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RESEARCH ARTICLE

Changes in mammography screening in Ontario and Alberta following national guideline dissemination: an interrupted time series analysis [version 1; peer review: 2 approved with reservations]

Christine Fahim¹, Natasha Wiebe², Rosane Nisenbaum^{3,4}, Jemila S. Hamid⁵, Joycelyne E. Ewusie⁶, Marcello Tonelli⁷, Paula Brauer⁸, Elizabeth Shaw⁹, Neil Bell¹⁰, Dawn Stacey^{11,12}, Nathalie M. Holmes¹³, Sharon E. Straus^{1,14}

¹Ottawa Hospital Research Institute, Ottawa, Ontario, K1H 8L6, Canada

²Public Health Agency of Canada, Ottawa, Ontario, K1A 0K9, Canada

³Department of Medicine, University of Toronto, Toronto, Ontario, M5S 1A8, Canada

⁴Knowledge Translation Program, Li Ka Shing Knowledge Institute, St. Michael's Hospital, Toronto, Ontario, M5B 1T8, Canada

⁵Department of Medicine, University of Alberta, Edmonton, Alberta, T6G 2G3, Canada

⁶MAP Centre for Urban Health Solutions, Li Ka Shing Knowledge Institute, Toronto, Ontario, M5B 1T8, Canada

⁷Dalla Lana School of Public Health, University of Toronto, Toronto, Ontario, M5T 3M7, Canada

⁸Department of Mathematics and Statistics, University of Ottawa, Ottawa, Ontario, K1N 6N5, Canada

⁹Biostatistics Unit, Father Sean O'Sullivan Research Centre, Hamilton, Ontario, L8N 4A6, Canada

¹⁰Cumming School of Medicine, University of Calgary, Calgary, Alberta, T2N 1N4, Canada

¹¹Department of Family Relations and Applied Nutrition, University of Guelph, Guelph, Ontario, N1G 2W1, Canada

¹²Department of Family Medicine, McMaster University, Hamilton, Ontario, L8S 4K1, Canada

¹³Department of Family Medicine, University of Alberta, Edmonton, Alberta, T6G 2R3, Canada

¹⁴Faculty of Health Sciences, University of Ottawa, Ottawa, Ontario, K1N 6N5, Canada

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Abstract

Background: In November 2011, the Canadian Task Force on Preventive Health Care released guidelines for screening women at average breast cancer risk. Weak recommendations (framed using GRADE methodology) were made for screening women aged 50 to 74 years every two to three years, and for not screening women aged 40 to 49 years.

Methods: We conducted an interrupted time series analysis using administrative data to examine bilateral mammography use before and after a national guideline dissemination strategy targeting primary care physicians. Women aged 40 to 74 years living in Ontario or Alberta from 30th November 2008 to 30th November 2014 were included. Strata included age, region of residence, neighbourhood income quintile, immigration status, and education level.

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1. Sisse Helle Njor^{id}, Randers Regional Hospital, Randers, Denmark
 Aarhus University, Aarhus, Denmark

Results: In both provinces, mammography use rates were lower in the post-intervention period (527 vs. 556 and 428 vs. 465/1000 participant-months - the monthly screening rate/1000 - in Ontario and Alberta, respectively). In Ontario, mammography trends decreased following guideline release to align with recommendations for women aged 40 to 74 (decrease of 2.21/1000 women, SE 0.26/1000, $p < 0.0001$). In Alberta, mammography trends decreased for women aged 40 to 49 years (3/1000 women, SE 0.32, $p < 0.001$) and 50 to 69 (2.9/1000 women, SE 0.79, $p < 0.001$), but did not change for women aged 70 to 74 (0.7/1000 women, SE 1.23, $p = 0.553$). In both provinces, trends in mammography use rates were sustained for up to three years after guideline release.

Conclusions: The guideline dissemination strategy appeared to increase uptake of guideline-concordant screening practice in women aged 40 to 49 years in Ontario and Alberta and for women aged 50 to 74 years in Ontario. Further work is required to understand these findings and whether shared decision making about mammography between women and providers increased among women considering mammography.

Keywords

Breast Cancer, Mammography, Screening, Preventive Health Care, Knowledge Translation

This article is included in the [Oncology](#) gateway.

2. **Jacqueline M. Hirth** , Baylor College of Medicine, Houston, USA

Judith Gutierrez , Baylor College of Medicine, Houston, USA

Tiffany Ostovar-Kermani, Baylor College of Medicine, Houston, USA

Any reports and responses or comments on the article can be found at the end of the article.

Corresponding author: Christine Fahim (Christine.Fahim@unityhealth.to)

Author roles: **Fahim C:** Conceptualization, Investigation, Methodology, Project Administration, Visualization, Writing – Original Draft Preparation, Writing – Review & Editing; **Wiebe N:** Conceptualization, Formal Analysis, Investigation, Methodology, Project Administration, Validation, Visualization, Writing – Original Draft Preparation, Writing – Review & Editing; **Nisenbaum R:** Conceptualization, Formal Analysis, Investigation, Methodology, Project Administration, Validation, Visualization, Writing – Original Draft Preparation, Writing – Review & Editing; **Hamid JS:** Conceptualization, Investigation, Methodology, Visualization, Writing – Original Draft Preparation, Writing – Review & Editing; **Ewusie JE:** Conceptualization, Methodology, Writing – Review & Editing; **Tonelli M:** Conceptualization, Writing – Review & Editing; **Brauer P:** Conceptualization, Writing – Review & Editing; **Shaw E:** Conceptualization, Writing – Review & Editing; **Bell N:** Writing – Original Draft Preparation, Writing – Review & Editing; **Stacey D:** Conceptualization, Writing – Review & Editing; **Holmes NM:** Conceptualization, Writing – Review & Editing; **Straus SE:** Conceptualization, Funding Acquisition, Investigation, Methodology, Project Administration, Resources, Supervision, Visualization, Writing – Original Draft Preparation, Writing – Review & Editing

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Abbreviations

AKDN: Alberta Kidney Disease Network
 CCI: Canadian Classification of Health Intervention procedure codes
 CMAJ: Canadian Medical Association Journal
 ICES: Institute for Clinical Evaluative Sciences
 ITS: Interrupted Time Series
 OBSP: Ontario Breast Screening Program
 OCR: Ontario Cancer Registry
 OHIP: Ontario Health Insurance Program
 RPDB: Registered Persons Database
 Task Force: Canadian Task Force on Preventive Health Care

Introduction

The **Canadian Task Force on Preventive Health Care** (Task Force) was reconstituted in 2009 to develop and disseminate evidence-based clinical practice guidelines to support preventive practices in primary care. Breast cancer screening was the first topic selected for guideline development because the U.S. Preventive Services Task Force¹ had produced recommendations in 2009 favouring screening for women aged 40 years and older, yet questions about costs and benefits remained given the lower rate of breast cancer at younger ages and the potential risk of harms.²

Breast cancer is the most common cancer in Canadian women with one in eight women receiving a diagnosis over her lifetime and **one in thirty-three dying from the disease**. In 2020, there were an estimated **27,400 new cases and 5,100 deaths from breast cancer**, which is 13% of all cancer deaths in women in Canada. Mammography can identify asymptomatic breast cancer, but there are harms associated with screening, including overdiagnosis.³ Several provinces and countries have implemented breast cancer screening programs with established targets; for instance, **Alberta Health Services** identified a target of screening 70% of eligible women aged 50 to 74 years every two years, which is consistent with the Canadian target of screening 70% of eligible women every 30 months.

In 2011, the Task Force aimed to provide a recent review of evidence to inform breast cancer screening practices. In keeping with the use of Grading of Recommendations Assessment, Development and Evaluation (GRADE) methodology, the Task Force reviewed available evidence using a systematic review to develop screening guidelines for women at average risk of breast cancer (see **Box 1** for recommendations).⁴ The Task Force developed weak recommendations based on moderate to low quality evidence. In keeping with GRADE methods, weak recommendations are those for which the benefits probably outweigh the harms, or the harms probably outweigh the benefits, but uncertainty exists.^{4,5} The guidelines also highlighted the need for clinicians to help patients make a decision that is consistent with the patient's informed values and preferences.⁴ This guideline was an update to the 2001 guideline published by the Task Force which recommended screening with mammography every one to two years for women aged 50 to 69.^{6,7}

The Task Force developed a tailored guideline dissemination strategy in partnership with stakeholder groups, including primary care physicians and women in the target age groups. We evaluated the impact of this dissemination strategy by investigating mammography use in Ontario and Alberta before and after the strategy was implemented.

The objective of this study was to determine, using an interrupted time series, the impact of the 2011 Task Force breast cancer screening guidelines on rates of mammography screening by age group in Ontario and Alberta. We hypothesized that there would be a significant change in mammography screening rates over time to align with the Task Force breast cancer recommendations, and that effects would be sustained for up to three years post-guideline release.

Box 1. Task Force 2011 Breast Cancer Guideline Recommendations.⁴

Recommendations follow the Grading of Recommendations Assessment, Development and Evaluation (GRADE) nomenclature

- **For women aged 40–49 years** we recommend **not routinely** screening with mammography. (*Weak recommendation; moderate quality evidence*)
- **For women aged 50–69 years** we recommend routinely screening with mammography every two to three years. (*Weak recommendation; moderate quality evidence*)
- **For women aged 70–74 years** we recommend routinely screening with mammography every two to three years. (*Weak recommendation; low quality evidence*)

Methods

We performed an interrupted time series (ITS) analysis to examine mammography use in Ontario and Alberta 36 months before (30th November 2008 to 30th November 2011) and after (1st December 2011 to 30th November 2014) the breast cancer screening guidelines were released in Canada in November 2011.

Ethics statement

This study was approved by the Unity Health Toronto Research Ethics Board (REB# 12-220). Participant consent was waived by the REB, given all data analyses were conducted by ICES and Alberta Health Services using aggregate, non-identifiable data.

Setting and participants

We included women aged 40 to 74 years who lived in Ontario or Alberta between November 2008 and November 2014. In Ontario, the [Registered Persons Database](#) (RPDB) and the [Ontario Cancer Registry](#) (OCR) were used to identify eligible participants. The databases were accessed and linked by ICES scientists^{8,9} and not by members of the study team. The OCR database is considered the most comprehensive cancer registry in the province; the [Institute for Clinical Evaluative Sciences](#) (ICES) has access to data from January 1964 to present. Via a validated administrative algorithm, we identified eligible participants in Ontario; we used International Classification of Diseases for Oncology (ICD-O-3) C50 topography codes to identify women with a diagnosis of breast cancer. The algorithm is a sequence of programming codes in SAS software to assemble the cohort of people who were alive (i.e. no death date or death date was after the index date), were eligible for health care (i.e. date of end of eligibility was after the index date), and had an Ontario postal code at the index date. There is no available link to the SAS codes. Women with a history of breast cancer and/or a bilateral mastectomy before each period were excluded from the analysis. Bilateral mastectomy was identified using the Canadian Classification of Health Intervention (CCI) procedure codes. In Alberta, the Alberta Kidney Disease Network (AKDN) database (incorporating data from Alberta Health), which includes >99% of adult Albertans, was used to identify participants.¹⁰ MT had access to de-identified data in the AKDN database; specifically, no health care numbers or names were available. For Alberta data, a validated administrative algorithm was used to identify and exclude women with a history of breast cancer using ICD-9 174 and ICD-10 C50 codes and 1 hospitalization or 2 claims in 2 years.^{11,12} Procedure codes from claims data (CCP codes 97.12A, 97.12B, and 97.22A) were used to exclude women with previous bilateral mastectomies (extended data).

Intervention

The intervention was the Task Force's guideline dissemination strategy, which included theory- and evidence-based printed and online education materials and a mass media campaign.^{13–18} The content of the education materials was based on the guideline recommendations, discussions with stakeholders about barriers to implementing the recommendations, and barriers to guideline implementation. The mass media campaign focused on key messages for the target audiences as identified from discussions with the Task Force and its stakeholders. The detailed approach to developing and testing the education materials is [available online](#). The guidelines were published in the Canadian Medical Association Journal (CMAJ) on 21st November 2011 accompanied by a mass media launch.⁴ The print CMAJ (including the guidelines) was mailed to over 60,000 primary care and specialty physicians nationally. The printed education materials provided in this mailing included a one-page decision algorithm for patients and clinicians, and a one-page 'Frequently Asked Questions' document for patients and clinicians. These education materials were also available on the Task Force's website along with a patient decision aid infographic explaining the risks and benefits of mammograms, a video and script that role modelled shared decision making (the process for patients and physicians to collectively make a decision regarding treatment), a presentation on the methods used to create the guidelines, and the systematic review used to inform guideline development.¹⁹

Outcomes

Data were cleaned to ensure that participants were adult and female. The Ontario and Alberta datasets were analysed separately and were not linked. NW conducted and oversaw the analysis of the Alberta data and RN oversaw the analysis of the Ontario data. Use of bilateral mammogram was the primary outcome, identified from the [Ontario Health Insurance Program](#) (OHIP, fee code in 'X185' and 'X178') and [Ontario Breast Screening Program](#) (OBSP) databases in Ontario and the AKDN claims data (CCP codes X27C, X27D, X27E)¹⁰ in Alberta. For both Ontario and Alberta data, a mammogram was considered a duplicate if repeated within seven days and was then removed from the data; the date of the first mammogram within each time period was used for analysis. Additional variables collected included age group, setting (rural versus non-rural), income quintile, immigrant status, visible minority status¹, and education status. Urban area was defined as having a population of at least 1,000 and a density of 400 or more people per square kilometre. Income

¹ 'Visible minority' is a term used in the ICES database.²⁰

quintile was used as a proxy for the women's socioeconomic status and was based on their postal code (neighbourhood) using [Statistics Canada census data](#). Immigrant status and visible minority status were defined as the percentage of immigrants and visible minorities in the postal code, respectively. Education was specified as the proportion of women with a bachelor's degree as the highest level of educational attainment. Details on immigrant, minority, and education status were not available for Alberta participants.

Statistical analysis

Data were summarized descriptively using mammography counts and rates per 1000 participant-months. Data from each province were aggregated monthly to calculate rates (number of monthly screening tests/1000 participant-months) and ITS was performed using segmented regression. The model was defined as:

$$\text{Rate}_t = \beta_0 + \beta_1 \times \text{time}_t + \beta_2 \times \text{intervention}_t + \beta_3 \times \text{time after intervention}_t + e_t$$

where Rate_t is the rate of breast cancer screening at each month t ($t = 1$ to 72 months) and e_t is the random error at time t . β_0 is the intercept or pre-intervention baseline level of the rate; β_1 is the slope of the rate until the intervention is introduced (slope prior to the intervention); β_2 is the change in rate level that occurs in the period immediately following the introduction of intervention; and β_3 is the change in rate trend (i.e. difference between post-intervention and pre-intervention slopes). We used this approach to test the significance of β_2 (an immediate intervention effect) and β_3 (significant intervention effect over time to determine sustained impact).²¹

Subgroup analyses were performed for age categories. In Ontario, subgroup analyses were also separately performed by rural or urban setting, neighbourhood income quintile (mean income per person equivalent in an area obtained from census data), education categories (population in a neighbourhood with a bachelor's degree), immigration categories (population in a neighbourhood of immigrant status), and minority categories (created as a % of visible minority in a total population by postal code). The cut off values for categories were determined using distributions of the 1st and 3rd quartiles (interquartile range) of the neighbourhood distributions at pre- and post-intervention periods.

For Ontario data, regression parameters were estimated by maximum likelihood using SAS Enterprise Guide, version 7.15 software procedure AUTOREG (SAS Institute Inc., Cary, NC, USA), which adjusts for autocorrelation.^{22,23} For Alberta data, analysis was conducted using Stata MP 15.1 software command 'itsa'; however, the same models and parameters were used.²⁴ Canadian mammography screening is recommended every 24 to 36 months²⁵; final models included autoregressive terms for only up to 12 lags, selected by backward elimination. The Durbin-Watson statistic was calculated to test autocorrelation terms. All statistical tests were two-sided and statistical significance was defined as a p-value less than 0.05.

Results

Ontario

Descriptive

A total of 2,935,241 women were included before guideline dissemination and 3,098,205 women were included after dissemination; the cohorts had similar demographic characteristics ([Table 1](#)). Overall, the number of women who had a mammogram decreased in the post-intervention period compared to pre-intervention (527 versus 556 per 1000 participant-months, respectively). Similar trends were observed in women aged 40 to 49 and 50 to 69 years. The proportion of women aged 70 to 74 years who underwent a mammogram was slightly higher in the post-intervention period ([Table 1](#)). Both at pre- and post-guideline release, women in higher income quintiles (compared to lower quintiles) and women in rural areas (compared to urban areas) had higher screening mammography use.

ITS results

Among women aged 40 to 49 years, monthly screening mammography rates increased before the guideline release (slope 0.06/1000, SE 0.01/1000, $p < 0.0001$). Immediately following the guideline release, there was a significant rate decrease of 2.21 per 1000 women (SE 0.26/1000, $p < 0.0001$) who received a mammogram. This rate was sustained; however, the slope was not, meaning the rate of women who received a mammogram did not continue to decrease further during this period ([Table 2](#), [Figure 1](#)).

Among women aged 50 to 69 years, monthly screening mammography rates decreased before the guideline release ([Table 2](#)). Immediately following the guideline release, there was a significant increase of 3.82 per 1000 women who received a mammogram. This rate was sustained; however, the slope was not.

Table 1. Participant characteristics (extended data).

Characteristics	Pre-guideline		Post-guideline	
	Total (N)	Screened with mammogram N (per 1000)	Total (N)	Screened with mammogram N (per 1000)
Ontario data				
Overall	2,935,241	1,630,535 (556)	3,098,205	1,633,248 (527)
Age group				
40-49	1,050,145	339,728 (324)	1,018,506	250,974 (246)
50-69	1,657,828	1,141,380 (688)	1,825,012	1,213,113 (665)
70-74	227,268	149,427 (657)	254,687	169,161 (664)
Income quintile			3,098,205	
1	516,929	249,585 (483)	591,497	275,248 (465)
2	564,645	302,604 (536)	612,049	314,777 (514)
3	584,511	326,112 (558)	614,834	328,724 (535)
4	626,764	363,790 (580)	610,857	334,676 (548)
5	632,732	383,991 (607)	665,303	378,271 (569)
Place of residence				
Urban	2,579,041	1,430,293 (555)	2,754,946	1,447,086 (525)
Rural	356,175	200,233 (562)	339,661	184,638 (544)
Immigration status				
Low	649,391	364,866 (562)	676,066	367,600 (544)
Moderate	1,302,240	742,379 (570)	1,352,420	729,345 (539)
High	650,969	344,527 (529)	676,104	338,386 (500)
Education level				
Low	651,732	354,736 (544)	680,395	358,288 (527)
Moderate	1,307,640	729,642 (558)	1,352,696	720,646 (533)
High	650,806	370,766 (570)	679,739	360,033 (530)
Alberta data				
Overall	788,131	366,547 (465)	861,014	368,735 (428)
Age group				
40-49	291,601	102,225 (351)	298,891	82,822 (277)
50-69	445,294	239,115 (537)	503,230	257,375 (511)
70-74	51,236	25,207 (492)	58,893	28,538 (485)
Income quintile				
1	129,739	55,125 (425)	138,547	54,365 (392)
2	142,411	67,369 (473)	150,603	65,165 (433)
3	141,065	72,418 (513)	150,079	70,471 (470)
4	149,755	79,936 (534)	162,997	79,362 (487)
5	156,731	88,649 (566)	168,915	87,162 (516)
Place of residence				
Urban	645,739	335,744 (520)	713,032	339,172 (476)
Rural	77,577	29,662 (382)	80,320	28,407 (354)

Table 2. Interrupted time series results for Ontario data (per 1000).

Outcome	Regression coefficients	Estimate	Std Err	Probt
All women	Pre-intervention baseline rate level	24.2589	0.5508	0.0000
	Pre-intervention slope	−0.0551	0.0144	0.0003
	Change in rate level (immediate effect post-intervention)	1.9574	0.2978	0.0000
	Change in rate trend (sustained impact post-intervention)	0.0034	0.0210	0.8703
Women aged 40-49	Pre-intervention baseline rate level	11.5055	0.2881	0.0000
	Pre-intervention slope	0.0619	0.0111	0.0000
	Change in rate level (immediate effect post-intervention)	−2.2084	0.2570	0.0000
	Change in rate trend (sustained impact post-intervention)	<0.0001	0.0168	0.9985
Women aged 50-69	Pre-intervention baseline rate level	31.1162	0.7051	0.0000
	Pre-intervention slope	−0.1084	0.0187	0.0000
	Change in rate level (immediate effect post-intervention)	3.8229	0.3880	0.0000
	Change in rate trend (sustained impact post-intervention)	0.0072	0.0273	0.7941
Women aged 70-74	Pre-intervention baseline rate level	32.9099	1.0495	0.0000
	Pre-intervention slope	−0.2084	0.0207	0.0000
	Change in rate level (immediate effect post-intervention)	7.4953	0.4141	0.0000
	Change in rate trend (sustained impact post-intervention)	0.0028	0.0295	0.9236
Income Q1	Pre-intervention baseline rate level	20.1457	0.5069	0.0000
	Pre-intervention slope	−0.0323	0.0130	0.0158
	Change in rate level (immediate effect post-intervention)	1.1814	0.2688	0.0000
	Change in rate trend (sustained impact post-intervention)	0.0006	0.0190	0.9754
Income Q2	Pre-intervention baseline rate level	22.9990	0.5525	0.0000
	Pre-intervention slope	−0.0459	0.0155	0.0042
	Change in rate level (immediate effect post-intervention)	1.7047	0.3240	0.0000
	Change in rate trend (sustained impact post-intervention)	−0.0007	0.0227	0.9763
Income Q3	Pre-intervention baseline rate level	24.0921	0.5490	0.0000
	Pre-intervention slope	−0.0472	0.0147	0.0021
	Change in rate level (immediate effect post-intervention)	1.6950	0.3058	0.0000
	Change in rate trend (sustained impact post-intervention)	0.0023	0.0215	0.9155
Income Q4	Pre-intervention baseline rate level	25.6099	0.5823	0.0000
	Pre-intervention slope	−0.0629	0.0158	0.0002
	Change in rate level (immediate effect post-intervention)	2.2163	0.3281	0.0000
	Change in rate trend (sustained impact post-intervention)	0.0049	0.0231	0.8317

Table 2. *Continued*

Outcome	Regression coefficients	Estimate	Std Err	Probt
Income Q5	Pre-intervention baseline rate level	27.6219	0.5892	0.0000
	Pre-intervention slope	−0.0806	0.0157	0.0000
	Change in rate level (immediate effect post-intervention)	2.7806	0.3246	0.0000
	Change in rate trend (sustained impact post-intervention)	0.0090	0.0229	0.6952
Education 1	Pre-intervention baseline rate level	23.3601	0.5941	0.0000
	Pre-intervention slope	−0.0486	0.0156	0.0026
	Change in rate level (immediate effect post-intervention)	1.7650	0.3218	0.0000
	Change in rate trend (sustained impact post-intervention)	0.0012	0.0227	0.9577
Education 2	Pre-intervention baseline rate level	24.3047	0.5652	0.0000
	Pre-intervention slope	−0.0568	0.0142	0.0002
	Change in rate level (immediate effect post-intervention)	2.0191	0.2924	0.0000
	Change in rate trend (sustained impact post-intervention)	0.0032	0.0207	0.8783
Education 3	Pre-intervention baseline rate level	25.7350	0.5303	0.0000
	Pre-intervention slope	−0.0706	0.0159	0.0000
	Change in rate level (immediate effect post-intervention)	2.4675	0.3360	0.0000
	Change in rate trend (sustained impact post-intervention)	0.0067	0.0234	0.7770
Immigration 1	Pre-intervention baseline rate level	24.2314	0.6186	0.0000
	Pre-intervention slope	−0.0486	0.0171	0.0059
	Change in rate level (immediate effect post-intervention)	1.7023	0.3565	0.0000
	Change in rate trend (sustained impact post-intervention)	0.0050	0.0250	0.8414
Immigration 2	Pre-intervention baseline rate level	25.2624	0.5641	0.0000
	Pre-intervention slope	−0.0705	0.0147	0.0000
	Change in rate level (immediate effect post-intervention)	2.4623	0.3029	0.0000
	Change in rate trend (sustained impact post-intervention)	0.0060	0.0214	0.7784
Immigration 3	Pre-intervention baseline rate level	23.0136	0.5425	0.0000
	Pre-intervention slope	−0.0431	0.0148	0.0049
	Change in rate level (immediate effect post-intervention)	1.6446	0.3082	0.0000
	Change in rate trend (sustained impact post-intervention)	−0.0029	0.0217	0.8956
Minority 1	Pre-intervention baseline rate level	24.8682	0.6375	0.0000
	Pre-intervention slope	−0.0547	0.0168	0.0017
	Change in rate level (immediate effect post-intervention)	1.9096	0.3467	0.0000
	Change in rate trend (sustained impact post-intervention)	0.0054	0.0244	0.8253

Table 2. *Continued*

Outcome	Regression coefficients	Estimate	Std Err	Probt
Minority 2	Pre-intervention baseline rate level	25.1783	0.5621	0.0000
	Pre-intervention slope	−0.0695	0.0149	0.0000
	Change in rate level (immediate effect post-intervention)	2.4343	0.3074	0.0000
	Change in rate trend (sustained impact post-intervention)	0.0054	0.0217	0.8043
Minority 3	Pre-intervention baseline rate level	22.4733	0.5244	0.0000
	Pre-intervention slope	−0.0390	0.0145	0.0090
	Change in rate level (immediate effect post-intervention)	1.4664	0.3030	0.0000
	Change in rate trend (sustained impact post-intervention)	−0.0016	0.0213	0.9413
Urban	Pre-intervention baseline rate level	24.2510	0.5299	0.0000
	Pre-intervention slope	−0.0548	0.0143	0.0003
	Change in rate level (immediate effect post-intervention)	1.9529	0.2963	0.0000
	Change in rate trend (sustained impact post-intervention)	0.0030	0.0209	0.8849
Rural	Pre-intervention baseline rate level	24.3173	0.7912	0.0000
	Pre-intervention slope	−0.0569	0.0186	0.0031
	Change in rate level (immediate effect post-intervention)	1.9840	0.3781	0.0000
	Change in rate trend (sustained impact post-intervention)	0.0062	0.0268	0.8169

Figure 1. Ontario data.

Among women aged 70 to 74 years, monthly screening mammography rates decreased before the guideline release (Table 2). Immediately following the guideline release, there was a significant increase of 7.50 per 1000 women who received a mammogram. This rate was sustained three years following the intervention.

Among all women, rates of mammography screening were significantly declining pre-guideline release; following the release, a significant decrease in mammography use was observed in all income quintiles and across all education levels. There were no significant changes to the slopes in the three years following the guideline release. Similar trends (significantly decreasing slope, increase in mammography use, no significant difference in slope three years after guideline release) were observed across neighbourhoods with a low, moderate, or high percentage of women who were immigrants or identified as a visible minority and among women in urban and rural areas (Table 2).

Alberta

Descriptive

A total of 788,131 women were included pre-intervention and 861,014 women were included post-intervention; demographic details are provided in Table 1. Overall, mammography use decreased post-intervention compared to pre-intervention (428 versus 465 per 1000 participant-months, respectively).

These trends were observed in women aged 40 to 74 years. In both the pre- and post-intervention periods, women in higher income quintiles had increased rates of mammography use compared to women in low income quintiles (Table 1). In Alberta, women residing in urban areas had higher rates of mammography use pre- and post-intervention as compared to women residing in rural areas.

ITS results

Among women aged 40 to 49 years, monthly screening mammography rates in Alberta were slightly decreasing before guideline release. Immediately following guideline release, there was a significant rate decrease of 3 per 1000 women who received a mammogram. This rate was sustained; however, the rate of women who received a mammogram did not decrease further during this period (post- minus pre-intervention slope difference 0.0015/1000, SE 0.02/1000, $p = 0.933$).

Among women aged 50 to 69 years, monthly screening mammography rates were stable. Immediately following the guideline release, there was a significant decrease of 2.9 per 1000 women who received a mammogram; this rate was sustained for the remainder of the study period (Figure 2, Table 3).

Figure 2. Alberta data.

Table 3. Interrupted time series results for Alberta data (per 1000).

Outcome	Regression coefficients	Estimate	StdErr	Probt
All women	Pre-intervention baseline rate level	22.4458	0.4425	<0.001
	Pre-intervention slope	-0.0253	0.0230	0.275
	Change in rate level (immediate effect post-intervention)	-1.8754	0.6446	0.005
	Change in rate trend (sustained impact post-intervention)	0.00002	0.0228	0.999
Women aged 40-49	Pre-intervention baseline rate level	17.8318	0.2892	<0.001
	Pre-intervention slope	-0.0330	0.0151	0.033
	Change in rate level (immediate effect post-intervention)	-3.0380	0.3222	<0.001
	Change in rate trend (sustained impact post-intervention)	0.0015	0.0181	0.933
Women aged 50-69	Pre-intervention baseline rate level	24.5529	0.5153	<0.001
	Pre-intervention slope	0.0104	0.0271	0.701
	Change in rate level (immediate effect post-intervention)	-2.9100	0.7874	<0.001
	Change in rate trend (sustained impact post-intervention)	0.0031	0.0262	0.906
Women aged 70-74	Pre-intervention baseline rate level	22.9821	0.6908	<0.001
	Pre-intervention slope	-0.0671	0.0335	0.050
	Change in rate level (immediate effect post-intervention)	0.7317	1.2270	0.553
	Change in rate trend (sustained impact post-intervention)	0.0095	0.0426	0.825
Income Q1	Pre-intervention baseline rate level	18.8552	0.4006	<0.001
	Pre-intervention slope	0.0178	0.0188	0.346
	Change in rate level (immediate effect post-intervention)	-2.3166	0.4793	<0.001
	Change in rate trend (sustained impact post-intervention)	-0.0244	0.0208	0.246
Income Q2	Pre-intervention baseline rate level	21.9090	0.4367	<0.001
	Pre-intervention slope	-0.0076	0.0230	0.743
	Change in rate level (immediate effect post-intervention)	-2.2720	0.6255	0.001
	Change in rate trend (sustained impact post-intervention)	-0.0132	0.0237	0.580
Income Q3	Pre-intervention baseline rate level	24.4766	0.5242	<0.001
	Pre-intervention slope	-0.0208	0.0269	0.443
	Change in rate level (immediate effect post-intervention)	-2.4265	0.7449	0.002
	Change in rate trend (sustained impact post-intervention)	-0.0036	0.0262	0.891
Income Q4	Pre-intervention baseline rate level	26.1657	0.5731	<0.001
	Pre-intervention slope	-0.0346	0.0294	0.243
	Change in rate level (immediate effect post-intervention)	-2.2011	0.7877	0.007
	Change in rate trend (sustained impact post-intervention)	-0.0048	0.0289	0.867

Table 3. *Continued*

Outcome	Regression coefficients	Estimate	StdErr	Probt
Income Q5	Pre-intervention baseline rate level	28.7066	0.5406	<0.001
	Pre-intervention slope	−0.0621	0.0270	0.025
	Change in rate level (immediate effect post-intervention)	−2.1283	0.8175	0.011
	Change in rate trend (sustained impact post-intervention)	0.0219	0.0265	0.411
Urban	Pre-intervention baseline rate level	25.1714	0.4877	<0.001
	Pre-intervention slope	−0.0313	0.0255	0.23
	Change in rate level (immediate effect post-intervention)	−2.1717	0.7107	0.003
	Change in rate trend (sustained impact post-intervention)	0.0040	0.0253	0.876
Rural	Pre-intervention baseline rate level	16.8876	0.3954	<0.001
	Pre-intervention slope	0.0310	0.0185	0.098
	Change in rate level (immediate effect post-intervention)	−2.4010	0.5681	<0.001
	Change in rate trend (sustained impact post-intervention)	−0.0589	0.0214	0.008

Among women aged 70 to 74 years, monthly screening mammography rates were stable before the guideline release. Immediately following the guideline release, there were no significant changes in the rate of women aged 70 to 74 who received a mammogram.

All strata (by age, income quintile, rural/urban region) experienced significant drops in mammography rates at intervention, with the exception of women 70 to 74 years. Prior to the intervention, most slopes were stable pre- and post-intervention with the exception of women 40 to 49 years (rate decreased immediately post-intervention) and women in high income quintiles, who demonstrated a slight decrease in mammography use prior to guideline release (Income Q5, see Table 3). Trends were stable three years following guideline release, with the exception of women living in rural areas, for whom mammography rates continued to decrease over time.

Discussion

In comparing rates of mammography screening following guideline dissemination, we observed trend differences in the two provinces. Overall, Alberta women underwent less mammography screening both pre- and post-guideline dissemination compared to Ontario women. In both provinces, fewer women underwent mammography in the 36 months after guideline dissemination compared to the same period before guidelines were released. In Ontario, mammography rates among women aged 40 to 49 years decreased immediately following guideline release and increased for women aged 50 to 74, in keeping with the guideline recommendations. In Alberta, mammography use decreased for women aged 40 to 69 and did not significantly change among women aged 70 to 74. In Ontario, mammography use decreased overall following guideline release across all income quintiles and education levels and among women living in both urban and rural areas. Similarly, in Alberta, mammography decreased among women in all income quintiles and decreased for women living in both urban and rural areas; the rate of mammography use continued to decrease among women living in rural areas in Alberta.

In both Ontario and Alberta, mammography among women aged 40 to 49 years immediately decreased following guideline release. This decrease may correlate with the difference in screening recommendations in the 2011 guideline compared to the previous 2001 Task Force guideline, which suggested that upon reaching the age of 40, women should consider the benefits and risks of screening to determine whether to begin routine mammography between 40 and 49 or whether to delay until age 50.⁷ Similarly, rates of mammography among women aged 50 to 59 in Alberta may have decreased following the recommendation for extending screening intervals to 2 to 3 versus 1 to 2 years.^{25,26}

Our results are similar to findings reported in the United States (U.S.), where an overall decline in mammography for women aged 40 to 49 years was observed post-dissemination of the 2009 U.S. Preventive Services Task Force guidelines.^{27–29} For women aged 50 to 69 years, U.S. studies showed a decline in mammography following release of their national guidelines, which were similar to the Task Force recommendations.^{27–29} Given the Canadian Task Force's weak (or 'conditional') recommendation to screen women aged 50 to 69 and advice to engage in shared decision making about screening, fewer women may have decided not to undergo screening.⁴

Higher income levels were associated with more screening. These results are similar to those from other studies of breast cancer screening conducted in the U.S.^{30–34} and Canada.³⁵ In Ontario, women living in rural areas had higher mammogram screening rates compared to women living in urban areas; this may indicate the effect of organized screening programs in rural communities. Additional studies further examining trends in Canadian breast cancer screening, particularly following the most recent 2018 release of the Task Force's breast cancer guideline update, may provide further insights into these trends.

There are several limitations to this study. Firstly, individual level data (such as exact age, education status, ethnicity) were not available; rather, these data were available as categories, and education and immigration status were only available at a neighbourhood level. Consequently, we were not able to investigate the impact of patient level factors on screening activities. Secondly, there may have been other interventions targeting breast cancer screening in Ontario and Alberta during the study periods. In Ontario, for instance, **Cancer Care Ontario** launched a campaign to increase screening for breast, cervical, and prostate cancer in November 2012. This media campaign encouraged people to send cards to friends and family to undergo cancer screening. However, the Task Force engaged provincial partners on the guidelines and we were not able to identify any large-scale strategies that may have overlapped with dissemination. An additional confounder may be that pay-per-performance models (meaning practitioners receive compensation based on their activities, such as screening, and not a standard salary) were introduced in Ontario at this time; however, the models don't definitively explain the trends observed in this study, as the literature is not conclusive on the impact of these models on rates of breast cancer screening.^{36,37} In addition, we were not able to assess the use of shared decision making, which was recommended in the guideline, as these data are not captured in administrative databases. Finally, these data were not created to answer the specific research question, which is a limitation of all population-level administrative database studies.

In summary, the decline in mammography for women aged 40 to 49 years was in alignment with guideline recommendations. Future strategies should focus on optimizing implementation of the recommendations for women aged 50 to 74 years. This requires understanding barriers to behavioural changes at the clinician and patient level and investigating the use of shared decision making.

Data availability

Underlying data

The datasets generated and analysed during the current study are not publicly available. They could potentially be made available with assistance from the corresponding author, if for the purpose of further research. Obtaining Ontario data which are owned by the Ontario Ministry of Health and Long-Term Care would require providing a research protocol and consultation with ICES, who will also request a budget be submitted for data access and analysis. Researchers could alternatively request to obtain a **similar dataset** for Alberta or **Ontario data**.

Extended data

Open Science Framework: Changes in mammography screening in Ontario and Alberta following national guideline dissemination: an interrupted time series analysis. <http://doi.org/10.17605/OSF.IO/5H2T8>.³⁸

This project contains the following extended data:

- Supplementary File 1: Sustaining Change_OntarioandAlbertaPopulationData
- Supplementary File 2: Supplementary File 2_Sustaining Change_OntarionandAlbertaCodes

Data are available under the terms of the **CC0 1.0 Universal (CC0 1.0) Public Domain Dedication**.

Disclaimer

This study is based in part by data provided by Alberta Health and Alberta Health Services. The interpretation and conclusions contained herein are those of the researchers and do not represent the views of the Government of Alberta or

Alberta Health Services. Neither the Government of Alberta nor Alberta Health Services express any opinion in relation to this study.

Acknowledgements

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Reviewer Report 20 September 2022

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Jacqueline M. Hirth

Baylor College of Medicine, Houston, USA

Judith Gutierrez

Baylor College of Medicine, Houston, TX, USA

Tiffany Ostovar-Kermani

Baylor College of Medicine, Houston, TX, USA

This manuscript described the change in mammography screening, as a rate of screenings per 1000 participant months, in Ontario and Alberta, Canada, before and after a national change in guideline on mammography. While the topic is important in assessing the impact of guidelines on practice, there are some issues the authors may want to consider addressing to strengthen their manuscript.

General

1. In the abstract and body of the paper, the new guidelines are described as “weak recommendations.” This description gives the impression that the authors may feel that the guidelines are inappropriate. Therefore, we suggest that this wording be amended to, “recommendations based on weak evidence.” This would help an international audience get a clearer picture of what is meant by the authors.
2. The purpose of the paper is not well-developed. There is mention of a dissemination strategy, which is discussed in the methods, but does not seem to be tested for or mentioned in the conclusion. If there was no comparison for differences in dissemination strategies, then it appears that the manuscript evaluates the effect of the guideline change on mammography rates, but not dissemination strategy of the guidelines. We recommend changing the second to last paragraph in the introduction to reflect that dissemination strategy was not assessed and the methods section to reflect that it was the change in guidelines that was assessed rather than the dissemination strategy.

Abstract

1. Amend description of “weak recommendations” to “recommendations based on weak evidence.”

2. Recommend removing information about dissemination strategy in line with recommendations above.
3. Recommend clarifying that “trends in mammography use rates” be changed to “declining trends in mammography use rates” in last sentence of results in abstract. Consider removing standard errors to stay within word limit.
4. Recommend changing conclusion to indicate that it was the guideline that changed uptake, rather than the dissemination strategy.
5. The conclusion does not match the results in the abstract. The results indicate a decrease in mammography trends, but the conclusion indicates that there was an increased uptake in guideline-concordant screening practice. As this was not actually assessed (would require individual level data) the conclusion would be more accurate if discussed along the lines of, “decreasing trends in mammography rates among 40-49 year old women indicated that this group may be receiving fewer screenings, possibly in response to the new guidelines.”

Introduction

1. The dissemination strategy was not elaborated on in the introduction. Since this study did not test the dissemination strategy, it is recommended that the description of the strategy be moved from Methods section to the Introduction section.
2. Change “weak recommendations” to “recommendations based on weak evidence.”

Methods

1. We recommend reorganization of the methods section.
 1. Begin with the setting and participants with integration of the dates of data collection in the current first sentence, followed by the ethics statement then Outcomes and statistical analysis.
 2. We recommend that the description of the dissemination strategy be shortened and included in the Introduction section.
 3. We recommend that the statistical analyses used (ITS) be moved to the statistical analyses section. The method used for this study looked like a retrospective population surveillance study.
 4. Provide a justification for using interrupted times series analyses in the statistical analyses section.

Results

1. Were the women included in the study cohorts? This was mentioned in sentence 1 of Results section. With shifting ages across the timeline, it seems they could be described as the “study population,” as women would shift into different age groups across the times assessed.
2. Recommend using p-value designation of <0.001 in last column of tables where currently 0.0000 is listed, as these are more accepted statistical notations in the literature.
3. In the Alberta results section, Alberta was mentioned in the text as well as subheading.

Would be more clear if the Ontario section was written in similar fashion. At first I thought that the total population estimates were for the entire study, not just Ontario.

Discussion

1. It appears new results are added in first paragraph. We saw no evidence of direct comparisons of mammography rates between Alberta and Ontario in the results section. Recommended to amend statistical analyses section and results section accordingly. The first paragraph of the Discussion section could then be the final paragraph of the Results section.
2. Last sentence in 3rd paragraph not clear. If fewer women decided not to undergo screening, wouldn't the trend have been positive after guideline implementation?
3. Consider subheadings for Limitations and Conclusion sections.
4. The Conclusion section in the Discussion appears to differ from the conclusion in the Abstract.
5. Given the importance placed on shared decision-making in the conclusion, more context could be given in the Introduction and/or Discussion section(s).

Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Partly

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Yes

Are all the source data underlying the results available to ensure full reproducibility?

Partly

Are the conclusions drawn adequately supported by the results?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Population health, primary and secondary cancer prevention, women's health

We confirm that we have read this submission and believe that we have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however we have significant reservations, as outlined above.

Author Response 02 Nov 2022

Christine Fahim

Response to Reviewer 2

This manuscript described the change in mammography screening, as a rate of screenings per 1000 participant months, in Ontario and Alberta, Canada, before and after a national change in guideline on mammography. While the topic is important in assessing the impact of guidelines on practice, there are some issues the authors may want to consider addressing to strengthen their manuscript.

General

1. In the abstract and body of the paper, the new guidelines are described as “weak recommendations.” This description gives the impression that the authors may feel that the guidelines are inappropriate. Therefore, we suggest that this wording be amended to, “recommendations based on weak evidence.” This would help an international audience get a clearer picture of what is meant by the authors.

Thank you for this comment. Our language is consistent with that of GRADE methodology (<https://bestpractice.bmj.com/info/toolkit/learn-ebm/what-is-grade/>; PMID: PMC4364259) that provides a tool for rating the quality of evidence for clinical guidelines. GRADE recommendations can be ‘strong’ or ‘weak’ depending on the strength of the evidence. According to the GRADE definition, “weak recommendations imply that there is likely to be an important variation in the decision that informed persons are likely to make.. a weak recommendation indicates that engaging in a shared decision making process is essential, while a strong recommendation suggests that it is not usually necessary to present both options” (Siemieniuk and Guyatt, BMJ). Because the Canadian Task Force used GRADE methodology to develop their guideline and recommendations, we believe it is important to refer to the terms that the guideline developers used. However, we appreciate the author’s guidance that ‘weak recommendations’ may be unclear and we have ensured details around GRADE methodology have been included in the introduction.

2. The purpose of the paper is not well-developed. There is mention of a dissemination strategy, which is discussed in the methods, but does not seem to be tested for or mentioned in the conclusion. If there was no comparison for differences in dissemination strategies, then it appears that the manuscript evaluates the effect of the guideline change on mammography rates, but not dissemination strategy of the guidelines. We recommend changing the second to last paragraph in the introduction to reflect that dissemination strategy was not assessed and the methods section to reflect that it was the change in guidelines that was assessed rather than the dissemination strategy.

Thank you for this important point. The dissemination strategy was passive and was disseminated via avenues considered ‘routine’ for primary care practitioners (including via a leading Canadian medical journal, at conferences, etc.) The aim was to determine mammography trends following release of the guideline and the dissemination strategy, rather than test the dissemination strategy in a controlled study design. We recognize that the findings may not be causally linked to the dissemination strategy, and we have amended our introduction to clarify the purpose and outline potential confounders in our limitations section. We have also clarified

the study objective in the introduction.

Abstract

1. Amend description of “weak recommendations” to “recommendations based on weak evidence.”

In order to remain consistent with GRADE language, we have revised this sentence to “weak recommendations based on GRADE terminology (i.e., the benefits and risks are closely balanced and/or uncertain).”

2. Recommend removing information about dissemination strategy in line with recommendations above.

Thank you, we have removed “dissemination strategy targeting primary care physicians” from the abstract and the sentence in the abstract now reads “We conducted an interrupted time series analysis using administrative data to examine bilateral mammography use before and after release of a national breast cancer screening guideline”.

3. Recommend clarifying that “trends in mammography use rates” be changed to “declining trends in mammography use rates” in last sentence of results in abstract. Consider removing standard errors to stay within word limit.

Thank you for this comment. The trends did not decline in all cases. While we saw a decrease in screening for all women in Ontario, and for women aged 40-69 in Alberta, we did not see a decrease among women aged 70-74 in Alberta.

4. Recommend changing conclusion to indicate that it was the guideline that changed uptake, rather than the dissemination strategy.

Thank you, we have revised the concluding sentence.

5. The conclusion does not match the results in the abstract. The results indicate a decrease in mammography trends, but the conclusion indicates that there was an increased uptake in guideline-concordant screening practice. As this was not actually assessed (would require individual level data) the conclusion would be more accurate if discussed along the lines of, “decreasing trends in mammography rates among 40-49 year old women indicated that this group may be receiving fewer screenings, possibly in response to the new guidelines.”

Thank you for this comment. We have revised the wording as suggested by the reviewer.

Introduction

1. The dissemination strategy was not elaborated on in the introduction. Since this study did not test the dissemination strategy, it is recommended that the description of the strategy be moved from Methods section to the Introduction section.

Thank you; our goal was to evaluate the impact of guideline release, which was disseminated using a national strategy. We thus have kept the description of the strategy in the methods section. We recognize there are limitations to drawing conclusions of impact of the strategy, which we have outlined in the limitations.

2. Change “weak recommendations” to “recommendations based on weak evidence.”

Please see comments above regarding consistency with GRADE language.

Methods

We recommend reorganization of the methods section.

1. Begin with the setting and participants with integration of the dates of data collection in the current first sentence, followed by the ethics statement then Outcomes and statistical analysis.

Thank you for this suggestion. We have reorganized the methods section accordingly.

2. We recommend that the description of the dissemination strategy be shortened and included in the Introduction section.

Thank you, please see above comment for our rationale.

3. We recommend that the statistical analyses used (ITS) be moved to the statistical analyses section. The method used for this study looked like a retrospective population surveillance study.

Thank you, we have provided details on the ITS in the statistical analysis section.

4. Provide a justification for using interrupted times series analyses in the statistical analyses section.

Thank you, this has been provided.

Results

1. Were the women included in the study cohorts? This was mentioned in sentence 1 of Results section. With shifting ages across the timeline, it seems they could be described as the “study population,” as women would shift into different age groups across the times assessed.

Thank you for this comment. We have revised “cohorts” to “study populations”.

2. Recommend using p-value designation of <0.001 in last column of tables where currently 0.0000 is listed, as these are more accepted statistical notations in the literature.

Thank you for this suggestion, we have updated the tables accordingly.

3. In the Alberta results section, Alberta was mentioned in the text as well as subheading. Would be more clear if the Ontario section was written in similar fashion. At first I thought that the total population estimates were for the entire study, not just Ontario.

Thank you for this suggestion, we have added "in Ontario" to provide clarity for this section.

Discussion

1. It appears new results are added in first paragraph. We saw no evidence of direct comparisons of mammography rates between Alberta and Ontario in the results section. Recommended to amend statistical analyses section and results section accordingly. The first paragraph of the Discussion section could then be the final paragraph of the Results section.

Thank you. We have moved the first paragraph of the discussion to the results.

2. Last sentence in 3rd paragraph not clear. If fewer women decided not to undergo screening, wouldn't the trend have been positive after guideline implementation?

We observed a decrease in screening rates for all women, except for those aged 70-74 in Alberta.

3. Consider subheadings for Limitations and Conclusion sections.

Thank you for this suggestion. We have added subheadings for Limitations and Conclusions.

4. The Conclusion section in the Discussion appears to differ from the conclusion in the Abstract.

Thank you; we have revised our wording to ensure consistency and clarity.

5. Given the importance placed on shared decision-making in the conclusion, more context could be given in the Introduction and/or Discussion section(s).

Thank you; we have added included wording on shared decision making in the introduction, and have also described the concept in the 'intervention' section of the methods.

Competing Interests: No competing interests.

Reviewer Report 20 September 2022

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Sisse Helle Njor

¹ Randers Regional Hospital, Randers, Denmark

² Aarhus University, Aarhus, Denmark

Page 4, 'Setting and participants' line 2: What information did you receive from the Cancer Registry?

Page 4, 'Setting and participants' last 2 lines: For readers that do not know the system it would be nice to know what '1 hospitalization or 2 claims in 2 years' means.

Page 4, 'Outcomes' line 7: '.... was considered a duplicate if repeated within seven days...' Does this mean that two mammograms are included if they are more than 7 days apart. If yes, the authors should discuss how this has affected their results

Page 5, 'Statistical analysis', line 1: How is participant-month defined and calculated?

Page 5, 'Descriptive', line 2: It would be nice to have proportions in table 1, so that it is easy to see that the cohorts had similar demographic characteristics.

Page 10, 'ITS results': It is surprising that the decrease for 40-49y is almost similar in Alberta and Ontarios as the decrease seem to be quite larger in Alberta, when you look at figure 1 and 2.

Page 12, 'Discussion', last 2 lines: Please explain why we then also see a decrease in Ontario among those aged 50-69y. At the moment there is only an explanation for Alberta. A minor thing: Shouldn't 50 to 59 be 50 to 69?

Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Partly

Are sufficient details of methods and analysis provided to allow replication by others?

Partly

If applicable, is the statistical analysis and its interpretation appropriate?

Yes

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Evaluation of cancer screening

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 02 Nov 2022

Christine Fahim

Response to Reviewer 1

Page 4, 'Setting and participants' line 2: What information did you receive from the Cancer Registry?

Thank you for this question. The Ontario Cancer Registry (OCR) was used to exclude women from the analysis – specifically those with a history of breast cancer prior to the start of the study period. We used dxcode = 174.x, where x is any digit. Women with mastectomy at any time prior to the start of the period were also excluded.

Page 4, 'Setting and participants' last 2 lines: For readers that do not know the system it would be nice to know what '1 hospitalization or 2 claims in 2 years' means.

Thank you. This refers to our exclusion of women with hospitalization of breast cancer or malignant neoplasm of the breast; we have specified this in the manuscript.

Page 4, 'Outcomes' line 7: '... was considered a duplicate if repeated within seven days...' Does this mean that two mammograms are included if they are more than 7 days apart. If yes, the authors should discuss how this has affected their results.

Thank you for this comment. We did not explore the number of mammograms per woman; rather, whether a woman received a mammogram, or not, within the study period.

Page 5, 'Statistical analysis', line 1: How is participant-month defined and calculated?

Thank you for flagging this. Our interrupted time series was calculated as the number of monthly screening tests divided by the total number of women at risk at the beginning of the month. We have clarified this in the methods and have removed use of the term 'participant month' to avoid confusion.

Page 5, 'Descriptive', line 2: It would be nice to have proportions in table 1, so that it is easy to see that the cohorts had similar demographic characteristics.

Thank you, in addition to the totals, we provide the rates per 1000 women to allow for comparisons across the pre/post guideline groups.

Page 10, 'ITS results': It is surprising that the decrease for 40-49y is almost similar in Alberta and Ontario as the decrease seem to be quite larger in Alberta, when you look at figure 1 and 2.

Thank you for this comment. In Ontario, screening for women 40-49years was increasing before the guideline release and decreased by 2.21/ 1000 women immediately following release. In Alberta, mammography screening was slightly decreasing pre guideline release. Following the release there was a decrease of 3/1000 women.

Page 12, 'Discussion', last 2 lines: Please explain why we then also see a decrease in Ontario among those aged 50-69y. At the moment there is only an explanation for Alberta. A minor thing: Shouldn't 50 to 59 be 50 to 69?

Thank you for this comment. We did not observe a decrease in Ontario for those 50-69. Rather, we observed an increase of 3.8/1000 women who underwent mammography screening. With respect to Alberta, mammography decreased for women aged 40-49 and for women aged 50-69, but increased slightly for women aged 70-74 (please see Table 3). We therefore indicate that "in Alberta, mammography use decreased for women aged 40-69".

Competing Interests: No competing interests to disclose.

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