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Proliferation of prenatal ultrasonography

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Abstract

Background: The extent to which temporal increases in the use of prenatal ultrasonography reflect changes in maternal risk is unknown. In this population-based study, we examined the use of prenatal ultrasonography from 1996 to 2006 in Ontario.

Methods: With fiscal year 1996/97 as the baseline, we evaluated the relative risk (RR) and 95% confidence interval (CI) for the change in rates of ultrasonography for each subsequent year. The RR was adjusted for maternal age, income, rural residence, maternal comorbidities, receipt of genetics consultation or amniocentesis — all in the index pregnancy — and history of complications in a prior pregnancy.

Results: The study sample consisted of 1 399 389 singleton deliveries. The rate of prenatal ultrasonography increased from 2055 per 1000 pregnancies in 1996 to 3264 per 1000 in 2006 (adjusted RR 1.55, 95% CI 1.54–1.55). The rate increased among both women with low-risk pregnancies (adjusted RR 1.54, 95% CI 1.53–1.55) and those with high-risk pregnancies (adjusted RR 1.55, 95% CI 1.54–1.57). The proportion of pregnancies with at least four ultrasound examinations in the second or third trimesters rose from 6.4% in 1996 to 18.7% in 2006 (adjusted RR 2.68, 95% CI 2.61–2.74). Paradoxically, this increase was more pronounced among low-risk pregnancies (adjusted RR 2.92, 95% CI 2.83–3.01) than among high-risk pregnancies (adjusted RR 2.25, 95% CI 2.16–2.35).

Interpretation: Substantial increases in the use of prenatal ultrasonography over the past decade do not appear to reflect changes in maternal risk. Nearly one in five women now undergo four or more ultrasound examinations during the second and third trimesters. Efforts to promote more appropriate use of prenatal ultrasonography for singleton pregnancies appear warranted.

The rapid proliferation of diagnostic imaging is a challenge for the containment of health care expenditures and for system sustainability in many countries.[1] The ensuing debate among clinicians, researchers and policymakers has become increasingly contentious and highly politicized.[2,3] In Canada, the annual operational costs for diagnostic imaging now total more than $2.2 billion.[4] Prenatal ultrasonography is one of the most rapidly proliferating imaging tests, this expansion being marked most strikingly by an increase in the proportion of women undergoing multiple prenatal examinations for a single pregnancy.[5] Although guidelines generally recommend that two ultrasound examinations be performed in a pregnancy without complications — one in the first trimester, for measurement of nuchal translucency to screen for aneuploidy, and one in the second trimester to screen for fetal anomalies — it is conceivable that the proliferation of prenatal ultrasonography reflects changes in maternal risk over time.[6–10]

In other areas of health care, interventions that are most beneficial to high-risk individuals are frequently directed to low-risk populations.[11–13] We hypothesized that increasing trends in the use of prenatal ultrasonography could not be explained solely by pregnancy risk and would be evident among low-risk pregnancies. Accordingly, we performed a population-based study to examine the annual rates of prenatal ultrasonography, adjusted for maternal risk profiles.

Methods

Study design

We conducted a repeated cross-sectional population-based study of all women with a singleton obstetric delivery during the period 1996/97 to 2006/07 in Ontario, Canada's most populous province (12 million people).

Data sources

For this study, we used two linked administrative databases. We obtained records of hospital admissions from the Canadian Institute for Health Information Discharge Abstract Database. We used these records to identify obstetric deliveries and maternal comorbidities. The anonymized discharge abstracts contained a unique encrypted identifier, the patient's age, sex, date of admission, up to 16 diagnoses from the International Classification of Diseases, 9th revision, and up to 25 diagnoses from the International Classification of Diseases,

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10th revision. Outpatient data were obtained from the database of the Ontario Health Insurance Plan, which contains billing information for physician services, including a service date and a single diagnosis. We used the Ontario Health Insurance Plan database to identify all outpatient claims for prenatal ultrasonography.[9] We also used this database to identify maternal comorbidities, because some of these conditions may be diagnosed on an outpatient basis. Neighbourhood income quintile for each patient was defined according to postal code, using census data from Statistics Canada.[14]

Participants

For the period Apr. 1, 1996, to Mar. 31, 2007, we identified all deliveries across all Ontario hospitals in each fiscal year. To do this, we used a main patient service code for obstetric delivery in the Discharge Abstract Database.[15] Participants were women with an admission to hospital for delivery of a liveborn or stillborn singleton infant after at least 20 weeks' gestation. We excluded women younger than 15 years or older than 54 years at the date of admission to hospital for delivery and women with deliveries associated with an abortive procedure. If a woman had more than one delivery in a given fiscal year, we included only the first eligible delivery. The hospital admission date was used to define the date of the index delivery.

Maternal risk profile

We classified a pregnancy as "high-risk" if it was associated with a maternal comorbidity, genetics consultation, amniocentesis or history of complications in a prior pregnancy (see Appendix 1, available at www.cmaj.ca/cgi/content/full/cmaj.090979/DC1). We deemed all other index pregnancies to be "low-risk." We considered a maternal comorbidity to be present if any of the following diagnoses could be identified in the Ontario Health Insurance Plan database or the Discharge Abstract Database within the 12 months before (and during) the hospital stay for the index delivery: any diabetes mellitus (gestational or prepregnancy), any hypertension, thyroid disease, cardiac disease, rheumatologic disease, venous thromboembolism, renal disease or epilepsy; we also considered hospital admission for supervision of a high-risk pregnancy to represent maternal comorbidity. Similarly, we used the Ontario Health Insurance Plan database to identify claims for genetics consultation and amniocentesis during the 12 months before (and during) the hospital stay for the index delivery. Finally, we defined a history of a prior pregnancy with complications as any pregnancy in the preceding five years that had been associated with stillbirth or with a genetics consultation, amniocentesis or hospital admission for supervision of a high-risk pregnancy during the 12 months before delivery.

Prenatal ultrasonography

The main study outcome was the annual rate of utilization of prenatal ultrasonography. For each woman's index delivery in a given fiscal year, we considered all prenatal ultrasonography examinations performed during the 40-week period before her delivery date. We ascribed each examination to the fiscal year during which she delivered. Ultrasound examinations performed on an inpatient basis are not captured by the Ontario Health Insurance Plan database.

We classified prenatal ultrasound examinations according to estimated gestational age at the time of the procedure: first trimester (0 to 14 weeks), second trimester (15 to 27 weeks) or third trimester (28 to 40 weeks). We estimated gestational age at the time of ultrasonography by calculating the number of days between the date of the ultrasound examination and the delivery date and assuming that the delivery occurred at 40 weeks' gestation. For example, if a woman delivered on Aug. 30, 2004, and had undergone ultrasonography on Aug. 10, 2004 (20 days before), the examination would be categorized as having taken place during the third trimester. This approach has a reported sensitivity of 90% and specificity of 99%.[16]

Data analysis

For each fiscal year, we computed the rate of prenatal ultrasonography by dividing the number of examinations attributed to that fiscal year by the corresponding number of in-hospital singleton deliveries. We used Poisson regression to estimate the crude increase in the rate of prenatal ultrasonography within each fiscal year, relative to 1996, expressed as a relative risk (RR) and 95% confidence interval (CI). In a multivariate model, we then adjusted for maternal age, neighbourhood income quintile, rural place of residence, any diabetes mellitus (gestational or prepregnancy), any hypertension, any other maternal comorbidity (i.e., one or more of thyroid disease, cardiac disease, rheumatologic disease, venous thromboembolism, renal disease, epilepsy or admission to hospital for supervision of high-risk pregnancy), a genetics consultation and amniocentesis — all in the index pregnancy — as well as history of a prior pregnancy with complications, as defined above. We then restricted these multivariate analyses to women with a low-risk pregnancy, as well as to ultrasonography examinations performed in the second or third trimesters (to lessen the effect of a high uptake of first-trimester ultrasonography for measurement of nuchal translucency in recent years).[17]

In secondary analyses, we used the same multivariate model to generate the RR for undergoing prenatal ultrasonography in 2006 relative to 1996, stratified by maternal age at delivery, neighbourhood income quintile, place of residence (urban v. rural), any maternal diabetes mellitus (yes v. no) and any maternal hypertension (yes v. no). To evaluate whether the number of ultrasound examinations performed during pregnancy changed over time, we categorized all index pregnancies in 1996 into approximate quartiles, according to the number of second- and third-trimester ultrasound examinations per pregnancy. First-trimester examinations were excluded from this particular analysis to remove the potential effect of the recent introduction of first-trimester ultrasound testing for nuchal translucency. We used the same regression models as above to estimate the adjusted RR for the proportion of women receiving the fixed categorized number of ultrasound examinations in each year relative to 1996, both for the entire cohort and stratified by low-risk versus high-risk status.

Table 1: Characteristics of singleton pregnancies in Ontario, 1996 to 2006, *n* = 1 399 389

Characteristic	Fiscal year; no. (%) of singleton deliveries*										
	1996 *131 746*	1997 *128 976*	1998 *126 841*	1999 *126 078*	2000 *122 019*	2001 *126 062*	2002 *123 502*	2003 *127 086*	2004 *127 610*	2005 *128 721*	2006 *130 748*
Maternal age, yr, mean (SD)	28.9 (5.4)	29.1 (5.5)	29.1 (5.5)	29.2 (5.5)	29.3 (5.6)	29.5 (5.5)	29.6 (5.5)	29.7 (5.5)	29.7 (5.5)	29.8 (5.5)	29.8 (5.5)
15–19	6 990 (5.3)	6 577 (5.1)	6 621 (5.2)	6 010 (4.8)	5 730 (4.7)	5 519 (4.4)	5 233 (4.2)	5 148 (4.1)	4 808 (3.8)	4 834 (3.8)	5 029 (3.8)
20–24	20 683 (15.7)	20 038 (15.5)	19 990 (15.8)	19 465 (15.4)	18 762 (15.4)	18 562 (14.7)	17 959 (14.5)	17 900 (14.1)	17 861 (14.0)	17 903 (13.9)	18 480 (14.1)
25–29	40 814 (31.0)	39 576 (30.7)	38 150 (30.1)	37 795 (30.0)	35 824 (29.4)	36 829 (29.2)	35 674 (28.9)	36 675 (28.9)	36 836 (28.9)	36 796 (28.6)	36 684 (28.1)
30–34	43 346 (32.9)	42 247 (32.8)	40 707 (32.1)	40 608 (32.2)	39 271 (32.2)	41 677 (33.1)	41 188 (33.4)	42 744 (33.6)	43 201 (33.9)	43 459 (33.8)	43 874 (33.6)
35–54	19 913 (15.1)	20 538 (15.9)	21 373 (16.9)	22 200 (17.6)	22 432 (18.4)	23 475 (18.6)	23 448 (19.0)	24 619 (19.4)	24 904 (19.5)	25 729 (20.0)	26 681 (20.4)
Income quintile†											
Q1 (lowest)	29 414 (22.3)	28 376 (22.0)	28 355 (22.4)	28 492 (22.6)	27 558 (22.6)	27 491 (21.8)	26 340 (21.3)	26 341 (20.7)	26 078 (20.4)	25 995 (20.2)	26 040 (19.9)
Q2	27 744 (21.1)	26 978 (20.9)	26 040 (20.5)	25 659 (20.4)	24 495 (20.1)	24 986 (19.8)	23 934 (19.4)	24 477 (19.3)	23 966 (18.8)	24 249 (18.8)	24 564 (18.8)
Q3	26 413 (20.0)	25 542 (19.8)	25 262 (19.9)	24 704 (19.6)	24 045 (19.7)	24 732 (19.6)	24 083 (19.5)	24 725 (19.5)	24 571 (19.3)	24 522 (19.1)	24 935 (19.1)
Q4	26 247 (19.9)	26 191 (20.3)	25 213 (19.9)	23 807 (18.9)	23 150 (19.0)	25 045 (19.9)	25 243 (20.4)	26 137 (20.6)	26 928 (21.1)	27 208 (21.1)	27 799 (21.3)
Q5 (highest)	21 133 (16.0)	21 196 (16.4)	20 765 (16.4)	20 400 (16.2)	19 841 (16.3)	20 798 (16.5)	20 766 (16.8)	22 048 (17.3)	22 498 (17.6)	23 197 (18.0)	23 664 (18.1)
Rural place of residence	17 565 (13.3)	16 810 (13.0)	16 072 (12.7)	14 756 (11.7)	14 094 (11.6)	14 315 (11.4)	13 792 (11.2)	14 143 (11.1)	13 929 (10.9)	13 813 (10.7)	14 167 (10.8)
Maternal comorbidities											
Any hypertension	5 691 (4.3)	5 994 (4.6)	5 592 (4.4)	5 601 (4.4)	5 598 (4.6)	5 486 (4.4)	5 743 (4.7)	6 035 (4.7)	6 210 (4.9)	6 305 (4.9)	6 189 (4.7)
Any diabetes mellitus	6 688 (5.1)	6 410 (5.0)	6 331 (5.0)	6 267 (5.0)	6 433 (5.3)	7 241 (5.7)	7 495 (6.1)	7 750 (6.1)	8 685 (6.8)	8 875 (6.9)	9 596 (7.3)
Other comorbidity‡	4 169 (3.2)	3 991 (3.1)	3 998 (3.2)	4 343 (3.4)	4 161 (3.4)	4 449 (3.5)	4 038 (3.3)	4 313 (3.4)	4 001 (3.1)	4 069 (3.2)	4 202 (3.2)
Genetics consultation	564 (0.4)	698 (0.5)	758 (0.6)	884 (0.7)	907 (0.7)	969 (0.8)	914 (0.7)	920 (0.7)	944 (0.7)	953 (0.7)	876 (0.7)
Amniocentesis	1 488 (1.1)	1 682 (1.3)	1 861 (1.5)	1 916 (1.5)	1 852 (1.5)	1 868 (1.5)	1783 (1.4)	1 723 (1.4)	1 638 (1.3)	1 592 (1.2)	1 364 (1.0)
Pregnancy in prior 5 yr											
None	75 279 (57.1)	74 231 (57.6)	73 421 (57.9)	74 089 (58.8)	72 919 (59.8)	75 287 (59.7)	75 137 (60.8)	77 816 (61.2)	78 231 (61.3)	77 758 (60.4)	79 133 (60.5)
Without complications	53 466 (40.6)	51 459 (39.9)	49 792 (39.3)	48 139 (38.2)	45 071 (36.9)	46 584 (37.0)	44 379 (35.9)	45 273 (35.6)	45 338 (35.5)	46 784 (36.3)	47 556 (36.4)
With complications§	3 001 (2.3)	3 286 (2.5)	3 628 (2.9)	3 850 (3.1)	4 029 (3.3)	4 191 (3.3)	3 986 (3.2)	3 997 (3.1)	4 041 (3.2)	4 179 (3.2)	4 059 (3.1)
High-risk pregnancy¶	20 634 (15.7)	20 629 (16.0)	20 596 (16.2)	21 002 (16.7)	21 050 (17.3)	22 160 (17.6)	22 060 (17.9)	22 958 (18.1)	23 888 (18.7)	24 385 (18.9)	25 178 (19.3)

Note: Q = quintile, SD = standard deviation.
*Unless indicated otherwise.
†Income quintiles for each fiscal year do not sum to 100% because of missing data for up to 3% of patients.
‡Thyroid disease, cardiac disease, rheumatologic disease, venous thromboembolism, renal disease, epilepsy or admission to hospital for supervision of high-risk pregnancy.
§Defined as prior pregnancy associated with genetics consultation, amniocentesis, admission to hospital for supervision of high-risk pregnancy or pregnancy ending in stillbirth.
¶Defined as any hypertension, any diabetes mellitus, any other comorbidity (as defined above), genetics consultation or amniocentesis during index pregnancy or history of pregnancy with complications (as defined above).

The study was approved by the Sunnybrook Health Sciences Centre Research Ethics Board.

Results

We captured data for 1 424 767 in-hospital deliveries over the 11-year study period. A total of 25 378 deliveries were excluded because of multiple-gestation pregnancies (*n* = 22 785), a second delivery within the same fiscal year (*n* = 1628), extremes of maternal age (*n* = 665) or delivery after 20 weeks' gestation in association with an abortive procedure (*n* = 300). The final study sample was 1 399 389 singleton deliveries (Table 1).

The annual number of ultrasound examinations increased linearly over the study period (p for trend < 0.001; Figure 1). The rate rose from 2055 per 1000 pregnancies in 1996 to 3264 per 1000 in 2006, which represents a crude 11-year RR (i.e., increase in utilization) of 1.59 (95% CI 1.58–1.60) and an adjusted RR of 1.55 (95% CI 1.54–1.55) (Table 2).

The magnitude of the increase in ultrasonography rates over the 11-year study period was similar for women with low-risk pregnancies (adjusted RR 1.54, 95% CI 1.53–1.55, 2006 relative to 1996) and those with high-risk pregnancies (adjusted RR 1.55, 95% CI 1.54–1.57) (Figure 1, Table 2) and for examinations performed in the second and third trimesters (adjusted RR 1.45, 95% CI 1.44–1.46) (Figure 1). Although within-stratum interactions were statistically significant (p < 0.001), the magnitude of the adjusted RRs was comparable upon stratification by maternal characteristics (Figure 2). The relative increase in ultrasonography across the 11-year study period was evident in all trimesters, but was most pronounced for examinations performed in the first trimester (Figure 2).

In 1996, the quartiles for the number of ultrasound examinations performed in the second and third trimesters were zero or one, two, three, and four or more (Table 3). Among all women, the proportion of pregnancies with four or more fetal ultrasound examinations in the second or third trimester rose from 6.4% in 1996 to 18.7% in 2006, corresponding to an adjusted RR of 2.68 (95% CI 2.61–2.74) across the decade. This change was more pronounced among low-risk pregnancies (adjusted RR, 2.92, 95% CI 2.83–3.01) than among high-risk pregnancies (adjusted RR 2.25, 95% CI 2.16–2.35). By 2006, more than one-third (37.2%) of all women were receiving three or more ultrasound examinations during the second and third trimesters of pregnancy (Table 3).

Interpretation

In a health care system with universal access to prenatal services, we observed a 55% relative increase (adjusted) in the use of outpatient obstetric ultrasonography among singleton pregnancies over the decade from 1996/97 to 2006/07. This change was statistically significant and robust across subgroups, regardless of pregnancy risk, maternal demographic characteristics or maternal comorbidities. By 2006, over one-third of women with a singleton pregnancy were undergoing three or more outpatient ultrasound examinations during the second and third trimesters.

Our findings are consistent with a growing body of evidence suggesting that some health interventions most beneficial to high-risk individuals are frequently directed at apparently low-risk populations. This "treatment–risk paradox" has been described for statin therapy in high-risk elderly patients,[11] for pharmacotherapy in patients with congestive heart failure[12] and for temporal trends in the utilization of noninvasive cardiac testing.[13] Although the use of prenatal ultrasonography among women with low-risk pregnancies may not account for a large proportion of total expenditures for medical imaging, it serves as a test case of a rapidly proliferating diagnostic technology. As such, it is a microcosm of a much bigger phenomenon that may be occurring with many other diagnostic imaging tests and that, cumulatively, may account for billions of dollars of health care expenditures.[1,2]

Others have documented substantial regional differences in utilization of obstetric ultrasonography and evidence of inappropriate use of this technology.[5,18–20] In our study, rising utilization could not be explained solely by increases in maternal age, changes in maternal risk profiles or increases in uptake of first-trimester scanning for nuchal translucency. Hence, it would appear that nonclinical factors may largely explain the increases in prenatal ultrasonography that we observed. These factors may include the practice of defensive medicine, the desire to reassure a patient that her pregnancy is progressing normally, patient demand and even the "entertainment" value of seeing one's fetus.[21–24] Although the benefits of prenatal ultrasonography in high-risk pregnancies may be clearer, the value of repeat ultrasonography in low-risk patients is not.[25,26] Prenatal ultrasonography is widely regarded as safe.[27] However, some studies have suggested that frequent prenatal ultrasonography may be associated with intrauterine growth restriction, delayed speech and non–right-handedness.[28–31] Moreover, when a prenatal ultrasound examination is performed in a low-risk pregnancy, unintended harmful consequences may outweigh any potential benefits. For example, incidental benign findings — which are becoming increasingly prevalent with advances in technology — can cause anxiety and can lead to additional investigations, some of which may be invasive, such as amniocentesis.[32]

More than one-third of women now undergo three or more ultrasound examinations during the second and third trimesters of a singleton pregnancy, a rate that appears to be climbing for reasons unrelated to changes in maternal risk. As such, there is a need for patients, clinicians and policy-makers to carefully consider the optimal number of obstetric ultrasound examinations per pregnancy. Assuming an average cost of $64 per examination (based on the 2008 fee schedule in Ontario[33]), we estimate that the cumulative amount in fees for additional prenatal ultrasound examinations performed since 1996 was $30 million. Given the high aggregate costs of prenatal ultrasonography (because pregnancy is so common) and the evidence of potential overuse in populations not at high risk, health policy-makers could make a legitimate argument that costs be contained in groups for whom there is no documented benefit. Indeed, after the first trimester, most current guidelines recommend only a single second-trimester anatomic ultrasound examination during a pregnancy without complications.[6,7] However, obstetricians function in the highest-risk medico-legal environment, where the implicit rules governing practice may differ from those in other domains of medicine, including the need to reassure patients through safe and relatively inexpensive tests like ultrasonography.[21,22] In publicly funded health systems, citizens are key stakeholders in this debate, and efforts to engage citizens in deliberations about setting health care priorities should be encouraged.[34] Various options for optimizing the use of obstetric ultrasonography, such as preauthorization of claims and changes to the fee schedule, will require debate and will necessarily demand a balance between policy pragmatism and an honest

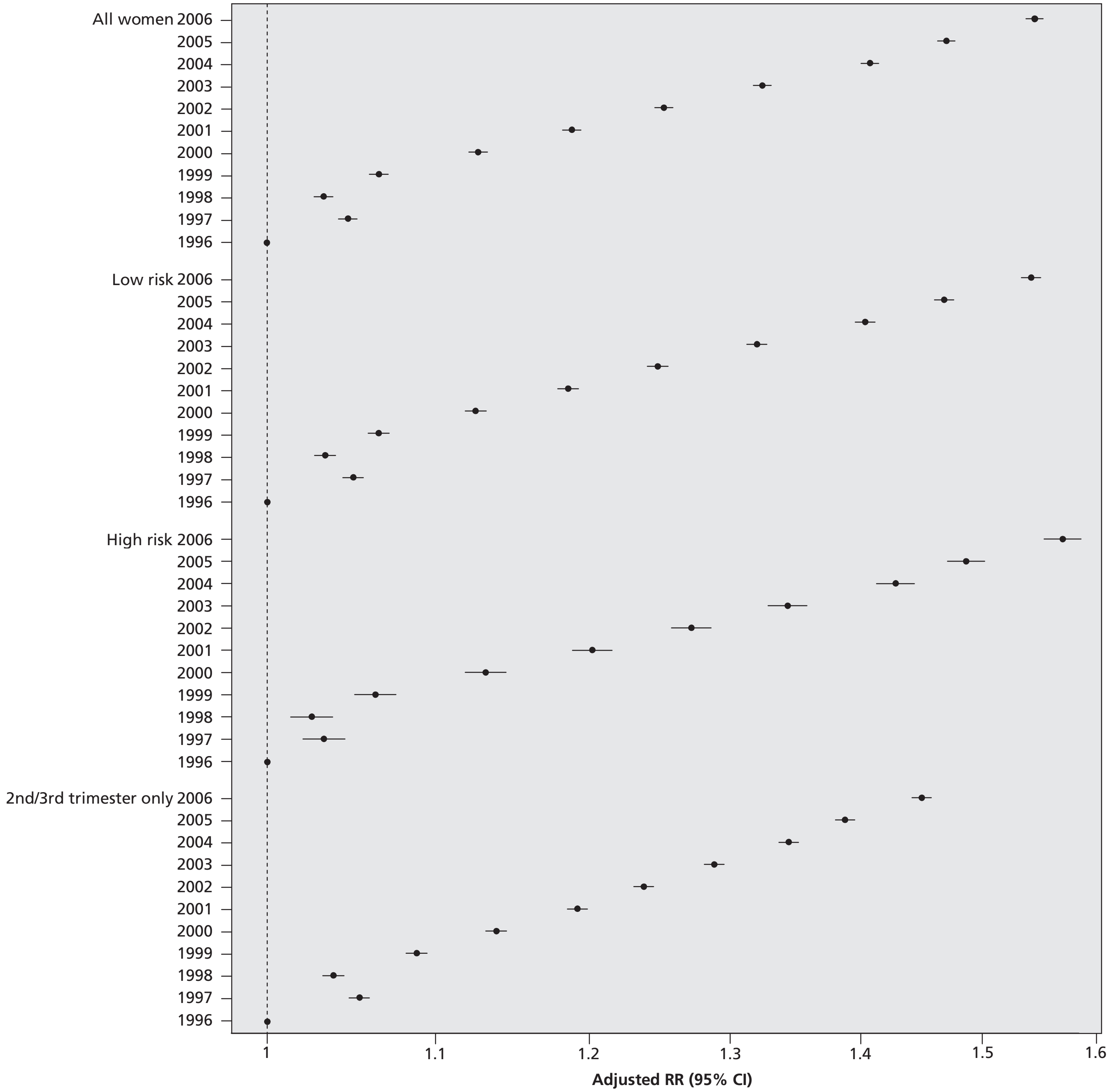

Figure 1: Relative risk (RR) of undergoing obstetric ultrasonography from fiscal year 1996/97 to fiscal year 2006/07. Increases in the annual rate of prenatal ultrasonography are expressed as relative risk, with fiscal year 1996/97 as the referent. Data were adjusted for maternal age, income quintile, rural versus urban place of residence, any diabetes mellitus, any hypertension, any other maternal comorbidity, genetics consultation and amniocentesis — all in the index pregnancy — and a history of complications in a prior pregnancy. For all trends, $p < 0.001$. CI = confidence interval.

Table 2: Use of prenatal ultrasonography for women with a singleton pregnancy in Ontario, 1996 to 2006, according to trimester

Timing of procedure	Measure	Fiscal year 1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Adjusted RR (95% CI)*
All women	Total no.	131 746	128 976	126 841	126 078	122 019	126 062	123 502	127 086	127 610	128 721	130 748	
Any trimester	No. US	270 687	278 089	270 185	278 068	285 758	312 527	323 216	352 815	377 852	398 905	426 757	-
	Rate/1000	2 055	2 156	2 130	2 206	2 342	2 479	2 617	2 776	2 961	3 099	3 264	1.55 (1.54–1.55)
First trimester	No. US	48 613	48 562	47 459	45 296	49 077	55 455	61 233	71 378	81 853	90 027	98 451	-
	Rate/1000	369	377	374	359	402	440	496	562	641	699	753	1.98 (1.96–2.00)
Second trimester	No. US	133 759	136 486	136 004	140 925	142 388	152 736	154 847	165 883	171 887	177 599	185 847	-
	Rate/1000	1 015	1 058	1 072	1 118	1 167	1 212	1 254	1 305	1 347	1 380	1 421	1.38 (1.37–1.39)
Third trimester	No. US	88 315	93 041	86 722	91 847	94 293	104 336	107 136	115 554	124 112	131 279	142 459	-
	Rate/1000	670	721	684	728	773	828	867	909	973	1 020	1 090	1.55 (1.54–1.56)
Low-risk pregnancy	Total no.	111 112	108 347	106 245	105 076	100 969	103 902	101 442	104 128	103 722	104 336	105 570	
Any trimester	No. US	216 673	222 299	214 726	219 193	222 805	241 873	248 628	270 827	286 855	302 103	321 185	-
	Rate/1000	1 950	2 052	2 021	2 086	2 207	2 328	2 451	2 601	2 766	2 895	3 042	1.54 (1.53–1.55)
First trimester	No. US	39 808	39 739	38 650	36 544	39 417	44 395	48 929	57 123	65 392	71 841	78 628	-
	Rate/1000	358	367	364	348	390	427	482	549	630	689	745	2.03 (2.00–2.05)
Second trimester	No. US	110 692	112 718	111 718	115 163	115 433	123 097	124 295	132 464	135 685	139 672	145 566	-
	Rate/1000	996	1 040	1 052	1 096	1 143	1 185	1 225	1 272	1 308	1 339	1 379	1.37 (1.36–1.38)
Third trimester	No. US	66 173	69 842	64 358	67 486	67 955	74 381	75 404	81 240	85 778	90 590	96 991	-
	Rate/1000	596	645	606	642	673	716	743	780	827	868	919	1.53 (1.51–1.55)
High-risk pregnancy	Total no.	20 634	20 629	20 596	21 002	21 050	22 160	22 060	22 958	23 888	24 385	25 178	
Any trimester	No. US	54 014	55 790	55 459	58 875	62 953	70 654	74 588	81 988	90 997	96 802	105 572	-
	Rate/1000	2 618	2 704	2 693	2 803	2 991	3 188	3 381	3 571	3 809	3 970	4 193	1.55 (1.54–1.57)
First trimester	No. US	8 805	8 823	8 809	8 752	9 660	11 060	12 304	14 255	16 461	18 186	19 823	-
	Rate/1000	427	428	428	417	459	499	558	621	689	746	787	1.80 (1.76–1.85)
Second trimester	No. US	23 067	23 768	24 286	25 762	26 955	29 639	30 552	33 419	36 202	37 927	40 281	-
	Rate/1000	1 118	1 152	1 179	1 227	1 281	1 338	1 385	1 456	1 515	1 555	1 600	1.42 (1.39–1.44)
Third trimester	No. US	22 142	23 199	22 364	24 361	26 338	29 955	31 732	34 314	38 334	40 689	45 468	-
	Rate/1000	1 073	1 125	1 086	1 160	1 251	1 352	1 438	1 495	1 605	1 669	1 806	1.60 (1.57–1.62)

Note: CI = confidence interval, RR = relative risk, US = ultrasonography examination.
*For 2006 v. 1996, adjusted for maternal age, income quintile, rural place of residence, diabetes mellitus, hypertension, other maternal comorbidity, genetics consultation and amniocentesis — all in the index pregnancy — and for history of complications of pregnancy.

acknowledgement of defensive practice styles among individual providers.

Our study has some limitations. First, we had to estimate the trimester in which ultrasonography had been performed. Therefore, for preterm deliveries, some examinations actually completed in the first or second trimester would have been ascribed to a later period in the pregnancy, which would have led us to underestimate the number of first-trimester examinations. To counter this effect, we excluded multifetal pregnancies and adjusted for maternal risk, each of which is more likely to result in preterm delivery. Second, we excluded women who aborted before 20 weeks' gestation, some of whom might have been considered to be at high risk. The remaining women in our study cohort whose pregnancies

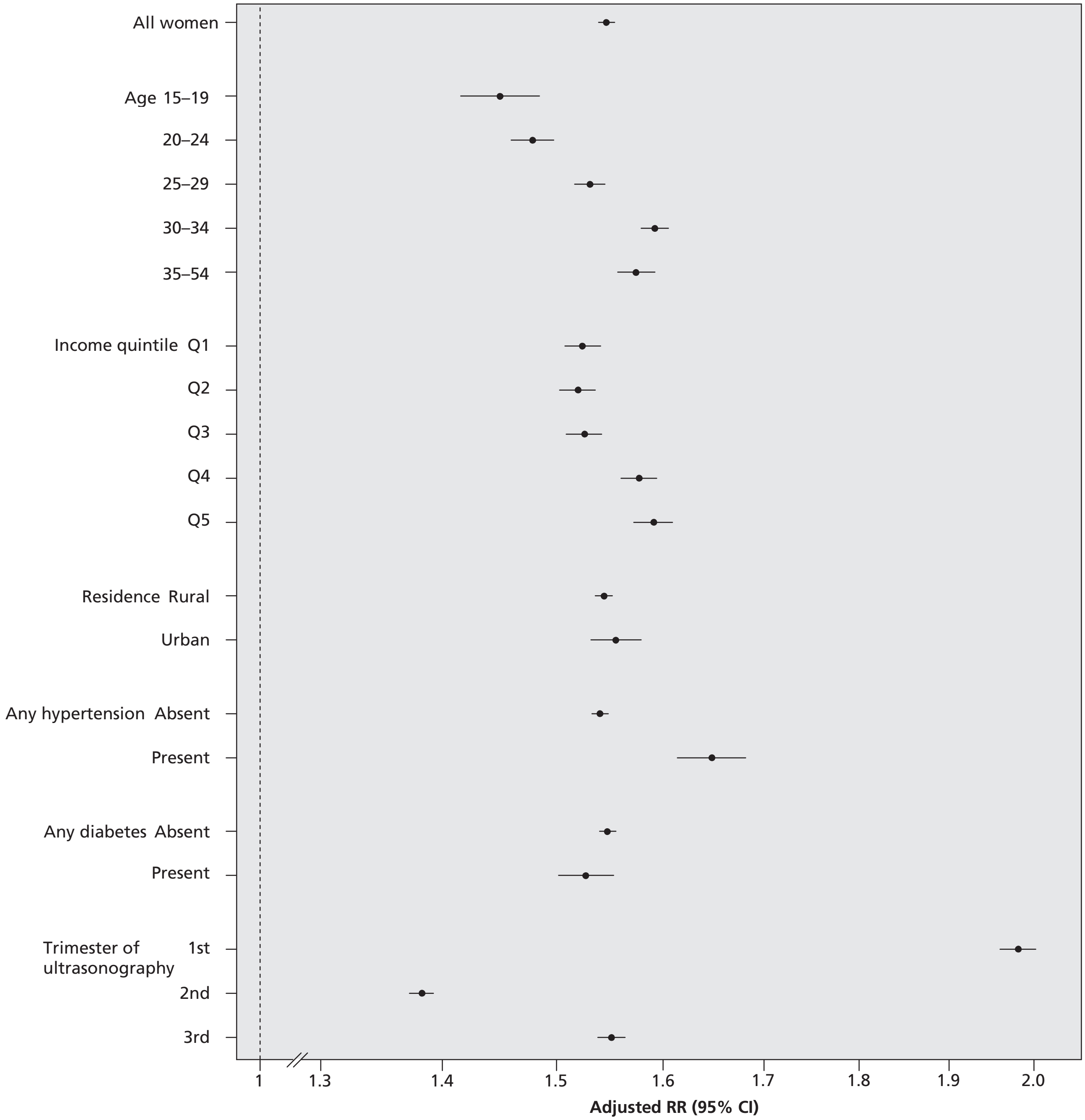

Figure 2: Relative risk (RR) of undergoing obstetric ultrasonography in fiscal year 2006/07 relative to fiscal year 1996/97. Data were adjusted for maternal age, income quintile, rural versus urban place of residence, any diabetes mellitus, any hypertension, any other maternal comorbidity, genetics consultation and amniocentesis — all in the index pregnancy — and a history of complications in a prior pregnancy. For all within-stratum interaction terms, $p < 0.001$. CI = confidence interval.

Table 3: Use of prenatal ultrasonography during the second and third trimesters among women with a singleton pregnancy in Ontario, 1996 to 2006

All participants, by quartile	Fiscal year										
	1996, *n* = *131 746*	1997, *n* = *128 976*	1998, *n* = *126 841*	1999, *n* = *126 078*	2000, *n* = *122 019*	2001, *n* = *126 062*	2002, *n* = *123 502*	2003, *n* = *127 086*	2004, *n* = *127 610*	2005, *n* = *128 721*	2006, *n* = *130 748*
All participants											
Q1 (0 or 1 US examinations)											
No. (%)	71 645 (54.4)	65 522 (50.8)	66 709 (52.6)	62 518 (49.6)	55 868 (45.8)	53 793 (42.7)	49 590 (40.2)	47 620 (37.5)	44 998 (35.3)	42 234 (32.8)	39 448 (30.2)
Adjusted RR (95% CI)*	1.00 (ref)	0.94 (0.93–0.95)	0.97 (0.96–0.98)	0.92 (0.91–0.93)	0.85 (0.84–0.86)	0.79 (0.79–0.80)	0.75 (0.74–0.76)	0.70 (0.69–0.71)	0.66 (0.65–0.67)	0.62 (0.61–0.62)	0.57 (0.56–0.57)
Q2 (2 US examinations)											
No. (%)	38 100 (28.9)	39 194 (30.4)	37 250 (29.4)	37 816 (30.0)	38 429 (31.5)	40 509 (32.1)	40 103 (32.5)	41 367 (32.6)	41 239 (32.3)	41 908 (32.6)	42 590 (32.6)
Adjusted RR (95% CI)*	1.00 (ref)	1.05 (1.04–1.07)	1.02 (1.00–1.03)	1.04 (1.03–1.06)	1.09 (1.08–1.11)	1.12 (1.10–1.13)	1.13 (1.11–1.14)	1.13 (1.11–1.14)	1.12 (1.11–1.14)	1.13 (1.12–1.15)	1.13 (1.12–1.15)
Q3 (3 US examinations)											
No. (%)	13 516 (10.3)	14 538 (11.3)	13 721 (10.8)	15 029 (11.9)	16 094 (13.2)	17 959 (14.2)	18 809 (15.2)	20 714 (16.3)	21 542 (16.9)	22 981 (17.9)	24 204 (18.5)
Adjusted RR (95% CI)*	1.00 (ref)	1.10 (1.07–1.12)	1.05 (1.03–1.08)	1.16 (1.13–1.19)	1.28 (1.25–1.31)	1.38 (1.34–1.41)	1.47 (1.44–1.50)	1.57 (1.53–1.60)	1.62 (1.58–1.65)	1.71 (1.67–1.75)	1.77 (1.74–1.81)
Q4 (≥4 US examinations)											
No. (%)	8 485 (6.4)	9 722 (7.5)	9 161 (7.2)	10 715 (8.5)	11 628 (9.5)	13 801 (10.9)	15 000 (12.1)	17 385 (13.7)	19 831 (15.5)	21 598 (16.8)	24 506 (18.7)
Adjusted RR (95% CI)*	1.00 (ref)	1.16 (1.13–1.20)	1.11 (1.08–1.14)	1.29 (1.25–1.33)	1.43 (1.39–1.47)	1.63 (1.58–1.67)	1.79 (1.75–1.84)	2.00 (1.95–2.05)	2.25 (2.19–2.31)	2.41 (2.35–2.47)	2.68 (2.61–2.74)
Low-risk subgroup	*n* = *111 112*	*n* = *108 347*	*n* = *106 245*	*n* = *105 076*	*n* = *100 969*	*n* = *103 902*	*n* = *101 442*	*n* = *104 128*	*n* = *103 722*	*n* = *104 336*	*n* = *105 570*
Q4 (≥ 4 US examinations)											
No. (%)	5 485 (4.9)	6 486 (6.0)	5 977 (5.6)	7 085 (6.7)	7 481 (7.4)	8 884 (8.6)	9 643 (9.5)	11 213 (10.8)	12 719 (12.3)	13 845 (13.3)	15 687 (14.9)
Adjusted RR (95% CI)*	1.00 (ref)	1.20 (1.16–1.25)	1.13 (1.09–1.17)	1.35 (1.30–1.39)	1.47 (1.42–1.53)	1.70 (1.64–1.76)	1.89 (1.83–1.95)	2.12 (2.05–2.19)	2.42 (2.34–2.50)	2.61 (2.53–2.69)	2.92 (2.83–3.01)
High-risk subgroup	*n* = *20 634*	*n* = *20 629*	*n* = *20 596*	*n* = *21 002*	*n* = *21 050*	*n* = *22 160*	*n* = *22 060*	*n* = *22 958*	*n* = *23 888*	*n* = *24 385*	*n* = *25 178*
Q4 (≥ 4 US examinations)											
No. (%)	3 000 (14.5)	3 236 (15.7)	3 184 (15.5)	3 630 (17.3)	4 147 (19.7)	4 917 (22.2)	5 357 (24.3)	6 172 (26.9)	7 112 (29.8)	7 753 (31.8)	8 819 (35.0)
Adjusted RR (95% CI)*	1.00 (ref)	1.08 (1.03–1.14)	1.07 (1.02–1.12)	1.19 (1.13–1.24)	1.34 (1.28–1.41)	1.48 (1.42–1.55)	1.61 (1.54–1.68)	1.78 (1.70–1.86)	1.94 (1.86–2.03)	2.06 (1.97–2.15)	2.25 (2.16–2.35)

Note: CI = confidence interval, Q = quartile, RR = relative risk, US = ultrasonography examination.
*Adjusted for maternal age, income quintile, rural place of residence, diabetes mellitus, hypertension, other maternal comorbidity, genetics consultation, amniocentesis – all in the index pregnancy – and for history of complications of pregnancy.

were defined as "high-risk" might have had a lower disease burden than the entire population of women with high-risk pregnancies, which might have limited somewhat the generalizability of our findings to pregnancies extending beyond 20 weeks' gestation. Third, we did not have data about trends in the locations where the prenatal ultrasound examinations were performed, such as private physicians' offices versus hospital-based facilities. Future studies will be needed to examine potential system-level reasons for the trends we observed. Finally, since the Ontario Health Insurance Plan database does not provide the indications for prenatal ultrasonography, we could not directly assess the appropriateness of the patterns of use that we observed. A detailed chart review, combined with surveys or interviews of mothers and their pregnancy caregivers, might better elucidate the underlying reasons for the rising use of prenatal ultrasonography.

In conclusion, there has been a substantial increase in the use of prenatal ultrasonography in the past decade, and more than one-third of women with a singleton pregnancy now receive three or more ultrasound examinations during the second and third trimesters. Efforts to promote more appropriate use of prenatal ultrasonography in low-risk groups appear warranted, but careful debate will be required to determine the most effective and acceptable approaches to achieve this goal.

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