)	1.45 (0.92, 2.28)	0.81 (0.52, 1.28)	1.34 (0.83, 2.16)
No enhanced 18-month well-baby visit[b]	Concordant	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)
	Discordant (2 FP)	1.31 (1.28, 1.34)	1.06 (1.03, 1.09)	1.45 (1.42, 1.48)	1.25 (1.21, 1.28)
	Pediatrician (Peds + FP)	0.53 (0.52, 0.54)	0.47 (0.46, 0.49)	0.53 (0.51, 0.54)	0.51 (0.50, 0.52)
Outcomes of children with complex chronic conditions and/or prematurity					
Child hospitalization	Concordant	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)
	Discordant (2 FP)	0.86 (0.80, 0.93)	0.86 (0.79, 0.94)	0.70 (0.65, 0.76)	0.69 (0.63, 0.76)
	Pediatrician (Peds + FP)	1.45 (1.37, 1.54)	1.41 (1.32, 1.50)	1.19 (1.13, 1.26)	1.15 (1.07, 1.22)
Child death[c]	Concordant	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)
	Discordant (2 FP)	1.90 (1.21, 2.98)	1.80 (1.14, 2.83)	1.85 (1.21, 2.83)	1.85 (1.20, 2.86)
	Pediatrician (Peds + FP)	2.05 (1.37, 3.06)	1.72 (1.14, 2.60)	1.46 (0.99, 2.16)	1.27 (0.85, 1.90)
No enhanced 18-month well-baby visit[b]	Concordant	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)	Ref. (1.00)
	Discordant (2 FP)	1.51 (1.41, 1.62)	1.29 (1.18, 1.40)	1.73 (1.61, 1.86)	1.50 (1.38, 1.63)
	Pediatrician (Peds + FP)	0.64 (0.60, 0.68)	0.61 (0.56, 0.65)	0.63 (0.60, 0.68)	0.63 (0.59, 0.67)

[a] Outcomes measured between 42 and 730 days following index birth date.

[b] For infants born 2010 and later as this visit/fee code was not introduced until 2009

Multivariable models adjusted for: maternal age, neighbourhood income quintile, rurality, immigrant status, number of comorbidities in mother, mental health hospitalization, primary care model, gestational age at birth, infant birth hospitalization length of stay, birth weight, presence of complex chronic condition

[c] Multivariable model included all above covariates except maternal primary care remuneration model as model would not converge with this variable included in model.

Peds, Pediatrician; FP, family physician; OR, Odds Ratio; CI, Confidence Interval

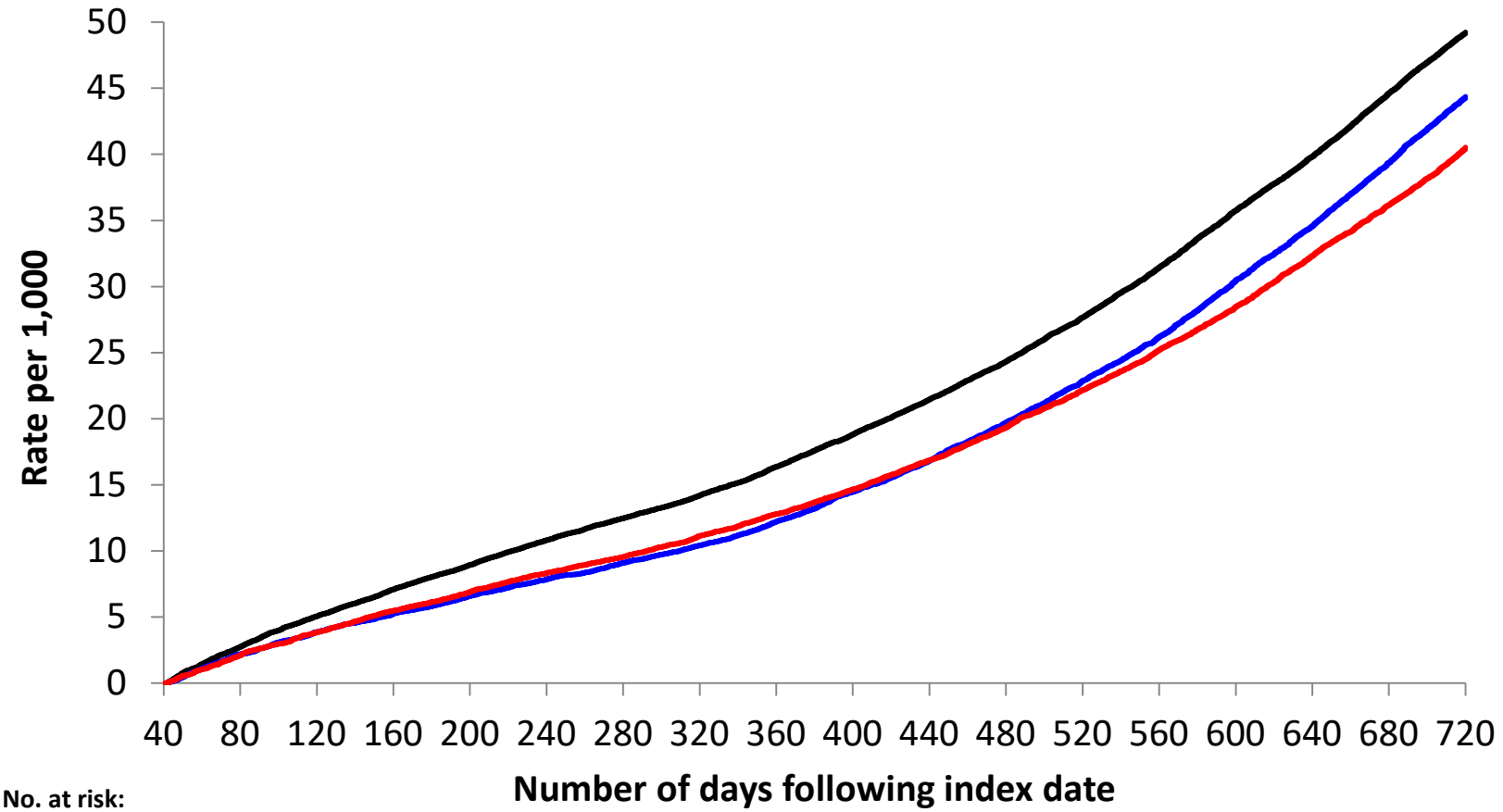
Table A1-10: Outcomes of the children in the study cohort using sensitive definition of primary care provider according to the primary care provider of the mother and of her child stratified by healthy children and children with complex chronic conditions or prematurity.[a] All data are presented as a number (%) unless otherwise indicated.

	Concordant: Mother and infant have the same family physician	**Discordant: Mother and infant each have different family physicians**	**Pediatrician: Mother has a family physician and child has a Pediatrician**
Healthy Children (no complex chronic condition or prematurity)	**N = 272 574**	**N = 71 658**	**N = 90 295**
Hospitalization	17 974 (6.6)	3682 (5.1)	5493 (6.1)
Death	89 (0.033)	36 (0.050)	24 (0.027)
No enhanced 18-month well-baby visit[c]	49 427 (40.8)	18 979 (50.0)	11 088 (26.6)
Children with complex chronic condition or prematurity	**N = 27 438**	**N = 7436**	**N = 12 320**
Hospitalization	3911 (14.3)	776 (10.4)	2039 (16.6)
Death	64 (0.233)	32 (0.430)	42 (0.341)
No enhanced 18-month well-baby visit[c]	5347 (41.6)	2189 (55.2)	1939 (31.1)

[a] Outcomes measured between 42 and 730 days following index birth date.

[c] For infants born 2010 and later as this visit/fee code was not introduced until 2009

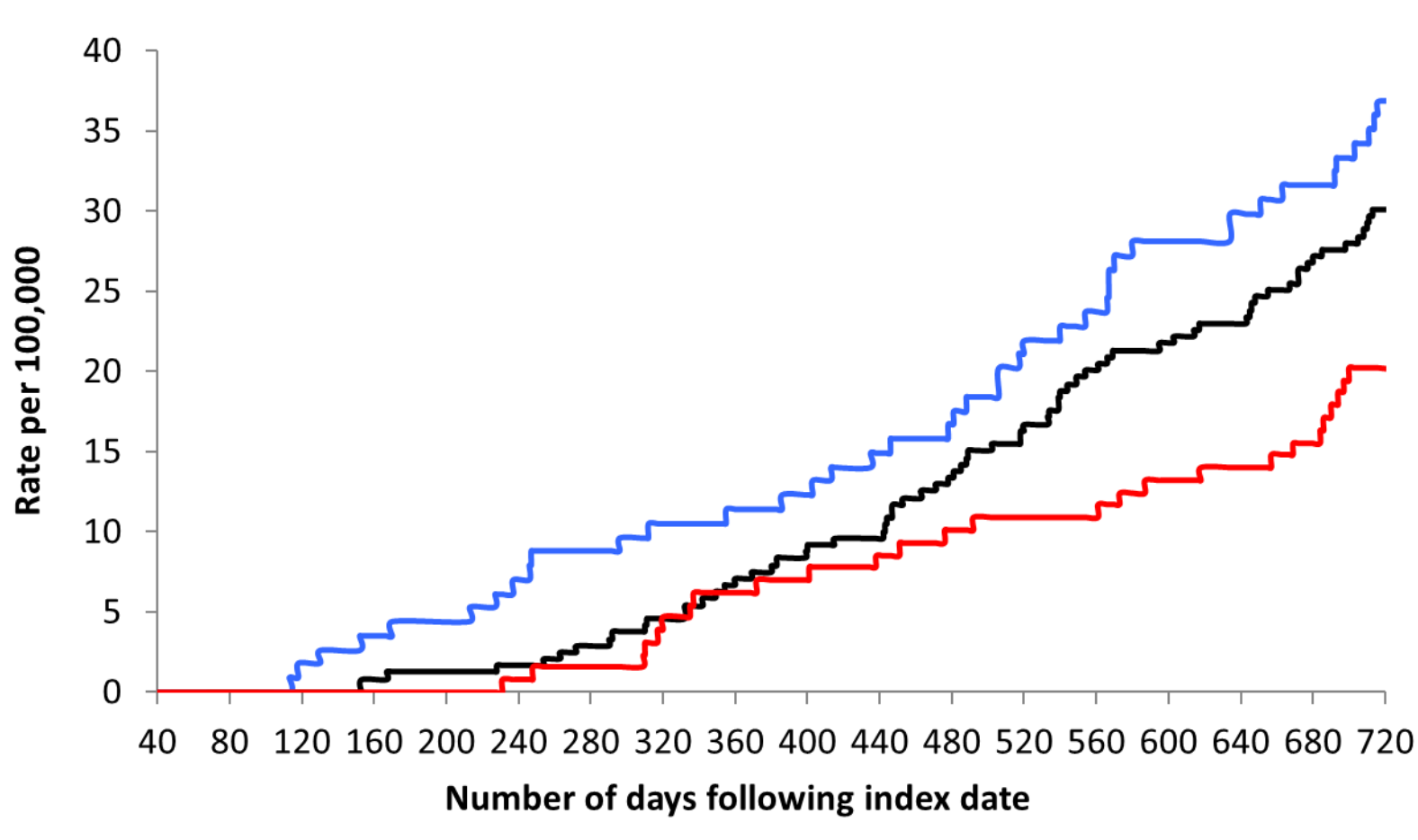
Figure A1-2A. Non-obstetrical maternal hospitalization by type of primary care model. Concordant: Mother and infant have the same family physician (FP) (upper black line); Discordant: Mother and infant have different FP (middle blue line); Pediatrician: Mother has a FP and child has a paediatrician (lower red line).



No. at risk:					
Concordant	239033	238230	236150	231965	227263
Discordant	114006	113714	113012	111214	108937
Pediatrician	128682	127895	127034	125644	123472

Appendix to: Saunders NR, Ray JG, Diong C, et al. Primary care of mothers and infants by the same or different physicians: a population-based cohort study. *CMAJ* 2020. DOI:10.1503/cmaj.191038.

Figure A1-2B. Maternal mortality by type of primary care model. Concordant: Mother and infant have the same family physician (FP) (middle black line); Discordant: Mother and infant have different FP (upper blue line); Pediatrician: Mother has a FP and child has a paediatrician (lower red line).



No. at risk:

Concordant	239033	239030	239017	238989	238961
Discordant	114006	114001	113993	113981	113964
Pediatrician	128682	128682	128674	128668	128656

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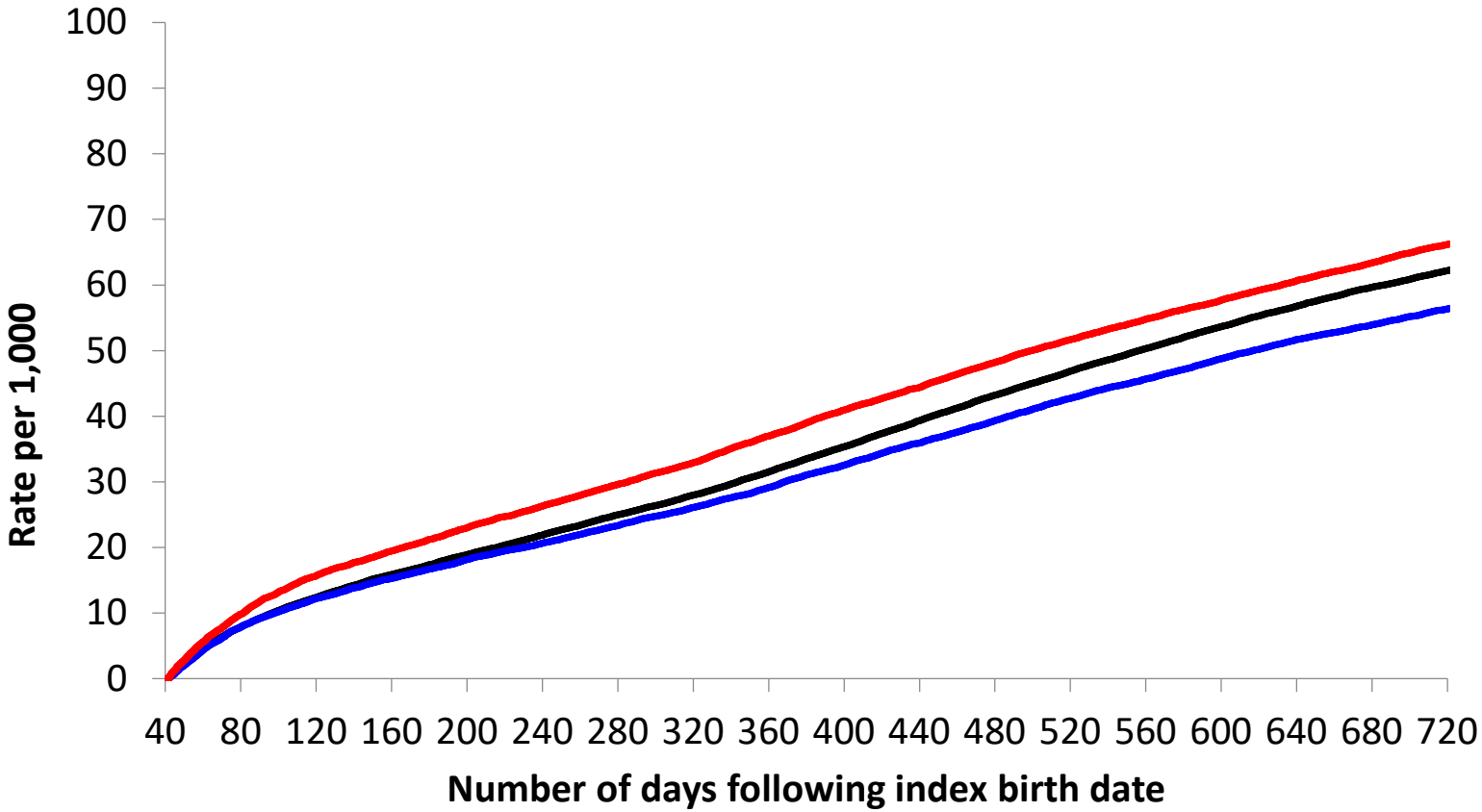
Figure A1-2C. Child hospitalization by type of primary care model. Concordant: Mother and infant have the same family physician (FP) (middle black line); Discordant: Mother and infant have different FP (lower blue line); Pediatrician: Mother has a FP and child has a paediatrician (upper red line). Included are apparently healthy children, neither born preterm nor with a complex chronic condition.

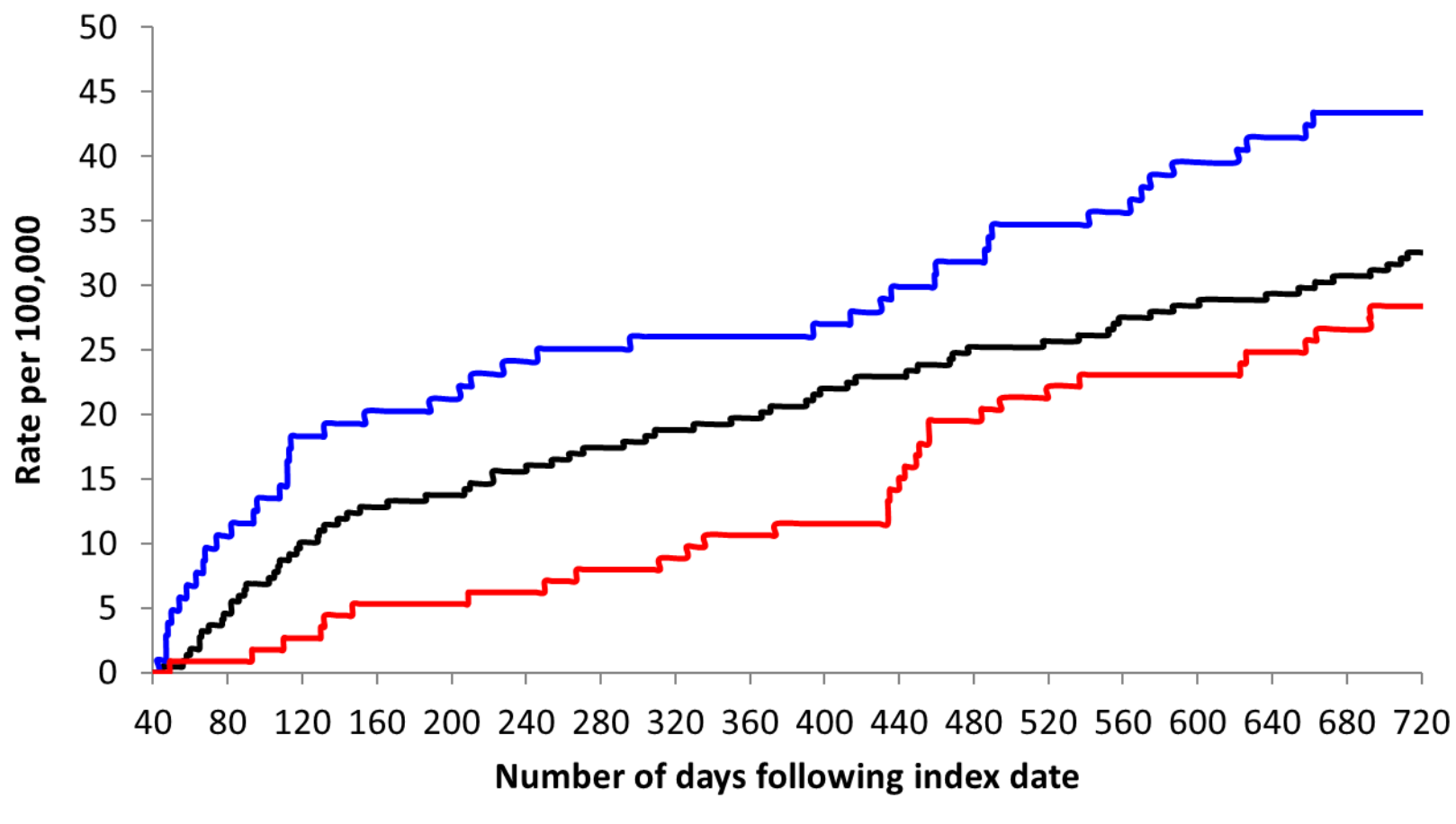


No. at risk:

Concordant	218321	214510	211418	207677	204705
Discordant	103629	101882	100593	99010	97758
Pediatrician	112577	110186	108408	106574	105116

Appendix to: Saunders NR, Ray JG, Diong C, et al. Primary care of mothers and infants by the same or different physicians: a population-based cohort study. *CMAJ* 2020. DOI:10.1503/cmaj.191038.

Figure A1-2D. Child mortality by type of primary care model. Concordant: Mother and infant have the same family physician (FP) (middle black line); Discordant: Mother and infant have different FP (upper blue line); Pediatrician: Mother has a FP and child has a paediatrician (lower red line). Included are apparently healthy children, neither born preterm nor with a complex chronic condition.



No. at risk:

Concordant	218321	218292	218278	218264	218250
Discordant	103629	103608	103602	103593	103584
Pediatrician	112577	112571	112565	112551	112545

Appendix to: Saunders NR, Ray JG, Diong C, et al. Primary care of mothers and infants by the same or different physicians: a population-based cohort study. *CMAJ* 2020. DOI:10.1503/cmaj.191038.