Pregnancy and the risk of a traffic crash

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Abstract

Introduction: Pregnancy causes diverse physiologic and lifestyle changes that may contribute to increased driving and driving error. We compared the risk of a serious motor vehicle crash during the second trimester to the baseline risk before pregnancy.

Methods: We conducted a population-based self-matched longitudinal cohort analysis of women who gave birth in Ontario between April 1, 2006, and March 31, 2011. We excluded women less than age 18 years, those living outside Ontario, those who lacked a valid health-card identifier under universal insurance, and those under the care of a midwife. The primary outcome was a motor vehicle crash resulting in a visit to an emergency department.

Results: A total of 507 262 women gave birth during the study period. These women accounted for 6922 motor vehicle crashes as drivers during the 3-year baseline interval (177 per mo) and 757 motor vehicle crashes as drivers during the second trimester (252 per mo), equivalent to a 42% relative increase (95% confidence interval 32%–53%; $p < 0.001$). The increased risk extended to diverse populations, varied obstetrical cases and different crash characteristics. The increased risk was largest in the early second trimester and compensated for by the third trimester. No similar increase was observed in crashes as passengers or pedestrians, cases of intentional injury or inadvertent falls, or self-reported risky behaviours.

Interpretation: Pregnancy is associated with a substantial risk of a serious motor vehicle crash during the second trimester. This risk merits attention for prenatal care.

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Motor vehicle crashes are the leading cause of fetal death related to maternal trauma.[1-4] The outcomes for survivors are also concerning, given that brain injury in early life can contribute to neurologic deficits in later life.[5] Emergency care of an injured pregnant woman is further problematic because the physiologic changes of pregnancy can mask the usual signs of acute blood loss (e.g., tachycardia, hypotension), resuscitation science is incomplete (e.g., clinical trials usually exclude pregnant women) and trauma protocols need adjustment (e.g., iodine contrast radiography can potentially harm a fetus).[4,5] Even rudimentary care such as analgesia can be complicated when a pregnant woman is involved.[6] Every crash creates worry and potential future litigation that might have been avoided if the crash had been prevented.[7,8]

Motor vehicle crashes occur when human error aligns with system failures.[9,10] In the United States, the net effect is about 15 million crashes annually, resulting in about 2.5 million individuals sent to hospital with fractures, concussions, ruptured vessels, organ lacerations, soft tissue damage or other injuries.[11] The specific details of common human errors are not well understood; in contrast, life-threatening defects in the vehicle or roadway are relatively blatant and infrequent.[12] One pattern of human error is that people are overly confident, misjudge their abilities and fail to take protective actions.[13] The shared nature of many motor vehicle crashes also makes it easy to blame the other person involved and fail to learn from past experience.[14]

We questioned whether pregnancy might interact with human error and increase the risk of a serious motor vehicle crash. Intermittent nausea, general fatigue, unintended distraction and sleep disruption are common features of a normal pregnancy that sometimes underlie human error.[15-17] Important physiologic changes related to pregnancy can occur before overt changes in anatomy are apparent.[18] Hence, the intermediate stages of pregnancy provide a potential interval of overconfidence when a person could be compromised yet still active.[19] The aim of our study was to examine the risk of a serious motor vehicle crash during pregnancy with special attention to the first, second and third trimesters separately.

Methods

Study population

We identified women (aged ≥ 18 yr) who gave birth between April 1, 2006, and March 31, 2011, by screening validated medical billing codes for a vaginal or cesarean delivery in Ontario (codes P006, P020, P018).[20–25] We followed each woman for 5 years (4 yr before delivery and 1 yr after delivery) representing all data available (Appendix 1, available at www.cmaj.ca/lookup'/suppl /doi:10.1503/cmaj.131650/-/DC1). We excluded women who lived outside Ontario, those who lacked a valid health-card identifier, and those under the care of a midwife (data unavailable). Women with more than 1 delivery during the study period were analyzed according to first delivery (hence, primiparous women outnumber multiparous women).[26]

This study was approved by the ethics board of Sunnybrook Health Sciences Centre and was granted a waiver of individual consent.

Research design

We used an analytic design in which each woman served as her own control for the risk of a motor vehicle crash associated with driving.[27] Similar to case-crossover analyses, self-matching designs remove confounding due to genetics, personality, education and other stable characteristics (measured or unmeasured).[28] Similar to time-series analyses, an extended observational interval before and after pregnancy addresses regression-to-the-mean, reverse-causality and temporal confounders.[29] Throughout the design, we directed special attention to the 9 months before delivery to define the trimesters of pregnancy, and we defined 1 month as exactly 28 days to ensure identical durations and weekend counts in all comparisons. We dated pregnancies relative to delivery, not last menstrual period, and noted the duration of pregnancy (preterm, at-term, or post-term delivery).

In further analyses, we evaluated robustness, additional outcomes, and potential measurement bias. The first set of analyses examined emergency department visits for women involved in a motor vehicle crash as a pedestrian or passenger. The second set of analyses examined emergency department visits related to inadvertent falls (selected as a diagnosis that was frequent in the community, recorded in databases, clinically important and potentially adversely affected by pregnancy). The third set of analyses examined emergency department visits related to poisoning, burns, deliberate self-harm and assault (including domestic violence).[30] The final set examined emergency department visits related to venous thrombosis (potentially increased during pregnancy) and depression (potentially decreased during pregnancy).

Data sources

Our primary outcome was a serious motor vehicle crash, defined as a crash that resulted in a visit to the emergency department of any hospital in Ontario. We identified traffic emergencies characterized as a crash using the International Classification of Diseases codes (V20–V69).[31] These included suffix digits for individuals involved as a driver and excluded emergencies where the woman was a passenger or pedestrian. In our secondary analyses, we examined the excluded emergencies, as well as time (clock-time, weekday, season), vehicle (car, miscellaneous), crash configuration (single or multiple vehicles) and preliminary severity (ambulance arrival, triage urgency). These methods have been validated in past research.[32–35]

Data on age, socioeconomic status and home location (urban or rural) were obtained from the demographic registry.[36] Past hospital admissions, emergency department visits and outpatient encounters were ascertained for the year before delivery based on linked identifiers. Obstetrical data were obtained in a similar manner from perinatal health records for pregnancy duration, mode of delivery, multiple gestations, maternal complications, chorioamniotic complications, fetal malposition and congenital fetal abnormality (coded as present or not). The distinction between primiparity and multiparity was based on birth records from the previous 20 years. The databases did not contain driving history, roadway infractions, chosen destinations, licence status, travel diaries, vehicle distances, injury severity or impact velocity.

We explored aspects of lifestyle by linking individuals to the Canadian Community Health Survey (CCHS; 2007–2008 cycle), a household survey that collects Canada-wide data on health determinants.[37] The survey included about 20 000 adult respondents each year in Ontario from interviews lasting 40–45 minutes. Responses for the subgroup of women in our study who completed the CCHS survey were analyzed for 3 questions related to risky behaviour (self-reported smoking, alcohol use, gambling). We also analyzed 1 question to test for a change where a change was anticipated (self-reported pregnancy) and 1 question to test for no change where no change was anticipated (self-reported country of birth). All analyses linked the CCHS survey date to the newborn delivery date to examine the distribution of responses relative to pregnancy.

Statistical analysis

We evaluated emergency department visits for drivers involved in motor vehicle crashes and compared each woman's risk during pregnancy to her baseline risk using an adapted McNemar test (Appendix 1).[38] Our primary analysis focused on the second trimester of pregnancy, selected as the interval with unequivocal physiologic changes yet uncertain behavioural changes.[39] We further divided time into consecutive segments of 28 days to provide identical intervals for all comparisons (hereafter termed "month"). Our primary prespecified subgroup analyses separated primiparous from multiparous women to distinguish different amounts of experience. We also examined all other characteristics in subgroup analysis to check robustness.

Results

Population characteristics

A total of 507 262 women gave birth during the study period. Of these, about two-thirds were identified as primiparous and one-third as multiparous (Table 1). Multiparous women were more likely than primiparous women to have an older age, a standard duration of pregnancy, a course with no obstetrical complications and a hospital stay of 2 or fewer days.

Crash rate during pregnancy

The time profile of motor vehicle crashes showed a distinct pattern related to pregnancy (Figure 1). The first month of the first trimester accounted for 169 crashes, equal to a crash rate of 4.33 events per 1000 individuals annually; this rate was not significantly different than the baseline rate. The first month of the second trimester accounted for 299 crashes, equal to a crash rate of 7.66 events per 1000 individuals annually; this was the most hazardous month. The last month of the third trimester accounted for 107 crashes, equal to a crash rate of 2.74 events per 1000 individuals annually; this was the least hazardous month. The 1-year period following delivery accounted for 1192 crashes, equal to a crash rate of 2.35 events per 1000 individuals annually; this was the least hazardous year during the study period. Relatively few women ($n = 456$, $< 0.1\%$) had more than 1 crash during their 5-year observation interval.

During the 3-year baseline interval before pregnancy, the women in the cohort accounted for a total of 6922 crashes as drivers (177 crashes/mo). This crash rate was equal to about 4.55 events per 1000 individuals annually and was about double the population average (in accordance with the large number of young drivers included; population average: about 2 crashes per 1000 drivers annually). Pregnant

Table 1: Characteristics of the 507 262 women* who gave birth in Ontario from April 1, 2006, to March 31, 2011

Characteristic	Primiparous women, % $n = 320\,094$	Multiparous women, % $n = 187\,168$
Age, yr		
18–25	22	9
25–29	31	24
30–34	30	37
35–39	14	24
≥ 40	3	5
Socioeconomic status		
Highest	15	17
Next to highest	20	21
Middle	20	21
Next to lowest	21	20
Lowest	23	22
Home location		
Urban	91	89
Rural	9	11
Prenatal care		
≥ 13 clinic visits	89	91
≥ 1 emergency department visits	33	33
≥ 1 hospital admissions	39	24
Pregnancy duration		
Preterm	7	6
At-term	79	85
Post-term	14	9
Delivery mode		
Vaginal	69	72
Cesarean	31	28
Perinatal complications		
Multiple gestations†	2	1
Fetal malposition‡	7	5
Perinatal obstetrical§	56	39
Miscellaneous amniotic¶	16	9
Potential fetal abnormality**	6	5
Duration of hospital stay, d		
≤ 2	55	72
≥ 3	45	28
Infant sex††		
Girl	46	46
Boy	49	48

*Grouped by first presentation (no repeats in subsequent multipara group).
†Includes twins and higher multiples (codes Z372, Z375).
‡Includes malpresentation (code O32).
§Inadequate contractions, obstructed labour, umbilical cord complicated, major perineal trauma, intrapartum hemorrhage, postpartum hemorrhage (codes O62–O75, except O70).
¶Polyhydramnios, oligohydramnios, premature rupture of membranes, amniotic cavity infection (codes O40–O42).
**Growth restriction, stillbirth, miscellaneous abnormality of fetus (codes O35–O37).
††Unlisted for 5 infants in the primapara group and 6 in the multipara group.

women also accounted for a total of 757 road crashes as drivers during the second trimester of pregnancy (252 crashes/mo). This crash rate was equal to 6.47 events per 1000 individuals annually and was triple the population average. The observed difference between the baseline crash rate and the second trimester crash rate equaled a 42% relative increase in risk (95% confidence interval 32%–53%, $p < 0.001$). Estimates accounting for baseline trends yielded slightly larger results (Appendix 1).

Individual characteristics

The relative increase in crashes during the second trimester extended to women with diverse characteristics. The increased risk was evident regardless of socioeconomic status, age or whether the woman had a standard duration of pregnancy (Table 2). The relative risk was higher among women who lived in urban areas than in rural areas. The increase in relative risk was slightly larger for multiparous women than for primiparous women and was the same for vaginal or cesarean delivery. The increased risk was independent of obstetrical complications and was unrelated to the sex of the newborn. Each subgroup had an absolute crash risk during the second trimester that was more than twice the general population average.

Crash characteristics

The relative increase in crashes was consistent for events with diverse characteristics. The increase was evident for crashes during different times of the year, week, and day (Table 3). The increase was almost fully explained by multiple-vehicle crashes in which the woman had been driving a car (not a truck or other miscellaneous vehicle) and had a high triage urgency. The increase was observed regardless of whether the woman arrived by ambulance. No subtype of crash had a significant contrary finding. All analyses with at least 4000 total events showed a significant increase, and single-vehicle crashes were uncommon. The relative risk was distinctly high in the morning (4 am to 11:59 am), and the absolute risk was distinctly high in the afternoon (12 pm to 7:59 pm).

Additional outcomes

The magnitude of increased risk did not extend to emergencies in which the woman was not the driver (Table 4). Crashes in which women were pedestrians equaled 0.54 events per 1000 individuals annually during the baseline period and 0.36 events per 1000 individuals annually during the second trimester, indicating no increase in risk. Crashes in which women were passengers equaled 3.42 events per 1000 individuals annually during the baseline period and 4.01 events

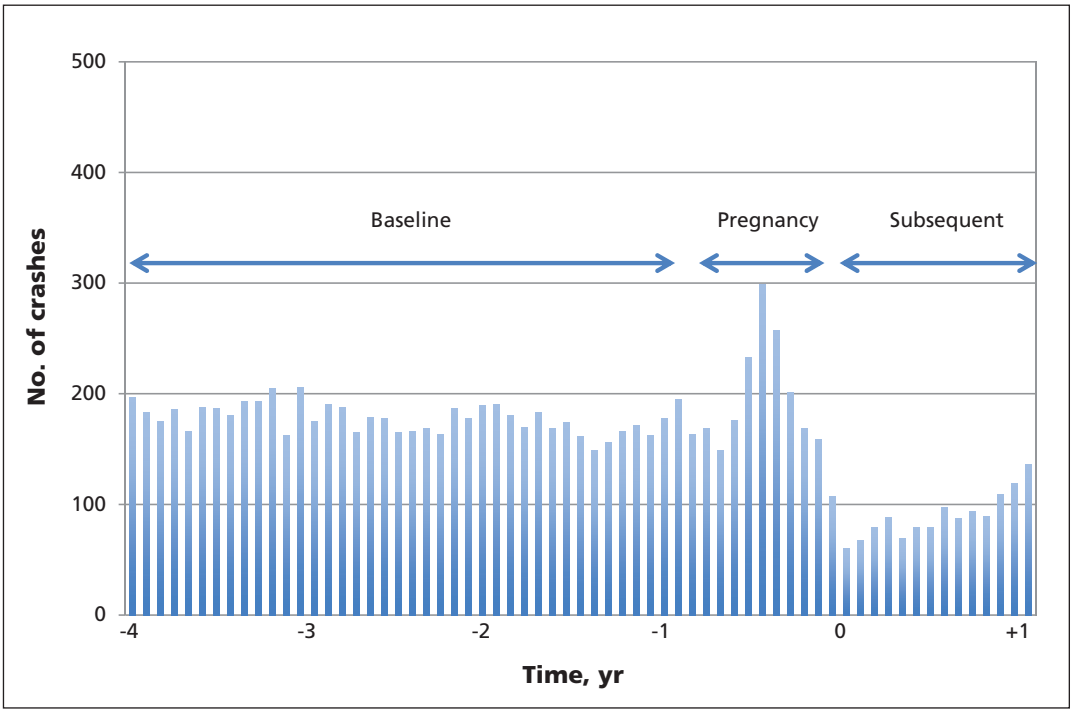

Figure 1: Bar graph showing the number of road crashes as a driver among 507 262 women followed over 5 years. Each bar represents a 28-day period, with time-zero defined as the day of newborn delivery. Crashes include those in which the individual was a driver and resulted in an emergency department visit. Baseline represents the 3-year period before pregnancy; pregnancy was defined as the 9-month period dated before delivery. The subsequent interval was the 1-year period following delivery. Because the analysis included all data, an individual might have more than 1 crash during the 5-year period.

per 1000 individuals annually during the second trimester, indicating a marginal increase in risk. Emergencies related to inadvertent falls increased slightly during the second trimester, and emergencies related to venous thrombosis increased substantially (Table 4). Emergencies related to poisonings, burns, intentional injury, and depression decreased significantly.

Self-report survey

The increased risk of motor vehicle crash while driving was not linked to an increase in self-reported risky behaviours among women who completed the CCHS survey (n = 1177). The prevalence of self-reported smoking was 25% during the baseline period and 10% during the second trimester (Table 5). Self-reported use of alcohol and gambling both also decreased significantly. Self-reported dental visits, eye clinic visits, new health goals, and life satisfaction did not change significantly between the baseline period and the second trimester. As expected, self-reported pregnancy increased significantly and self-reported country of birth did not change significantly.

Table 2: Event rates for serious motor vehicle crashes during the baseline period and the second trimester of pregnancy, by maternal characteristic

Characteristic	Total no. of events	Event rate*†		Relative risk (95% CI)
		Baseline	Pregnancy	
Full cohort	7679	4.55	6.47	1.42 (1.32–1.53)
Age, yr				
< 30	4456	5.83	7.55	1.30 (1.17–1.44)
≥ 30	3223	3.47	5.55	1.60 (1.43–1.79)
Socioeconomic status				
Higher	2676	4.40	6.11	1.39 (1.22–1.58)
Middle	1676	4.81	7.67	1.59 (1.37–1.86)
Lower	3327	4.59	6.26	1.36 (1.22–1.53)
Home location				
Urban	6477	4.21	6.31	1.50 (1.38–1.62)
Rural	1202	7.78	7.99	1.03 (0.83–1.28)
Pregnancy duration				
Preterm	562	5.36	5.05	0.94 (0.69–1.32)
At-term	6225	4.52	6.60	1.46 (1.35–1.59)
Post-term	892	4.34	6.33	1.46 (1.18–1.82)
Delivery mode				
Vaginal	5370	4.55	6.52	1.44 (1.31–1.57)
Cesarean	2309	4.56	6.33	1.39 (1.21–1.60)
Perinatal complication				
Present	3764	4.48	6.39	1.43 (1.28–1.59)
Absent	3915	4.62	6.54	1.42 (1.28–1.58)
Duration of hospital stay, d				
≤ 2	4463	4.30	6.47	1.50 (1.37–1.66)
≥ 3	3216	4.95	6.47	1.31 (1.16–1.48)
Infant sex				
Girl	3564	4.56	6.97	1.53 (1.38–1.70)
Boy	3696	4.54	6.13	1.35 (1.21–1.51)
Maternal experience				
Primiparous	4806	4.54	6.02	1.33 (1.20–1.46)
Multiparous	2873	4.56	7.22	1.58 (1.41–1.78)

Note: CI = confidence interval.
*Event rates were calculated per 1000 individuals annually during corresponding interval. Baseline spans the 3-year period before conception; pregnancy spans 3 total months of the second trimester. One month was defined as 28 consecutive days.
†Event rate for entire population of all ages is about 2 crashes per 1000 drivers annually.

Interpretation

We found that the risk of a serious motor vehicle crash was significantly increased during the second trimester of pregnancy. This increased risk extended to diverse populations, varied obstetrical cases, and different crash characteristics. The increased risk was greatest in the early second trimester and compensated for by the third trimester. No similar increase was observed among women who were passengers or pedestrians. There was also no increase in intentional injury, inadvertent falls or self-reported risky behaviours. The absolute risk of a crash during the second trimester was similar in magnitude to the risk associated with sleep apnea.[40] These findings suggest that pregnancy might contribute to the risk of a serious motor vehicle crash.

Subjective disturbances during pregnancy are commonly reported in the obstetrical literature where absentmindedness is denoted as "baby brain" or other negative terms.[41] Community surveys suggest that about half of pregnant women complain of sporadic cognitive lapses;[42] however, laboratory studies in this setting provide results with uncertain clinical relevance.[43] The gap between popular beliefs and scientific evidence has fueled speculations about survey respondents misattributing normal memory lapses to a current pregnancy.[44,45] No past study using driving simulators or detailed neuropsy-

Table 3: Event rates for serious motor vehicle crashes during the baseline period and the second trimester of pregnancy, by crash characteristic

Characteristic	Total no. of events	Event rate*		Relative risk (95% CI)
		Baseline	Pregnancy	
Full cohort	7679	4.55	6.47	1.42 (1.32–1.53)
Season				
Spring or summer	3464	2.05	2.93	1.43 (1.28–1.60)
Autumn or winter	4215	2.50	3.54	1.42 (1.28–1.57)
Day of week				
Weekday	5807	3.42	5.09	1.49 (1.37–1.62)
Weekend	1872	1.12	1.38	1.22 (1.04–1.44)
Time of day†				
Morning	1843	1.07	1.80	1.68 (1.46–1.94)
Afternoon	4096	2.42	3.51	1.45 (1.31–1.61)
Night	1740	1.05	1.15	1.09 (0.92–1.31)
Total vehicles				
Multiple	7093	4.19	6.18	1.48 (1.37–1.60)
Single	586	0.36	0.28	0.78 (0.56–1.12)
Driver's vehicle‡				
Car	7276	4.30	6.24	1.45 (1.34–1.57)
Other	403	0.25	0.23	0.93 (0.64–1.40)
Ambulance arrival				
Yes	3497	2.06	3.06	1.48 (1.33–1.66)
No	4182	2.49	3.41	1.37 (1.24–1.52)
Triage urgency§				
Higher	4547	2.62	4.78	1.82 (1.67–1.99)
Lower	3132	1.93	1.69	0.88 (0.76–1.02)
Hospital admission				
Yes	241	0.15	0.17	1.18 (0.77–1.89)
No	7438	4.40	6.30	1.43 (1.33–1.54)

Note: CI = confidence interval.
*Calculated per 1000 individuals annually during corresponding interval. Baseline spans the 3-year period before conception; pregnancy spans 3 total months of the second trimester. One month was defined as 28 consecutive days in all analyses
†Morning is 4 am to 11:59 am, afternoon is 12 pm to 7:59 pm, night is 8 pm to 3:59 am (8 h each).
‡Other includes truck or miscellaneous vehicle.
§Higher urgency denotes resuscitation, emergency, urgency; lower urgency includes all other triage levels.

Table 4: Event rates for serious motor vehicle crashes during the baseline period and second trimester of pregnancy

Variable	Total no. of events	Event rate*		Relative risk (95% CI)
		Baseline	Pregnancy	
Motor vehicle crash				
Driver	7 679	4.55	6.47	1.42 (1.32–1.53)
Passenger	5 669	3.42	4.01	1.17 (1.07–1.29)
Pedestrian	858	0.54	0.36	0.67 (0.50–0.92)
Miscellaneous†	3 464	2.17	1.39	0.64 (0.55–0.75)
Other incidents				
Fall‡	25 653	15.54	17.16	1.10 (1.06–1.16)
Poisoning§	6 539	4.17	1.67	0.40 (0.35–0.46)
Assault¶	6 334	3.93	3.00	0.76 (0.69–0.85)
Self-harm**	3 802	2.47	0.40	0.16 (0.12–0.22)
Burn††	2 963	1.84	1.36	0.74 (0.63–0.87)
General medical				
Pre-eclampsia	361	0.18	0.75	4.19 (3.31–5.35)
Venous thrombosis	1 289	0.70	1.92	2.75 (2.39–3.18)
Depression	6 268	3.97	1.87	0.47 (0.41–0.54)

Note: CI = confidence interval.
*Calculated per 1000 women annually during corresponding interval. Baseline spans the 3-year period before conception; pregnancy spans 3 total months of the second trimester. One month was defined as 28 consecutive days in all analyses
†Includes aircraft, watercraft, bicycling, animal drawn, industrial, boarding and alighting events.
‡Includes falls from the same level or a different level (codes W00–W19).
§Includes drug overdose or toxin exposure (codes T36–T65).
¶Includes injury, maltreatment and neglect (codes X85–X99; Y00–Y09).
**Includes poisoning, suffocation, firearm or other means (codes X60–X84).
††Includes thermal, lightning, radiation and chemical (codes T20–T32).

Table 5: Prevalence of risky behaviours and health characteristics during the baseline period and the second trimester of pregnancy, as reported in the Canadian Community Health Survey

Variable	Affirmative response	Prevalence rate*		Relative odds (95% CI)
		Baseline	Pregnancy	
Risky behaviors†				
Smoking	133	25	10	0.33 (0.16–0.76)
Alcohol	227	44	4	0.06 (0.02–0.19)
Gambling	126	23	11	0.42 (0.21–0.92)
Health and wellness‡				
Dental clinic visit	402	69	76	1.42 (0.79–2.47)
Eye clinic visit	166	30	21	0.63 (0.35–1.16)
Prohibit smoking in home	471	81	92	2.61 (1.06–5.63)
New health goal	362	64	56	0.73 (0.44–1.20)
Satisfied with life	532	92	99	6.36 (0.83–22.43)
Validation questions§				
Born in Canada	459	80	82	1.15 (0.59–2.10)
Currently pregnant	76	1	97	—

Note: CI = confidence interval.
*Calculated per 100 respondents during corresponding interval. Baseline spans the 3-year period before conception; pregnancy spans 3 total months of second trimester. One month was defined as 28 consecutive days in all analyses.
†Survey questions: SMK_Q202, ALW_Q5, CPG_Q02.
‡Survey questions: HCU_Q02E, EYX_Q140, ETS_Q30, CIH_Q1, GEN_Q02E.
§Survey questions: SDC_Q1, HWT_Q1.

chological surrogates has directly tested whether driving errors might be increased during the second trimester.

Limitations

Several limitations merit note. Our study relied on a self-matching approach that is vulnerable to indirect biases; however, major imbalances were avoided because the design removed confounding from stable characteristics and because driving distance is unlikely to explain the observed magnitude of risk.[46] Pregnancy was not randomly assigned so that selection bias may persist; however, most women do not consciously time a pregnancy relative to a possible future motor vehicle crash. No objective data were available on the use of alcohol or illicit drugs, fluctuating attention, driving diaries or vehicle speed; however, pregnant women are generally prone to conservative lifestyle choices and averse to reckless activity.[47,48] We were unable to analyze data for crashes in which the driver was at fault; thus, some of the observed risk might be a reflection of an inability to avoid a crash caused by someone else.

The lack of controlled laboratory testing may lead to an underestimation of the magnitude of risk. We included only women with a newborn delivery and did not include crashes of lethal severity that resulted in fetal demise (thereby underestimating the risk of a serious motor vehicle crash during every trimester). We excluded the large number of additional crashes that resulted in property damage or minor injuries (the ratio of serious crashes to total crashes in the general population is about 1:13).[49] Our analyses focused on the driver and did not assess other people involved in the same crash. We included each woman only once (thereby undercounting multiparous pregnancies and associated crashes). Finally, we did not include women whose care was provided by a midwife, yet we have no reason to believe that these women are immune to traffic risks.

Conclusion

Our study suggests that serious motor vehicle crashes are common during the second trimester. Past studies indicate that pregnant women can have complications following a crash during any trimester.[1] These findings underscore the importance of prevention and suggest that prenatal care guidelines for pregnant women should include safe driving.[50] Motor vehicle crashes can be prevented with basic safety practices such as avoiding excessive speed, minimizing distractions, signaling turns, obeying stop signs, and always using a seatbelt.[51]

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