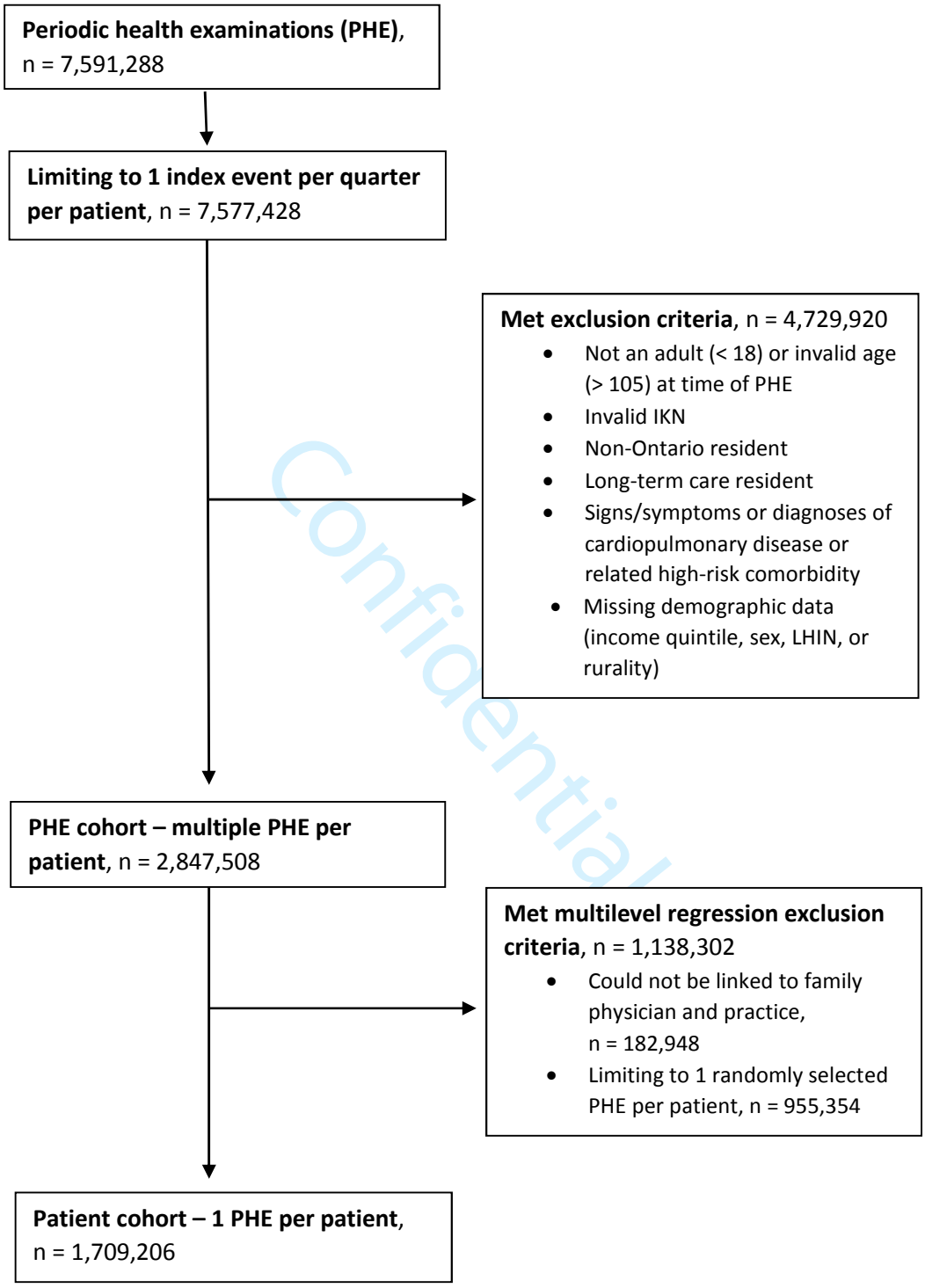
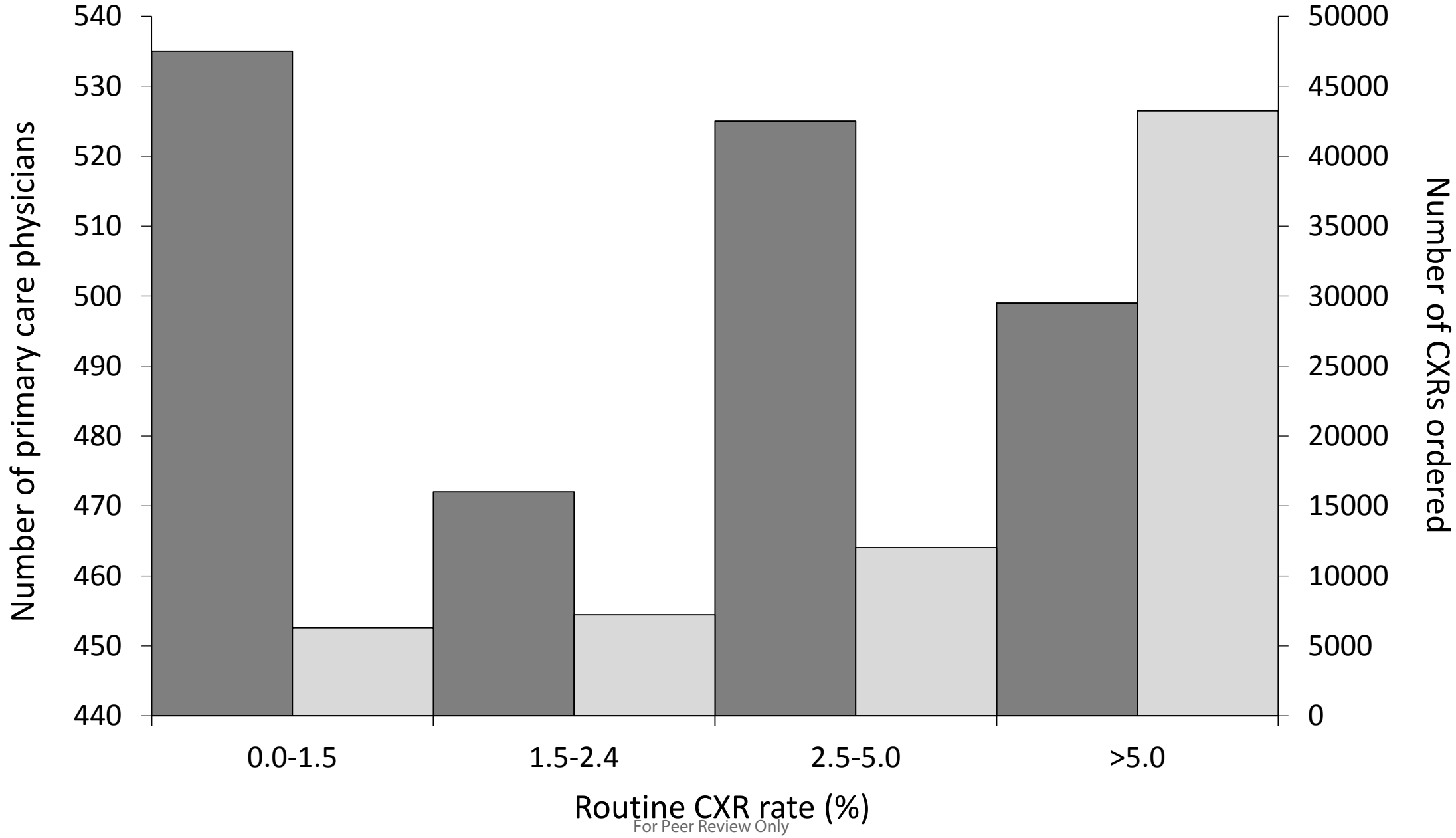
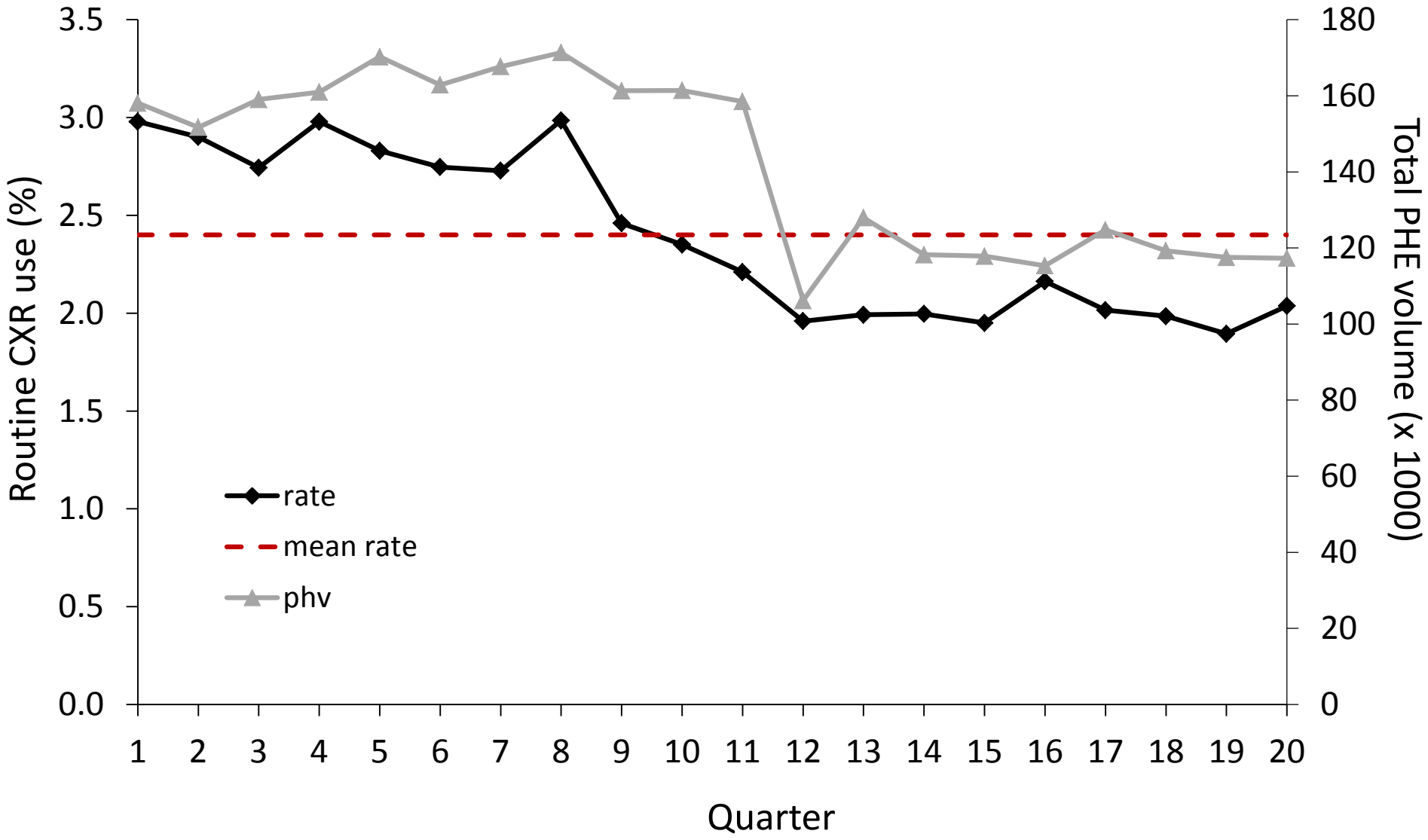
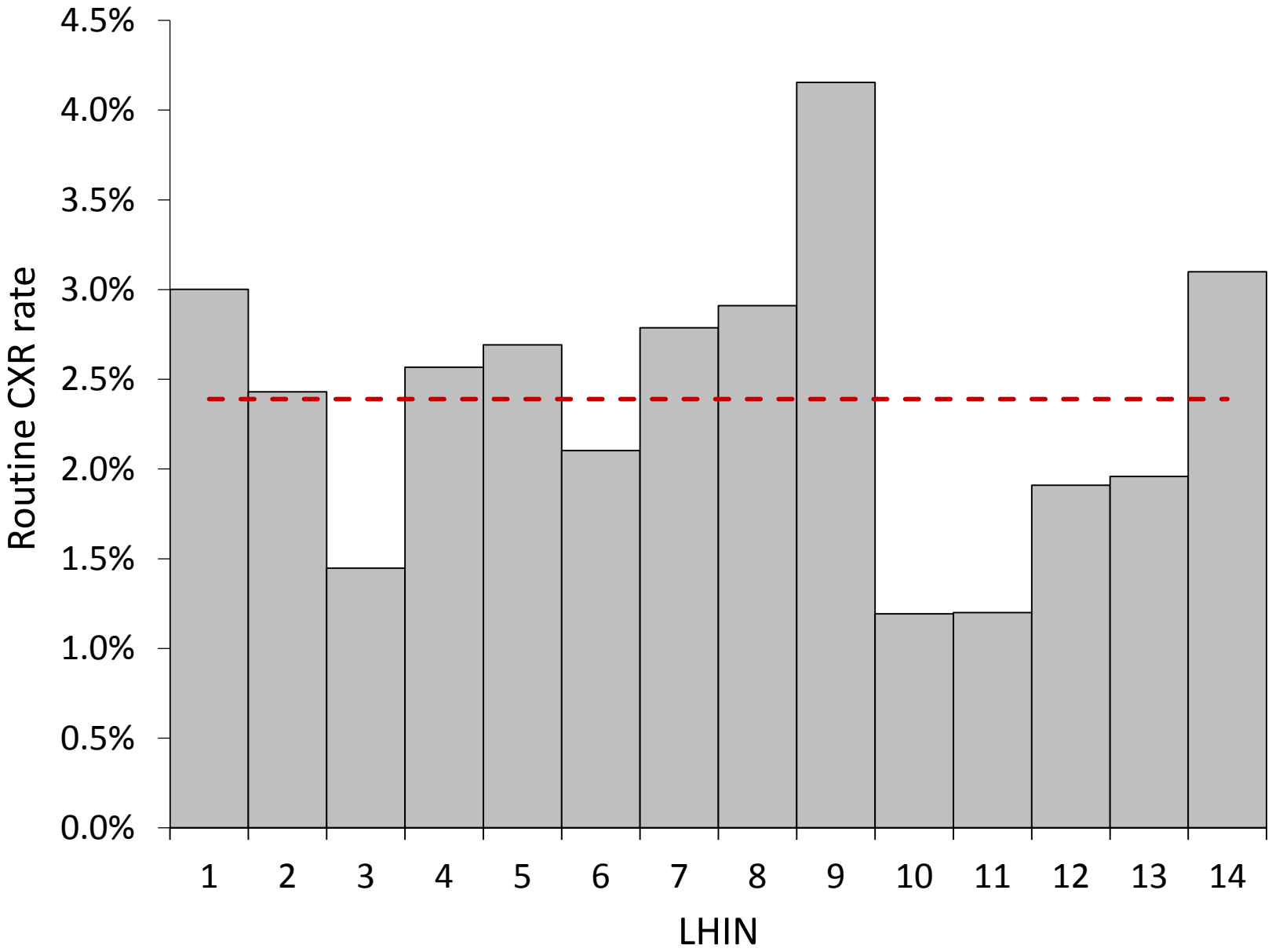
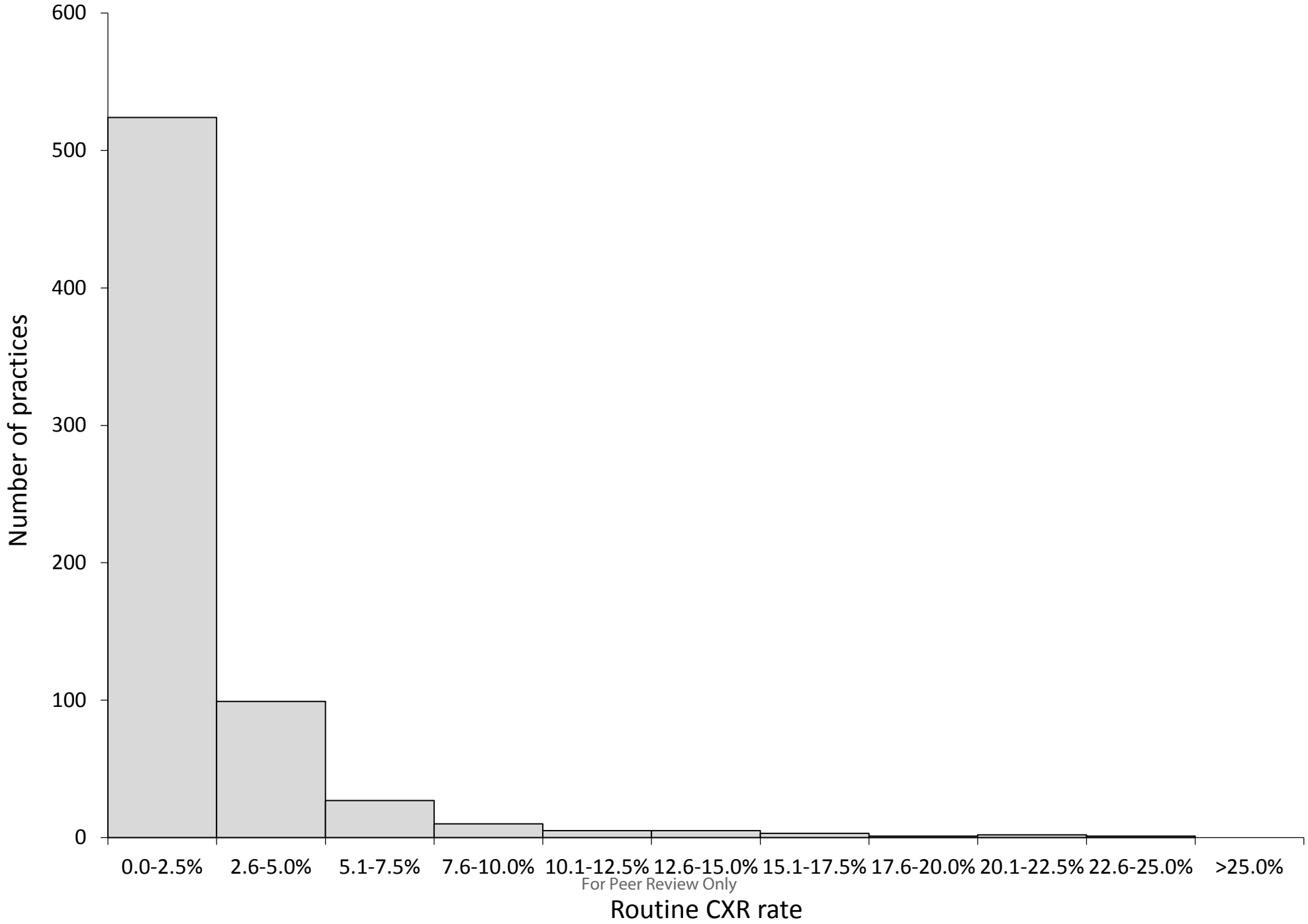
Figure 1. Cohort creation.











STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any pre-specified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	4-5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4-6
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4-6
Bias	9	Describe any efforts to address potential sources of bias	6-7
Study size	10	Explain how the study size was arrived at	4,6,8, Figure 1
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6,7
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	5,6 Figure 1
		(*d*) Describe any sensitivity analyses	9

Results			**Page #**
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Figure 1
		(b) Give reasons for non-participation at each stage	Figure 1
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	Figure 1
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	8
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	8,9, Table 1
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8,9 Table 2
		(*b*) Report category boundaries when continuous variables were categorized	8,9, Table 2
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9
Discussion			
Key results	18	Summarise key results with reference to study objectives	10-11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	10-11
Generalisability	21	Discuss the generalisability (external validity) of the study results	11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	1

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Routine chest X-ray use for low-risk patients undergoing a periodic health examination: a retrospective cohort study

Brief title: Routine chest X-rays for low-risk patients

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Funding: This study was supported by the Institute for Clinical Evaluative Sciences (ICES), which is funded in part by an annual grant from the Ontario Ministry of Health and Long-Term Care (MOHLTC). The funders had no role in the design and conduct of the study; the collection, management, analysis or interpretation of the data; the preparation, review or approval of the manuscript; or the decision to submit the manuscript for publication. The opinions, results and conclusions reported in this paper are those of the authors and are independent from the funding sources. No endorsement by ICES or the Ontario MOHLTC is intended or should be inferred. Parts of this material are based on data and information compiled and provided by CIHI. However, the analyses, conclusions, opinions and statements expressed herein are those of the author, and not necessarily those of CIHI. NM Ivers is supported by a New Investigator Award from the Canadian Institute of Health Research and the Department of Family and Community Medicine at the University of Toronto. RH Glazier is supported as a Clinician Scientist in the Department of Family and Community Medicine at St. Michael's Hospital and at the University of Toronto. RS Bhatia is supported by a Clinician Investigator Award from the Heart and Stroke Foundation of Canada and the F.M. Hill Chair in Health Systems Solutions at Women's College Hospital.

Competing interests: All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organization for the submitted work; no financial relationships with any organizations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

Key words: low-value care, chest radiography

Word count (excluding references, in-text citations, figures, tables, appendices): main paper 2646/2500; abstract 270

ABSTRACT

Background

Many evidence-based recommendations advocate against the use of routine chest X-rays (CXRs) for asymptomatic, low-risk outpatients; however, it is unclear how regularly CXRs are ordered in primary care. Our study aims to describe the frequency of, and variation in, routine CXR use in low-risk outpatients among primary care physicians.

Methods

A retrospective cohort study of Ontario residents aged 18 and older with a periodic health examination (PHE) between April 1st, 2010 and March 31st, 2015 was identified via administrative claims data. Patients with recent history (last three years) of any of the following were excluded: cardiac or pulmonary disease; high-risk comorbidity (e.g. diabetes); consultations/visits or procedures involving cardiac or pulmonary specialists; cancer; and/or severe chest trauma. The primary outcome, a routine CXR, was defined as at least one CXR claim within 7 days after a PHE.

Results

While a routine CXR only followed 2.4% of 2,847,508 PHEs, one quarter of family physicians (499/2,031) ordered CXRs for more than 5.0% of their PHEs (interquartile range 1.5%-5.0%) and accounted for 62.9% of all tests observed. Routine CXR use declined by 2.0% per quarter (adjusted rate ratio 0.98, 95% confidence interval [CI] 0.97-0.98). Older age (45-64 v 18-44, adjusted odds ratio [OR] 1.82, 95% CI 1.78-1.86; 65+ vs 18-44, adjusted OR 2.48, 95% CI 2.39-2.58) and male sex – patient (OR 2.19, 95% CI 2.14-2.24) and provider (OR 1.55, 95% CI 1.51-1.59) – were significantly associated with increased odds of a routine CXR.

Interpretation

Ordering a CXR as part of a PHE is relatively uncommon in Ontario; however, the substantial variation observed among physicians suggests potential for interventions targeted at the most frequent users.

INTRODUCTION

Chest radiography can assist in the diagnosis and management of cardiac and respiratory disease; however, there are many scenarios in which chest X-rays (CXRs) are low-value as the benefits of testing are unclear or offset by the potential for patient harm[1-4]. For example, the Canadian Association of Radiologists labels the use of routine chest radiography for a periodic health examination (PHE) – a service involving an outpatient with unremarkable history and physical examination – as not indicated due to low clinical value[4-7]. As primary care physicians are typically responsible for conducting PHEs, the College of Family Physicians of Canada identified routine CXRs in their Choosing Wisely 'top ten' list of low-value tests, treatments, and procedures that patients and physicians should question[8].

The limited utility of routine radiographs may be best evidenced by a cohort study of 1,282 primary care outpatients who received a CXR despite the absence of thoracic symptoms[9]. The authors found that only 1.2% of CXRs detected a major abnormality. Upon further inspection, 93% of these findings were false positives and none required treatment[9]. Due to its trivial diagnostic yield and high false positive rate, routine CXR for asymptomatic, low-risk outpatients often confers no clinical benefit, while leading to additional unnecessary services (e.g. advanced imaging, procedures and consultations) that can pose additional patient harms and system costs[5-7,9-11].

Despite extensive evidence against routine CXRs for asymptomatic or low-risk outpatients, the frequency with which family physicians are ordering these tests as part of a PHE is unknown. We aim to quantify the frequency of, and variation in, routine CXR use among health regions, practices, and individual physicians. Furthermore, we will assess temporal trends in province-wide use, and investigate patient- and provider-level characteristics associated with routine CXR use.

METHODS

Setting, study design and data sources

We conducted a retrospective cohort study in Ontario, Canada between fiscal years 2010 and 2014, using population-based administrative health care databases. The datasets were linked using unique encoded identifiers and analyzed at the Institute for Clinical Evaluative Sciences (ICES). The Ontario Health Insurance Plan (OHIP) claims database contains all billing claims made by Ontario physicians, whose demographic information is captured in the ICES Physician Database. The Registered Persons Database contains demographic information on all Ontario residents eligible for OHIP coverage. Client Agency Program Enrolment (CAPE) tables were cross-referenced with OHIP claims to identify patients rostered to primary care physicians, as well as groups of three or more physicians who submitted joint billing to the Ontario Ministry of Health and Long-Term Care (herein referred to as a practice)[12-14]. The Discharge Abstract Database and National Ambulatory Care Reporting System respectively contain inpatient hospitalization and emergency department visit records, which are both coded using the *International Classification of Diseases, Tenth Revision, Canada* (ICD-10-CA) and the Canadian Classification of Interventions (CCI) coding systems.

C*ohort selection*

Our cohort consisted of Ontario residents aged 18 and older with a valid provincial OHIP number who had at least one periodic health examination (PHE) – an annual health examination (A003 with diagnostic code 917) or periodic health visit (K131 or K132) – with a family physician between April 1st, 2010 and March 24st, 2015[12,15,16]. These codes are representative of a PHE, as they describe screening and prevention services performed on patients without apparent medical problems on the basis of history or examination[12,15,16]. The K131 and K132 codes were introduced in January 2013 to provide a more flexible alternative to the annual health examination with the expressed intention of reducing low-value examinations and tests[11,16-19]. We included one PHE per patient per quarter within the observation window[20]; however, OHIP guidelines limit reimbursement beyond one PHE per patient per 12-months per physician[16]. We excluded patients with incomplete demographic information and long-term care residents[12].

Additional exclusions were created by adapting the Canadian Association of Radiologists' (CAR) standards and referral guidelines for chest radiography (specifically the cardiovascular, thoracic, cancer, and trauma sections) to identify clinical scenarios in which CAR recommends CXR investigations are 'indicated', i.e. most likely to contribute to diagnosis or management[4,6,17]. We subsequently excluded patients with any of the following documented indications: signs/symptoms (e.g. dyspnea) or prior diagnosis of cardiac or respiratory disease; prior cardiac or thoracic surgery (e.g. aortic valve replacement); cancer diagnosis; or severe thoracic trauma or injury (e.g. pneumothorax)[4,17]. Patients with a high-risk comorbidity diagnosis (e.g. HIV/AIDS) or a prior consultation with a cardiac or respiratory disease specialist were also excluded[10,12,21,22]. All exclusions, detailed in **Appendix 1.1**, were applied using a three-year lookback window from the index PHE.

Routine CXR use

Our primary outcome was receipt of at least one CXR within 7 days after a PHE, assessed using OHIP claims[4,12]. We excluded CXRs that could not be linked to the physician who conducted the PHE or those performed during an emergency department visit or hospitalization (**Appendix 1.2**). Concurrent with the 2013 PHE billing changes, the OHIP *Schedule of Benefits* added statements against the reimbursement of routine CXR including investigations done as part of a PHE[11,16-18].

A short observation window was preferred to increase the likelihood an observed CXR was ordered as part of a PHE. A preliminary analysis supported a seven-day window by revealing that the majority of CXR claims within 30 days post-PHE (70.4%) occurred within the first week (**Appendix 1.3**).

Covariates

Time was compartmentalized into 20 quarters within our study window. We also captured patient-, physician-, and practice-level characteristics that have been previously associated with receipt of low-value care (**Appendix 1.4**)[12,24]. Demographic data was collected on both patients (age, sex, and rurality) and physicians (sex, years since graduation, International Medical Graduate status)[12,24]. Patients' socioeconomic status was approximated via quintiles of median neighbourhood income[25]. Patients with a hospitalization for a non-cardiopulmonary

reason within the past five years were identified[12]. Patient history of dementia and rheumatologic disease within the past five years, as well as receipt of any mental health care in the past year, was also noted[12]. Payment model was recorded per practice[12].

Statistical analysis

Routine CXR rates were calculated over time (by quarter) and by region (Local Health Integrated Network [LHIN]), practice, and physician. Variation was assessed via interquartile ranges and coefficients of quartile deviation ([Q3-Q1]/[Q3+Q1])[12,26].

Temporal trends in routine CXR use were analyzed via negative binomial regression with the number of routine CXR as the dependent variable, quarter as a continuous independent variable, and the log number of PHE as an offset term. To account for seasonality, three indicator variables were created to represent the quarter in which a PHE occurred irrespective of fiscal year. Rate ratios with 95% confidence intervals (CI) were calculated to assess the effect of explanatory variables on CXR use. Total PHE billing volume over time was independently analyzed via negative binomial regression. Utilization was modelled rather than associated cost as the CWC campaign's primary focus is on reducing the frequency of potentially harmful low-value care, rather than cost savings[23].

Mixed-effects logistic regression was used to analyze patients' odds of having a routine CXR while adjusting for all covariates detailed in the preceding section. Fixed effects were expressed via odds ratios with 95% CI. Random intercepts, included to account for within-practice correlation, enabled calculation of the median odds ratio (OR) – a measure of practice-level variation in the outcome adjusted for all other factors in the model – and the intraclass correlation coefficient[27-29]. If one were to calculate the OR for each pair of patients with the same covariates from different practices, while always placing the patient at higher risk in the numerator (OR $\geq$1), the median of the resulting OR distribution is the median OR[27-29]. The median OR is directly comparable to a fixed effect OR[27-29]. For example, a median OR of 1.50 suggests that, in the median case, a patient has 50% higher odds of having a routine CXR if their examination occurs at one randomly selected practice versus another[27]. Only PHEs involving a patient linked to an identifiable family physician and practice were included in the regression sample. We were unable to model physician-specific intercepts and repeated, patient-level

measures with random effects due to computational issues. We randomly sampled one PHE per patient to facilitate convergence without introducing temporal bias[30].

All analyses were performed using SAS version 9.4 (SAS Institute) at a significance level of $P \leq 0.05$. The use of data in this project was authorized under section 45 of Ontario's *Personal Health Information Protection Act*, which does not require review by a Research Ethics Board.

RESULTS

Cohort characteristics by routine CXR status

The resulting cohort consisted of 2,847,508 PHEs conducted on 1,819,696 Ontario outpatients aged 18 and older who were assumed to be asymptomatic and low-risk for cardiac and respiratory disease **(Figure 1**). In total, 2.42% of PHEs resulted in the examined patient having a CXR that was ordered by the attending family physician.

The corresponding characteristics for all eligible examinations are detailed in **Table 1**. In general, examinations followed by a routine CXR involved older, male patients and male physicians further removed from graduation.

Variation by health region, practice, and physician

Our sample consisted of 22.6% (2,031/8,992) of all family physicians in Ontario during the study period. Ordering variation was more pronounced among the 2,031 physicians (range 0.3%-70.8%, interquartile range [IQR] 1.5%-5.0%; coefficient of quartile deviation, 0.54) than among the 677 practices (IQR 0.9%-2.3%; coefficient of quartile deviation, 0.44) or 14 LHINs (IQR, 1.9%-2.9%; coefficient of quartile deviation, 0.20) (**Supplemental Figure 1** and **2**). **Figure 2** shows the number of physicians by CXR ordering rate quartile. Physicians in the top quartile by ordering rate accounted for 62.9% of all tests observed.

Variation over time

Figure 3 demonstrates declining use of routine CXRs and PHEs over the study period. Routine CXR use dropped 1.0% between April 1st, 2010 (3.0%) and March 31st, 2015 (2.0%) (interquartile range, 2.0%-2.8%; coefficient of quartile deviation, 0.16). **Supplemental Table 1** shows that, on average, routine CXR use decreased by 2.0% per quarter within Ontario (rate ratio [RR] 0.98, 95% CI 0.97-0.98; *P*<.001). Use was significantly higher in January to March compared to any other quarter, irrespective of fiscal year. **Figure 3** depicts lower total PHE volume from 2013 onward. Total PHE volume decreased, on average, by 2.0% per quarter (RR 0.98, 95% CI 0.97-0.98; *P*<0.001).

Factors associated with routine CXR use

Our final mixed effects logistic regression model is presented in **Table 2**. Older adults, males, and those in the lowest income quintile had increased odds of having a routine CXR. Male physicians and those further removed from graduation had increased odds of ordering a routine CXR. The degree of inter-practice variation was significant as, in the median case, the odds of a patient having a routine CXR at one randomly selected high-risk practice were 91% greater than a patient with the same covariates at another randomly selected, low-risk practice (median OR 1.91, 95% CI 1.86-1.96). Practice-level clustering accounted for 12.3% of the total variation in routine CXR use. The results of a sensitivity analysis with same-day CXR receipt as the dependent variable did not differ substantially from the main analysis (**Supplemental Table 2**).

INTERPRETATION

In this large, retrospective cohort study, we found that routine CXR are infrequently ordered for low-risk outpatients as part of a PHE in Ontario. Among the 2,847,508 PHEs conducted on 1,819,696 presumably asymptomatic, low-risk outpatients, only 2.4% were followed by a CXR. While province-wide use was low, substantial ordering variation was observed across regions, practices, and most notably, between individual family physicians. For example, the top 25% of physicians by routine CXR use ordered a potentially low-value CXR following more than 5% of their PHEs with a low-risk patient and accounted for 62.9% of total test volume, whereas the bottom 25% of physicians ordered a CXR at most 1.5% of the time and accounted for less than 10% of tests observed. Furthermore, we observed a significant decline in routine CXR use over time, with rates highest between January and March within any given year.

Previous literature has suggested that, despite low clinical value, routine CXR use for asymptomatic and/or low-risk outpatients in primary care may be quite common. In their review of radiograph reports, Tigges et al. found that 34% of CXRs ordered were for "routine or screening purposes"[9]; however, this study was limited to a single primary care center in the U.S[9]. Conversely, our study involved a large cohort of patients from multiple regions and practices across Ontario and suggests routine CXRs are uncommon in Canada. In fact, routine CXR appears to be appreciably less common than other forms of low-value imaging we have previously studied. In contrast, we have found other CWC recommendations with significantly higher frequency of use[12,24,31]. Our study underscores the importance of establishing baseline estimates to compare frequency of use across different tests and clinical scenarios, which can provide health care decision makers with a basis for prioritizing which tests they might preferentially target with quality improvement initiatives aimed at reducing low-value care[32].

The observed decline in routine CXR use over time may due to increased recognition of the limited utility of CXR for screening asymptomatic, low-risk patients among physicians, possibly promoted by 2013 OHIP *Schedule of Benefits* revisions that included recommendations against routine CXR reimbursement and new PHE codes to reduce low-value testing. However, it appears the downward trend in CXR use was initiated prior to the announcement of OHIP *Schedule* changes in November 2012 and their subsequent implementation in January

2013[4,5,11,16-18]. Further research to identify unmeasured factors that may explain the precipitous drop in CXR use from January-March 2012 to April-June 2012 is warranted.

Substantial variation among regions, practices, and individual primary care physicians was observed, which is consistent with previous research[12,22,24,31,32]. Significant within-practice variation in having a post-PHE CXR persisted even after we adjusted for several patient and physician characteristics, suggesting that unmeasured practice-level characteristics account for a sizeable portion of the observed variability in routine CXR use. Patients who were older and male were more likely to have a routine CXR. Male physicians and those further removed from their medical school graduation were more likely to order routine CXRs. These same characteristics have been previously associated with routine ECG use in low-risk outpatients[11]. Identification of common factors for ordering low-value care across tests could inform development of interventions that may effectively curb use of several low-value services. Furthermore, future investigations might consider estimating physician-specific ordering rates for multiple low-value tests (e.g. ECG and CXR) that may result from an PHE to create a broader, more robust profile of care per physician[12,33].

Limitations

Several methodological limitations are worth noting. Administrative, claims-based data does not provide all of the clinical information available to the physician in making their decision to order or withhold a test, such as symptoms or risk factors presented via physical exam or patient history[33]. For example, our data does not capture smoking or alcohol use, known risk factors for cardiac and respiratory disease that may indicate a CXR investigation[10]. Without this information, it is possible that patients or CXRs may have been misclassified as 'low-risk' or 'low-value' respectively, resulting in inaccurate estimates of overuse via denominator and/or numerator inflation[4,10]. Our application of an extensive list of risk-based exclusion criteria hopefully mitigated the extent of misclassification[12,15,16]. The omission of unmeasured risk factors from regression may also bias odds ratio (OR) estimates where the measured covariate and unmeasured risk factor are significantly correlated. The direction of bias would correspond with the direction of this correlation[34]. In addition, the accuracy of the algorithms used to rule in patients and tests have not been previously validated by independent studies. Lastly, our findings

may not be generalizable to other provinces and territories, as PHEs are not standardized across Canada and may target broader patient populations or entail different services[7].

Conclusion

It appears that Ontario family physicians are adhering to guidelines and recommendations by ordering a low frequency of routine CXRs for periodic health examinations with an asymptomatic or low-risk outpatient. Further research exploring the causes of variation in physician ordering practices, particularly among high ordering physicians, is warranted.

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Table 1. Cohort characteristics for eligible periodic health examinations (PHEs) based on routine chest X-ray (CXR) status, *N* = 2,847,508.

Characteristic*	No. with CXR (%) (*n* = 68,848)	No. without CXR (%) (*n* = 2,778,660)
Patient-level		

FIGURE LEGENDS

Figure 1. Cohort creation.

Figure 2. Frequency distribution of family physicians in Ontario according to their routine chest X-ray (CXR) ordering rate with corresponding total volume of CXR ordered per rate-based quartile – 2010/11 to 2014/15. *Note*: The x-axis is divided into quartiles based on physician CXR ordering rate.

Figure 3. Routine chest X-ray (CXR) ordering rates in Ontario over time – from April 1st, 2010 to March 31st, 2015. *Note*: The hatched, horizontal line represents the overall mean rate.

Supplemental Figure 1. Routine chest X-ray (CXR) ordering rate based on Local Health Integrated Network (LHIN). *Note*: The hatched, horizontal line represents the overall mean rate.

Supplemental Figure 2. Routine chest X-ray (CXR) ordering rate by practice (n = 677). *Notes:* Practices are arranged on the x-axis in ascending order according to their individual rates of CXR use. The hatched, horizontal line represents the overall mean rate.

Supplemental Figure 3. Frequency distribution of routine chest X-ray (CXR) ordering rate by practice (n = 677) in Ontario – 2010/11 to 2014/15. *Notes:* Physicians are arranged on the x-axis in ascending order according to their individual rates of CXR use. The hatched, horizontal line represents the overall mean rate.

Supplemental Figure 4. Routine chest X-ray (CXR) ordering rate by attending family physician (n = 2,031).

Age, years (y)		
Mean (95% CI)	46.4 (46.3-46.5)	42.1 (42.1-42.1)
18-44	29 542 (42.9)	1 585 698 (57.1)
45-64	32 771 (47.6)	1 023 450 (36.8)
65+	6 535 (9.5)	169 512 (6.1)
Sex		
Female	26 198 (38.1)	1 735 658 (62.5)
Male	42 650 (61.9)	1 043 002 (37.5)
Rurality		
Rural	3 775 (5.5)	212 201 (7.6)
Non-rural	65 073 (94.5)	2 566 459 (92.4)
Neighbourhood income quintile		
1 (lowest)	13 498 (19.6)	414 265 (14.9)
2	15 209 (22.1)	502 926 (18.1)
3	13 844 (20.1)	560 390 (20.2)
4	14 247 (20.7)	642 577 (23.1)
5 (highest)	12 050 (17.5)	658 502 (23.7)
Hospital admission - past 5 y	4 486 (6.5)	312 444 (11.2)
Mental health care - past y	7 012 (10.2)	339 760 (12.2)
Dementia - past 5 y	284 (0.4)	8 920 (0.3)
Rheumatologic disease - past 5 y	3 449 (5.0)	116 576 (4.2)
Rostered to primary care physician**		
Yes	68 822 (>99.9)	2 777 436 (>99.9)
No	26 (<0.1)	1 224 (<0.1)
*Physician-level****		
Sex		
Female	15 952 (23.2)	1 243 246 (44.9)
Male	52 678 (76.8)	1 526 081 (55.1)
IMG	22 689 (33.1)	824 840 (29.8)
Years since graduation, Mean (95% CI)	28.8 (28.7-28.9)	24.2 (24.2-24.2)
Practice-level		
Primary care practice model[a]		
Fee-for-service	13 891 (20.2)	422 355 (15.3)
Family health group	29 594 (43.1)	995 071 (35.9)
Family health network	110 (0.2)	8 548 (0.3)
Family health organization	10 709 (15.6)	656 365 (23.7)
Family health team	8 371 (12.2)	558 228 (20.2)
Other	5 955 (8.7)	128 760 (4.6)

Notes: CI = confidence interval; IMG = international medical graduate; *For all characteristics (except 'rostered to primary care physician'), $P < .001$ across groups defined by post-PHE CXR receipt status. *P*-values not adjusted for potential intra-practice correlation; ** Variable indicates whether patients were rostered to a primary care physician at study entry; *** provider-level variables only available for those index events involving a patient rostered to a primary care physician with a reported physician number for linkage (N = 2,837,957).

[a] Represents the primary care patient enrollment model which informs practice organization and remuneration.

Table 2. Factors associated with having a routine chest X-ray (CXR) based on a mixed effects logistic regression model, *N* = 1,709,206.

Fixed Effects, OR[a] (95% CI)	
Time-based variables	
Time (fiscal quarter)	0.98 (0.98-0.98)***
April-June vs January-March	0.92 (0.88-0.96)***
July-September vs January-March	0.91 (0.88-0.95)***
October-November vs January-March	0.90 (0.86-0.93)***
Patient characteristics	
Age, years (y)	
45-64 vs 18-44	1.82 (1.78-1.86)***
65+ vs 18-44	2.48 (2.39-2.58)***
Male	2.19 (2.14-2.24)***
Rural	1.00 (0.95-1.05)
Neighbourhood income quintile	
2 vs 1 (lowest)	0.94 (0.91-0.97)***
3 vs 1 (lowest)	0.85 (0.82-0.87)***
4 vs 1 (lowest)	0.82 (0.79-0.85)***
5 vs 1 (lowest)	0.71 (0.69-0.74)***
Hospitalization - past 5 y	0.89 (0.85-0.93)***
Mental health diagnosis - past 5 y	0.89 (0.86-0.92)***
Dementia diagnosis – past 5 y	1.19 (1.01-1.39)*
Rheumatologic disease diagnosis – past 5 y	1.02 (0.97-1.07)
Physician characteristics	
Male	1.55 (1.51-1.59)***
IMG	1.01 (0.98-1.03)
Years since graduation	
21-30 vs ≤20	1.21 (1.17-1.24)***
> 30 vs ≤20	1.63 (1.59-1.68)***
Practice characteristics	
Primary care practice model[b]	
Family health group vs FFS	0.92 (0.89-0.96)***
Family health network vs FFS	0.73 (0.51-1.03)
Family health organization vs FFS	0.81 (0.77-0.86)***
Family health team vs FFS	0.87 (0.82-0.93)***
Other vs FFS	1.20 (1.09-1.31)**
Random Effects[c]	
Variance (SE)	0.46 (0.03)
MOR (95% CI)	1.91 (1.86-1.96)
ICC[d], %	12.3

Notes: Significant at *P*<0.05*, *P*<0.01 **, *P*<0.001 ***; OR = odds ratio; CI = confidence interval; IMG = international medical graduate; FFS = fee-for-service; SE = standard error; MOR = median odds ratio; ICC = intraclass correlation coefficient; All reported values based on SAS PROC GLIMMIX output; model estimation method = RSPL; denominator degrees of freedom estimation method = between and within (bw); covariance structure = standard variance (vc).

[a] Adjusted for all other factors present in the model/table.
[b] Represents the primary care patient enrollment model which informs practice organization and remuneration.
[c] Estimated based on the distribution of random, practice-specific intercepts.
[d] Calculated using the linear threshold approach.

APPENDIX 1 – METHODS

Appendix 1.1 *Cohort creation*

Index event/inclusion criteria	Patient in Ontario with ≥ 1 periodic health examination (defined below) between April 1st, 2010 and March 31st, 2014. First applicable claim is date of study entry. **Periodic health examination** for adult patient [OHIP] – any of the following claims: ▪ Adult aged 18 to 64 inclusive: FEECODE = K131 ▪ Adult 65 and older: FEECODE = K132 ▪ General health assessment with family physician/general practitioner (FEECODE = A003) with reason as annual health examination (DXCODE = 917)
Exclusion criteria	1. Invalid IKN (IF VALIKN NE 'V' THEN DELETE) 2. Not an adult (age < 18) or invalid age (>105) at time of index PHE • *Necessary to apply as AHE codes not age-specific 3. Residents in long-term care: Lookback 1 year from cohort entry or anytime between a patient's first eligible PHV and their last eligible PHV within the observation window for the following long-term care exclusions: • [OHIP] record with LOCATION = 'L' • [ODB] record with LTC='1' [CAPE] record with STATUS_CAPE='15' (resides in LTC facility) 4. Non-Ontario resident (IF PSTLCODE doesn't start with K,L,M,N,O,P DELETE) [use NACRS] 5. Meet any of the high risk exclusion criteria below 6. Missing data for income quintile, sex, LHIN, or rurality
High-risk exclusion criteria	**Exclusion criteria within lookback window up to and including date of index event:** Lookback a maximum of 3 years from cohort entry or anytime between a patient's first eligible PHV and their last eligible PHV within the observation window for the following high risk exclusions unless otherwise stated: a. Signs and symptoms or diagnosis of cardiopulmonary disease [OHIP]- two physician claims within a two-year period with one of the following diagnostic codes (DXCODE): • 010-017 = Tuberculosis • 785 = Undiagnosed chest pain, tachycardia, syncope, shock, edema, masses • 786 = Undiagnosed epistaxis, hemoptysis, cough, dyspnea, masses, shortness of breath, hyperventilation, sleep apnea • 391 = Rheumatic fever with endocarditis, myocarditis or pericarditis • 402 = Hypertensive heart disease • 410 = Acute myocardial infarction • 412, 413 = Old myocardial infarction, chronic coronary artery disease of arteriosclerotic heart disease, without symptoms; angina pectoris • 415 = Pulmonary embolism, pulmonary infarction • 426 = Heart blocks, other conduction disorders • 427 = Paroxysmal tachycardia, atrial or ventricular flutter or fibrillation, cardiac arrest, other arrythmias • 428, 429 = Congestive heart failure; all other forms of heart

	disease • 432 = Intracranial haemorrhage • 435-437= transient cerebral ischemia, acute cerebrovascular accident, chronic arteriosclerotic cerebrovascular disease, hypertensive encephalopathy • 440 = Generalized arteriosclerosis, atherosclerosis • 441 = Aortic aneurysm (non-syphilitic) • 443 = Peripheral vascular disease • 446 = Polyarteritis nodosa, temporal arteritis • 447 = Other disorders of arteries • 451 = Phlebitis, thrombophlebitis • 452 = Portal vein thrombosis • 466 = Acute bronchitis • 491, 492 = Chronic bronchitis; emphysema • 494 = Bronchiectasis • 074 = Coxsackie myocarditis • 512 = Pneumothorax, spontaneous or tension • 511 = Pleurisy with or without effusion • 515 = Pulmonary fibrosis • 518 = Atelectasis, other disease of lung • 519 = Other diseases of the respiratory system • 530 = Esophagitis, cardiospasm, ulcer of esophagus • 745, 746 = Congenital anomalies of heart • 747 = Pulmonary artery stenosis, other anomalies of the circulatory system • 748 = Congenital anomalies of nose and respiratory system OR Signs, symptoms, or diagnosis related to the respiratory or cardiac system [CIHI – DAD] – at least one admission with one of the following ICD-10 diagnostic codes (DX10CODE:_): • Atrial fibrillation/flutter: I48; other cardiac arrhythmia (I44-147, I49) • Coronary artery disease: I20-I25 • Cardiac valvular disease: I05-I08, I09.1, I09.8, I34-I38 • Heart failure = I50 • Venous thromboembolism: I80.1, I80.2, I80.8, I82.2, I82.3, I82.8, I82.9 • Abnormalities of heart beat = R00 • Cardiac murmurs or other cardiac sounds = R01 • Abnormal blood pressure reading, without diagnosis = R03 • Abnormalities of breathing = R06 • Pain in throat and chest = R07 • Chest pain = R071-R074 • Previous cerebrovascular disease: I60, I61, I63, I64, G45, G46, H34 • Peripheral vascular disease: I70, I71, I73.1, I73.8, I73.9, I77.1, I79.0, I79.2, K55.1, K55.8, K55.9, Z95.8, Z95.9 • Other symptoms and signs involving the circulatory and respiratory system = R09, R098 • Pneumonia: Steptococcus pneumonia (J13); unspecified (J18.9); lobar pneumonia, unspecified (J18.1); bronchopneumonia, unspecified (J18.0) • R091 = Pleurisy • R092 = Respiratory arrest b. Prior or existing cancer diagnoses [OHIP, CIHI DAD]: • Two or more claims in OHIP with one of the following diagnostic

codes (DXCODE):
- Any neoplasm (malignant, unspecified or uncertain behavior) 140-165, 170-172, 174-215, 217-239

OR
- One hospital admission in [CIHI DAD] with one of the following ICD-10 codes: C00-C43, C45-C97, D00-D03, D05-D09

c. Heart failure diagnosis [CHF] any time prior to cohort entry

d. Hypertension diagnosis [HYPER] any time prior to cohort entry

e. Asthma diagnosis [ASTHMA] any time prior to cohort entry

f. Chronic obstructive pulmonary disease diagnosis [COPD] any time prior to entry

g. Diabetes diagnosis [ODD] any time prior to entry

h. Other comorbidities that suggest high risk for cardiopulmonary disease:
- *High-risk for cardiopulmonary diseases*:
  - [OHIP] – two physician claims within a two-year period with one of the following diagnostic codes: AIDS (042), AIDS-related complex (043), other human immunodeficiency virus infection (044); essential, benign hypertension (401); hypertensive renal disease (403); acute renal failure (584), chronic renal failure, uremia (585); chest pain, tachycardia, syncope, shock, edema, masses (785)

  OR
  - [CIHI-DAD] – at least one admission with one of the following ICD-10 diagnostic codes: HIV (B20-B24); chronic renal disease (I12, I13, N03.2-N03.7, N05.2-N05.7, N17-19, N25.0, Z49, Z94.0, Z99.2)

i. Visits to pulmonologist (respiratory disease specialist) (SPEC=47), cardiologist (SPEC=60), general thoracic surgeon (SPEC=64) or cardiothoracic surgeon (SPEC=09) – one of more claim(s) with the following [OHIP] fee codes:

- *Outpatient consultations and visits:*
  - *Pulmonologist (47):* consultation (A475), comprehensive consultation (A470), limited consultation (A575), repeat consultation (A476), medical specific assessment (A473), medical specific re-assessment (A474), complex medical specific re-assessment (A471), partial assessment (A478)
  - *Cardiologist (60):* consultation (A605), comprehensive consultation (A600), limited consultation (A675), repeat consultation (A606), medical specific assessment (A603), medical specific re-assessment (A604), complex medical specific re-assessment (A601), partial assessment (A608)
  - *General thoracic surgery (64):* consultation (A645), special surgical consultation (A935) with SPEC=64, repeat consultation (A646), specific assessment (A643), partial assessment (A644)
  - *Cardiothoracic surgery (09):* consultation (A095), special surgical consultation (A935) with SPEC=09, repeat consultation (A096), specific assessment (A093), partial

assessment (A094)

- *Non-emergency hospital in-patient services:*
  - *Pulmonologist (47):* consultation (C475), comprehensive consultation (C470), limited consultation (C575), repeat consultation (C476), medical specific assessment (C473), medical specific re-assessment (C474), complex medical specific re-assessment (C471); subsequent visits – first five weeks (C472), sixth to thirteenth week inclusive (C477), after thirteenth week (C479); concurrent care (C478)
  - *Cardiologist (60):* consultation (C605), comprehensive consultation (C600), limited consultation (C675), repeat consultation (C606), medical specific assessment (C603), medical specific re-assessment (C604), complex medical specific re-assessment (C601); subsequent visits – first five weeks (C602), sixth to thirteenth week inclusive (C607), after thirteenth week (C609); concurrent care (C608)
  - *General thoracic surgery (64):* consultation (C645), repeat consultation (C646), specific assessment (C643), specific re-assessment (C644); subsequent visits – first five weeks (C642), sixth to thirteenth week (C647), after thirteenth week (C649); concurrent care (C648); special surgical consultation (C935) where SPEC=09
  - *Cardiac surgeon (09):* consultation (C095); repeat consultation (C096); specific assessment (C093); specific re-assessment (C094); subsequent visits – first five weeks (C092), sixth to thirteenth week inclusive (C097), after thirteenth week (C099); concurrent care (C098); special surgical consultation (C935) where SPEC=09
  - OR any of the following fee codes where SPEC=47 (pulmonologist) OR SPEC=60 (cardiologist) OR SPEC=64 (general thoracic surgeon) OR SPEC=09 (cardiothoracic surgeon) for the Most Responsible Physician (MRP):
    - Subsequent visits by the MRP – day following hospital admission assessment (C122), second day following the hospital assessment (C123), day of discharge (C124); subsequent visits by the MRP following transfer from an intensive care area – first visit (C142), second visit (C143), additional visits due to intercurrent illness (C121)

j. History of prior cardiothoracic tests and procedures:

Cardiothoracic procedures:

- Misc surgical procedures:
  - [OHIP]: thoracotomy (M137, M134, Z401, Z414, R750), pericardiectomy (R748, R749), cardiotomy (R706-R714, E660, E661, E658), cardiovascular excisions (R920, R746, R747, E648, R741, E651), cardiac or cardiopulmonary transplantation (R874, R870)
- Aortic valve replacement:
  - [OHIP] FEECODE = R738, R863
  - [CIHI-DAD] CCI code = 1HV90
- Mitral valve replacement:
  - [OHIP] FEECODE = R735
  - [CIHI-DAD] CCI code = 1HU90
- Coronary artery repair/revascularization:
  - [OHIP] FEECODE = Z434, Z448, Z449, Z460, Z461,

	R742, R743; resection coarctation (R758); other heart and pericardium repair (R720-R723, R922-R929, R768-R771) ○ [CIHI-DAD] CCI codes = 1IJ126, 1IJ50, 1IJ55, 1IJ57, 1IJ76, 1IJ80 • Cardiac catheterization: ○ [OHIP]: Z439, Z440, Z441, Z442, Z456, Z457, G263, G269, G285, G286 • Device implantation: ○ [OHIP] FEECODE = ventricular assist devices (R701-R705), implantation of cardioverter defibrillator (R753, R761, Z415), cardiac massage including placement and replacement of pacemakers (R765, Z433, Z444, Z445, Z435, R752, R751, Z429) ○ [CIHI-DAD] CCI codes = 1HZ53GRFS, 1HZ53LAFS, 1HZ53GRNM, 1HZ53LANM, 1HZ53GRNK, 1HZ53LANK, 1HZ53GRNL, 1HZ53LANL, 1HZ53GRFR, 1HZ53LAFR • Pneumonectomy or lobectomy: ○ [OHIP] fee codes = M142 (pneumonectomy), M143 (lung lobectomy) ○ [CIHI-DAD] CCI codes = 1GR87:_(excision partial, lobe of lung), 1GR89:_ (excision total, lobe of lung), 1GR91:_ (excision radical, lobe of lung); history of lobectomy or pneumonectomy (Z902:_, Z8511:_) k. Patients who experienced severe trauma or injury to chest: • [OHIP] – one or more claims with the following diagnostic codes: ○ *Fractures:* Vertebral column – with spinal cord damage (806), ribs (807), clavicle (810) ○ 869 = Internal injuries to organ(s) OR • [CIHI – DAD, CIHI - NACRS] – at least one admission or ambulatory visit with the following ICD-10 diagnostic codes: ○ *Fractures:* thoracic vertebrae, sternum and ribs (S220-SS229), clavicle (S420), scapula (S421) ○ *Dislocations, sprains and strain of thoracic joints and ligaments:* S230-S235 ○ *Injury of thoracic blood vessels:* S250-S259 ○ *Injury of intrathoracic organs (includes pneumothorax, hemothorax and hemopneumothorax):* S26:_, S270-S279 ○ *Crushed chest*: S28 ○ *Other and unspecified injuries of thorax*: S290-S299
Notes: Where noted, specific variables are noted by their fully capitalized name (NAME). Any codes with abbreviated notation (ex. S26:_) are presented in this format (consistent with SAS coding) to show that any codes starting with the characters/values preceding the colon and underscore (:_) will be captured.	

Appendix 1.2 *Outcome measurement*

Primary Outcome Definition	≥ 1 CXR test following a periodic health examination [use OHIP]: CXR test (based on feecodes below) claimed within **7 days** after index event with the physnum OR refphys equivalent to the physnum on the index annual health exam claim: a. CXR single view = X090 b. CXR two views = X091 c. CXR three or more views = X092
Event exclusions	**Exclusions during observation window for each patient:** Any chest X-rays done during visits to hospital, emergency department, during admission process or inpatient stay within 7 days of index event [NACRS, OHIP, DAD] are excluded from the numerator and not captured as events: • Visit date (REGDATE) in NACRS = SERVDATE in OHIP for CXR claim (FEECODE = X090, X091, X092) OR ED visit (EDVISIT=1) in NACRS with following CCI code: 3GY10 (X-ray, thoracic cavity) • Exclude CXR claims (FEECODE = X090, X091, X092) where SERVDATE = between ADMDATE and DDATE in DAD
Notes: Where noted, specific variables are noted by their fully capitalized name (NAME).	

Appendix 1.3. Preliminary analysis results.

Appendix 1.3.1. Proportion of chest X-rays (CXR) occurring within 30 days of PHV/AHE that happened within 7 days of PHV/AHE.

Date of CXR after PHV/AHE	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Not within 7 days	29027	29.65	29027	29.65
Within 7 days	68880	70.35	97907	100.00

Appendix 1.3.2. Distribution of chest X-rays (CXR) occurring after a periodic health examination by time from visit/exam.

Days after PHV/AHE	No. CXR	% CXR within 30 d	Cumulative Frequency	Cumulative Percent
0	40150	41.01	40150	41.01
1	7297	7.45	47447	48.46
2	4326	4.42	51773	52.88
3	3452	3.53	55225	56.41
4	3167	3.23	58392	59.64
5	2935	3.00	61327	62.64
6	3076	3.14	64403	65.78
7	4477	4.57	68880	70.35
8	2767	2.83	71647	73.18
9	2056	2.10	73703	75.28
10	1691	1.73	75394	77.01
11	1542	1.57	76936	78.58
12	1513	1.55	78449	80.13
13	1683	1.72	80132	81.85
14	2651	2.71	82783	84.55
15	1556	1.59	84339	86.14
16	1140	1.16	85479	87.31
17	1013	1.03	86492	88.34
18	931	0.95	87423	89.29
19	921	0.94	88344	90.23
20	1082	1.11	89426	91.34
21	1614	1.65	91040	92.99
22	1036	1.06	92076	94.04
23	715	0.73	92791	94.77
24	623	0.64	93414	95.41
25	624	0.64	94038	96.05
26	602	0.61	94640	96.66
27	772	0.79	95412	97.45
28	1136	1.16	96548	98.61
29	743	0.76	97291	99.37
30	616	0.63	97907	100.00

Appendix 1.4. *Covariates*

History of hospitalization in 5 years prior to cohort entry [DAD]	• Dichotomous variable for any admissions to hospital other than admissions with high risk diagnoses defined in exclusion criteria above (including hospital admission codes included in CHF, ODD, HYPER, ASTHMA and COPD case definitions)
Mental health care in past year [OHIP, DAD]	• Outpatient physician claim by family physician (SPEC=00) with one of the following OHIP DXCODE values: 295-304, 306, 309, 311, 897-902, 904-906, 909 OR • Any hospitalization in CIHI DAD with a mental health ICD-10 code: F00-F99 OR • Any billing by a psychiatrist (SPEC=19) in OHIP
Dementia diagnosis in 5 years prior to cohort entry [OHIP, DAD]	Dementia diagnosis in 5 years prior to cohort entry [OHIP, CIHI DAD]: • Outpatient physician visit claim in OHIP with one of the following diagnostic codes: 290, 331, 797 OR • One hospital admission in CIHI DAD with one of the following ICD-10 codes: F00.0, F00.1, F00.2, F00.9, F01.0, F01.1, F01.2, F01.3, F01.8, F01.9, F02.0, F02.1, F02.2, F02.3, F02.4, F02.8, F03.X, F05.1, F06.5, F06.6, F06.8, F06.9, F09.X, G300, G30.1, G30.8, G30.9, G31.0 G31.1, R54.X
Rheumatological disease diagnoses in 5 years prior to cohort entry [OHIP, DAD]	• At least three physician visit claims with OHIP diagnostic code 714 over two-year period with at least one visit to a rheumatologist (SPEC=48) or internist (SPEC=13) OR • At least two outpatient physician visit claims within 1 year in OHIP with one of the following diagnostic codes: 710, 711, 715, 730, 733

Primary care practice model	A practice (a group of three or more physicians submitting joint billing claims to OHIP) was noted as belonging to one of the following payment models:
	• Fee-for-service (FFS):
	  ○ Should be family physicians who didn't switch from the old FFS model into one of the reformed family practice models.
	  ○ Old model involves remuneration by FFS payments only with no incentives for services rendered to rostered patients (distinction from FFS and CCM). As a result, under old model physicians did not formally roster patients. This model is more prevalent among small group practices, informing our exclusion of practices with < 3 physicians submitting joint claims to hopefully limit the number of practices using the old FFS model.
	• Family health groups:
	  ○ Family health groups are primarily reimbursed via FFS with additional incentives and bonuses for services to enrolled

	patients
	• Family health networks:
	  ○ Reimbursed via blended capitation model plus bonus and incentives for rostered patient services
	• Family health teams:
	  ○ Interdisciplinary teams reimbursed via blended capitation, blended salary, or complement-based remuneration plus bonus and incentives
	• Other:
	  ○ Includes remaining payment models including community health centres (salaried model) and rural-northern physician group agreements (complement-based remuneration plus bonus and incentives)
	
	Note: We did not capture physicians under CCM, as these physicians often do not submit joint claims to OHIP (i.e. typically solo physicians)."

Notes: Where noted, specific variables are noted by their fully capitalized name (NAME).	

SUPPLEMENTAL MATERIALS

Supplemental Table 1. Results of negative binomial regression model analyzing routine chest X-ray (CXR) use over time in Ontario (n = 2,847,508).

Factor*		Adjusted RR[a] (95% CI)	*P* value
Time (fiscal quarter)		0.98 (0.97-0.98)	< .001
April-June vs January-March		0.92 (0.88-0.96)	< .001
July-September vs January-March		0.91 (0.88-0.95)	< .001
October-November vs January-March		0.90 (0.86-0.93)	< .001
LHIN			
	2 vs 1	0.45 (0.42-0.49)	< .001
	3 vs 1	0.49 (0.45-0.53)	< .001
	4 vs 1	0.54 (0.50-0.58)	< .001
	5 vs 1	0.69 (0.64-0.74)	< .001
	6 vs 1	0.70 (0.65-0.75)	< .001
	7 vs 1	0.93 (0.86-0.99)	.032
	8 vs 1	1.21 (1.13-1.29)	< .001
	9 vs 1	1.37 (1.29-1.46)	< .001
	10 vs 1	0.40 (0.36-0.44)	< .001
	11 vs 1	0.41 (0.38-0.44)	< .001
	12 vs 1	0.51 (0.47-0.55)	< .001
	13 vs 1	0.66 (0.60-0.71)	< .001
	14 vs 1	1.04 (0.95-1.15)	< .001

Notes: *all factors significant at *P*<0.05; RR = relative risk; CI = confidence interval.
[a] adjusted for all other factors present in the table.

Supplemental Table 2. Patient- and provider-level indicators for a routine chest X-ray (CXR) being ordered on the same day as a periodic health examination based on a multilevel logistic regression with a random intercept for practice-level effects, *N* = 1,709,206.

Fixed Effects, OR[a] (95% CI)	
Time-based variables	
Time (fiscal quarter)	0.98 (0.97-0.98)***
April-June vs January-March	0.91 (0.87-0.96)***
July-September vs January-March	0.91 (0.88-0.95)***
October-November vs January-March	0.89 (0.85-0.94)***
Patient characteristics	
Age, years (y)	
45-64 vs 18-44	1.69 (1.65-1.74)***
65+ vs 18-44	2.06 (1.96-2.17)***
Male	2.46 (2.39-2.53)***
Rural	0.94 (0.88-1.01)
Income quintile	
2 vs 1 (lowest)	0.98 (0.94-1.02)
3 vs 1 (lowest)	0.88 (0.84-0.92)***
4 vs 1 (lowest)	0.88 (0.84-0.91)***
5 vs 1 (lowest)	0.76 (0.73-0.79)***
Hospitalization - past 5 y	0.87 (0.83-0.92)***
Mental health diagnosis - past 5 y	0.87 (0.83-0.91)***
Dementia diagnosis – past 5 y	1.25 (1.02-1.53)*
Rheumatologic disease diagnosis – past 5 y	0.97 (0.91-1.04)
Physician characteristics	
Male	1.57 (1.51-1.62)***
IMG	0.95 (0.92-0.98)**
Years since graduation	
21-30 vs ≤20	1.29 (1.25-1.34)***
> 30 vs ≤20	1.81 (1.74-1.87)***
Primary care practice model[b]	
Family health group vs FFS	0.97 (0.93-1.02)
Family health network vs FFS	0.56 (0.34-0.92)*
Family health organization vs FFS	0.83 (0.77-0.90)***
Family health team vs FFS	0.93 (0.86-1.02)
Other vs FFS	1.60 (1.40-1.83)***
Random Effects[c]	
Variance (SE)	0.65 (0.04)
MOR (95% CI)	2.16 (2.08-2.24)
ICC[c], %	16.5

Notes: Significant at *P*<0.05*, *P*<0.01 **, *P*<0.001 ***; OR = odds ratio; CI = confidence interval; IMG = international medical graduate; FFS = fee-for-service SE = standard error; MOR = median odds ratio; ICC = intraclass correlation coefficient; All reported values based on SAS PROC GLIMMIX output; model estimation method = RSPL; denominator degrees of freedom estimation method = between and within (bw); covariance structure = standard variance (vc).

[a] Adjusted for all other factors present in the table.

[b] Represents the primary care patient enrollment model which informs

practice organization and remuneration.

[c] Estimated based on the distribution of random, practice-specific intercepts.

[d] Calculated using the linear threshold method.