BMJ open
accessible medical research

Identifying geographical regions serviced by hospitals to assess laboratory-based outcomes

Sonja Gandhi,[1,2] Salimah Z Shariff,[1,3] Michael M Beyea,[1,4] Matthew A Weir,[1,2] Theresa Hands,[1] Glen Kearns,[1] Amit X Garg[1,2,3]

To cite: Gandhi S, Shariff SZ, Beyea MM, *et al*. Identifying geographical regions serviced by hospitals to assess laboratory-based outcomes. *BMJ Open* 2013;**3**:e001921. doi:10.1136/bmjopen-2012-001921

▸ Prepublication history for this paper are available online. To view these files please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2012-001921).

Received 2 August 2012
Revised 29 October 2012
Accepted 22 November 2012

[1]Division of Nephrology, Department of Medicine, Western University, London, Canada
[2]Department of Epidemiology & Biostatistics, Western University, London, Canada
[3]Institute for Clinical Evaluative Sciences, Ontario, Canada
[4]Department of Medicine, University of Toronto, Toronto, Canada

Correspondence to
Dr Amit Garg;
amit.garg@lhsc.on.ca

ABSTRACT

Objective: To define geographical regions (forward sortation areas; FSAs) in Southwestern Ontario, Canada from which patients would reliably present to a hospital with linked laboratory data if they developed adverse events related to medications dispensed in outpatient pharmacies.

Design: Descriptive research.

Setting: Forty-five hospitals in Southwestern Ontario, Canada, from 2003 to 2009.

Participants: Patients aged 66 years and older who received an outpatient prescription for any drug and presented to the emergency department in the subsequent 120 days.

Main outcome measure: The proportion of patients in a given FSA presenting to an emergency department at a hospital with linked laboratory data versus a hospital without linked laboratory data. To be included in the catchment area at least 90% of emergency department visits in an FSA must have occurred at laboratory-linked hospitals in a given year.

Results: Over the study period, there were 649 713 emergency department visits by patients with recent prescription claims from pharmacies in 1 of 118 FSAs. In total, 141 302 of these patients presented to an emergency department at a laboratory-linked hospital. For the year 2003, 12 FSAs met our criteria to be in the catchment area and this number grew to 25 FSAs by the year 2009.

Conclusions: The relevant geographical regions for hospitals with linked laboratory data have been successfully identified. Studies can now be conducted using these well-defined areas to obtain reliable information on the incidence and absolute risk of presenting to hospital with laboratory abnormalities in older adults dispensed commonly prescribed medications in outpatient pharmacies.

ARTICLE SUMMARY

Article focus

- The aim of this study was to define geographic regions in Southwestern Ontario, Canada, where we could be confident that patients who developed an adverse event from medications dispensed in an outpatient pharmacy would reliably present to a hospital with available linked laboratory data.

Key messages

- By 2009, a catchment area consisting of 25 geographical regions (forward sortation area) was identified.
- Similar approaches can be used to define relevant regions that can change over time in other jurisdictions.

Strengths and limitations of this study

- This is the first study to identify a catchment area for certain hospitals with laboratory values within Ontario's linked health administrative databases.
- Strict criteria were used to avoid misclassification of a region.
- This catchment area represents only 5% of Ontario's elderly residents.

BACKGROUND

Linked health administrative databases are powerful tools for conducting population-based observational studies. Initially intended for administrative purposes, the use of these databases has become increasingly popular in the field of health services research.[1] Linked databases contain a wide range of patient-related information at various levels (eg, national or provincial level). Typically, records include information on patient demographics, hospitalisations and ambulatory visits identified by diagnostic or procedural codes assigned during the encounter, and outpatient drug dispensations from pharmacies.[2]

Postmarketing drug studies have become important in understanding the real-world impact of commonly used medications in outpatient settings.[3–6] Drug safety studies are especially useful when exploring the effect of a drug on well-coded outcomes, such as skeletal fracture and acute myocardial infarction. Diagnostic codes for these outcomes are highly accurate with a sensitivity ≥89% and

positive predictive value ≥87%.[7] Certain drugs can also lead to adverse laboratory-based disorders such as hyponatraemia, hyperglycaemia or acute kidney injury. However, diagnostic codes for these conditions are less than ideal. The sensitivity of the International Classification of Diseases (ICD)-9 and ICD-10 codes for hyponatremia ranges from only 3 to 7%,[8 9 10] which causes underestimation of the true event rates and absolute risk differences when comparing two or more drugs. However, this could be improved by linking hospital-based laboratory data to the other data sources to provide better estimates of risk.

The use of linked healthcare administrative databases to estimate the risk of an outcome of interest is straightforward when considering a well-defined region such as the province of Ontario—the numerator is the number of patients suffering the outcome and the denominator is the entire registered population. However, when only a portion of hospitals have linked laboratory data, defining the denominator (ie, those patients at risk for both developing the outcome and presenting to a particular hospital) becomes more challenging. The goal of this project was to assign the laboratory-linked hospitals in Southwestern Ontario the regions from which its patients receiving medications from outpatient pharmacies would reliably arise.

METHODS

Setting

We conducted this study using several linked health administrative databases in Ontario, Canada. Ontario is the most populous Canadian province, with approximately 13 million residents in the year 2010, of whom 1.8 million were older than 65 years.[11] All residents received universal access to hospital and physician services, and elderly residents received coverage for prescription medications. Coverage for medical services and medications from a single provincial payer provided a comprehensive set of health administrative data. We completed the study according to a pre-specified protocol which was approved by the research ethics board at Sunnybrook Health Sciences Centre (Toronto, Ontario, Canada). The relevant datasets and the analyses were held and conducted at the Institute for Clinical Evaluative Sciences (ICES). The reporting of this study follows guidelines set out for observational studies (see online supplementary appendix 1).[12]

Overview

In Southwestern Ontario, we specified 118 geographical regions by postal FSAs and mapped a total of 45 hospitals with emergency departments, 12 of which had laboratory-linked data by the year 2009.[13 14] The 33 non-laboratory-linked hospitals were selected based on their proximity to the laboratory-linked hospitals (see online supplementary appendix 2). For each adult aged 66 years or older who visited an emergency department at one of the 45 hospitals from 1 June, 2003 to 31 December, 2009, we identified the Southwestern Ontario FSA of the pharmacy that dispensed their most recent outpatient prescription in the prior 120 days. We then classified a region as eligible for inclusion in the catchment area if at least 90% of emergency room visits in that region were to laboratory-linked hospitals in a given year.

Data sources

We identified emergency department visits to one of the 45 hospitals using the National Ambulatory Care Reporting System database that is maintained by the Canadian Institutes of Health Information. We characterised each hospital by a unique ambulatory-care institution number. We identified prescription drug claims using the Ontario Drug Benefits (ODB) database. The ODB programme provides Ontario residents 65 years of age and older with coverage for prescription medications. To ascertain the specific regions to be included in the catchment area, we used the ODB database to obtain postal information related to the dispensing pharmacy. Specifically, this geographical information is known as the FSA. In Canada, postal geography for each province begins with an FSA, which represents the first three characters of a postal code.[15 16] These geographical units were created by the Canada Post Corporation and assigned to regions in the province to facilitate the delivery of mail to businesses and households. Each character signifies important mailing information, including the postal district (first character), whether a particular region is urban or rural (second character), and specific areas within that region (third character).[16] See online supplementary appendix 3 for graphical presentation of FSAs. We preferentially assigned the pharmacy FSA to a patient instead of their home FSA since postal address information for a patient may be outdated (eg, if a patient still uses an older health card or has moved). Cerner (Kansas City, Missouri, USA) is a system that keeps patient electronic medical records, including laboratory test results for participating hospitals in one repository.[17] We recently linked a portion of the Cerner holdings for Southwestern Ontario hospitals with other healthcare datasets that are housed at the ICES in Ontario, Canada. This portion contained lab data including serum creatinine, potassium, sodium and glucose results for emergency department, inpatient and outpatient visits. Other information included the date and time of testing. The implementation of Cerner within Southwestern Ontario (sponsored by the provincial government) occurred in stages, with the number of hospitals in Ontario using the system increasing over time (see online supplementary appendix 4). In 2003, there were three laboratory-linked hospitals while in 2009, there were 12. We obtained patient demographic data from the Registered Persons Database, which contains demographic information on all Ontarians ever issued a health card. All these databases were reliably linked using a

unique identifier. We used census data (ie, linked to the FSA) to compare characteristics between our catchment area population and the Ontario population. Authorizations for use of this data were obtained from the London Health Sciences Centre (laboratory-linked hospital information) and ICES (all other datasets).

Cohort selection

Ontario residents 66 years of age and older were eligible for inclusion in the cohort. We excluded residents in their first year of eligibility of prescription drug coverage (age 65 years) to ensure at least one full year of available medication records. We also excluded patients who had a missing date of birth or missing sex. We enrolled patients into the cohort based on a two-step process for each year in the period of interest. First, we identified patients by their first unplanned visit to an emergency department for any cause at 1 of the 45 Southwestern Ontario hospitals. We denoted the date of this visit as the index date. We then looked back 120 days prior to the index date for the most recent outpatient prescription claim for any drug and identified the location of the dispensing pharmacy by the FSA. We excluded a small number of patients who had two or more prescriptions at two or more pharmacies on the day of the most recent prescription. If the identified FSA was not part of the Southwestern Ontario region (ie, not 1 of the 118 prespecified FSAs), we excluded these patients.

FSA selection

We calculated the proportion of patients who presented to laboratory-linked hospitals versus non-laboratory-linked hospitals in a given pharmacy FSA to determine the eligibility of FSAs. Because the number of laboratory-linked hospitals increased from year to year, we repeated the calculations for each year of interest. For an FSA to be included in the catchment area, at least 90% of emergency department visits in that FSA had to occur at laboratory-linked hospitals in a given year. FSAs in which more than 10% of emergency visits were to non-laboratory-linked hospitals were not included in the catchment area as we could not be confident that a medication-related lab-based disorder would prompt presentation to a laboratory-linked hospital. (Note: privacy regulations prohibit us from specifying cell sizes less than six; when this occurred, we treated these cell sizes as zero in all calculations.)

RESULTS

A flow diagram illustrating the procedures for catchment area ascertainment is presented in figure 1. From 2003 to 2009, there were a total of 649 713 emergency department visits with a most recent prescription claim in a particular FSA, of which 141 302 (22%) were to laboratory-linked hospitals. In the year 2003, there were 12 FSAs that met our criteria and this grew to 25 FSAs by the year 2009 (see online supplementary appendix 5). The map of Southwestern Ontario in figure 2 depicts the locations of these regions. Individuals from our catchment area (year 2009) were similar to the rest of the elderly population of Ontario (table 1). As of the year 2006 (most recent census profile), almost 5% of Ontario's elderly population (80 000 adults ≥65 years of age) resided in these 25 FSAs.

DISCUSSION

Determining the geographical regions that are predominantly serviced by laboratory-linked hospitals is an important first step to using hospital-based laboratory data in health outcomes research. Ours is the first study to use this methodology within Ontario's linked health administrative databases to determine a catchment area for particular hospitals. Where there is complete connectivity of data sources (eg, electronic medical record data, provincial hospital and procedure data, drug claim information, etc), other researchers may replicate these methods to define relevant regions for their jurisdiction of interest.

Since the year 2009, the number of hospitals with laboratory-linked data has remained consistent. As such, the catchment area has been kept the same since then. Certainly, the set of eligible FSAs may fluctuate depending on resident characteristics and available healthcare facilities. However, based on the patterns we observed from 2003 to 2009, the number of eligible FSAs only increased when additional hospitals began using the Cerner system. As such, once other hospitals have registered with Cerner, we will use the same methodology to update the existing catchment area. The study also highlights how regions of interest defined by geography can change over time.

Our study had several strengths that helped mitigate sources of error. We used emergency department visits as opposed to inpatient hospital admissions to ascertain encounters at a specific hospital. Inpatient hospital admissions can be planned and, particularly for tertiary care centres with specialised services, may include patients who live both near to and far from the hospital. Conversely, the emergency department setting allowed us to detect unplanned visits from patients within the area and likely reflected the true population who would present to the hospital if they were to incur a serious sudden medication-related laboratory disorder. We had a large number of emergency department visits from all over Southwestern Ontario to form the basis of our catchment area.

Some studies might restrict their analysis to only laboratory-linked hospitals and consider those FSAs where a large number of patients visited these hospitals. However, this would fail to ascertain the number of patients presenting to nearby non-laboratory-linked hospitals. For this reason, in our analysis we considered both laboratory and non-laboratory-linked hospitals to limit the possibility of falsely classifying a given FSA as part of the catchment area.

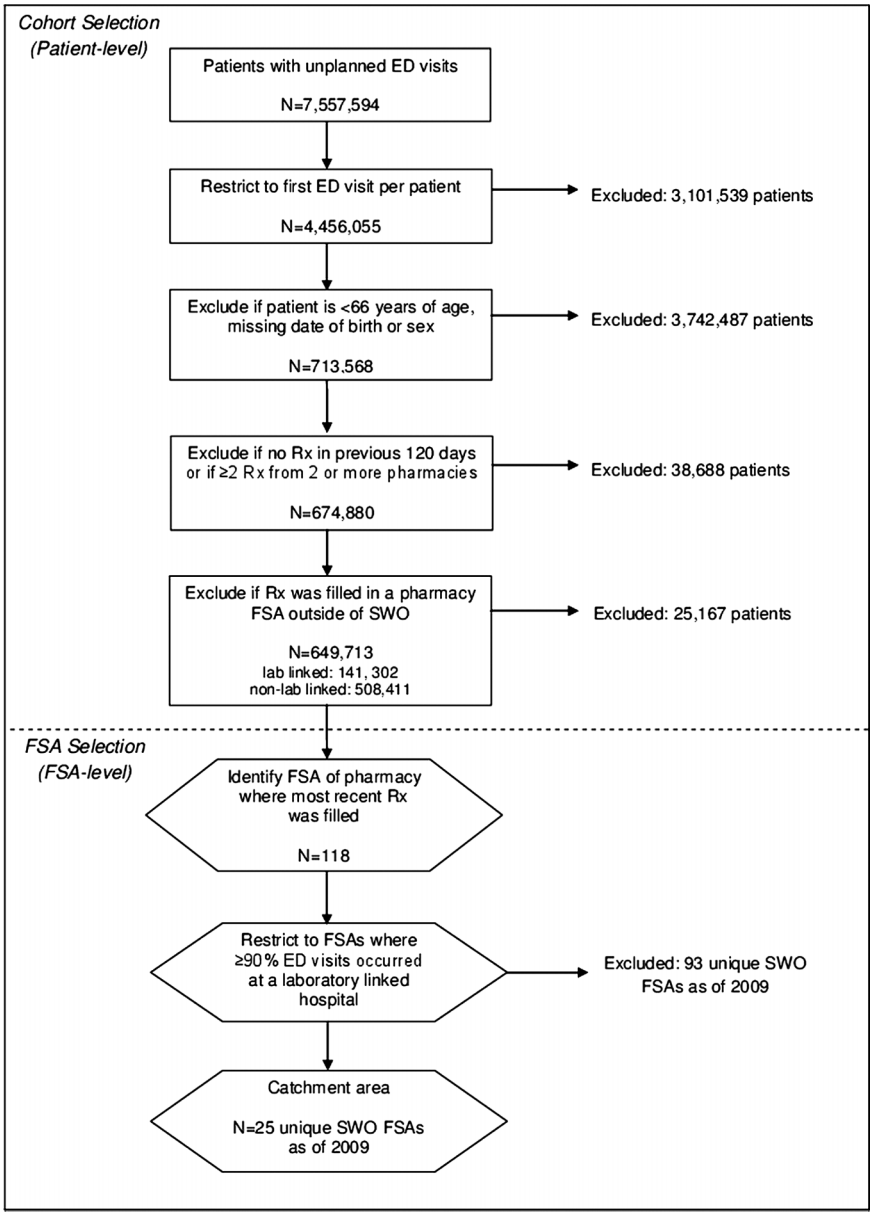


Figure 1 Flow chart describing methods for catchment area ascertainment from 2003 to 2009. ED, emergency department; FSA, forward sortation area; Rx, prescription; SWO, Southwestern Ontario.

ODB is a highly reliable database for prescription drug claims with a basic error rate under 1% (~0.7%, 95% CI 0.5% to 0.9%).[1] This indicates that previous prescription use was identified with a high degree of accuracy. Also, we ensured that temporality was established in that the prescription claim predated the emergency department visit. These methods were apt to detect an outpatient medication that was filled from a pharmacy in the patient's home region.

Our study does have some limitations. Although the ODB database was highly accurate for prescription drug claims, we did not have an indication about the validity of the pharmacy FSAs. If some pharmacy FSAs were incorrect, we might have misclassified them as being either eligible or ineligible for inclusion in the catchment area. If this was the case, we would not be capturing the true regions from which patients would present to a laboratory-linked hospital. However, this was likely not an issue since the FSAs identified for the corresponding hospitals had excellent face validity. For example, patient's who visited Tillsonburg District Memorial Hospital filled a prescription, mainly, from a Tillsonburg FSA.

Since the provincial drug plan only contains drug-dispensing information on patients over the age of 65, the current methods preclude us from capturing adverse events in younger patients. However, future drug safety studies that use this catchment area will still address adverse health outcomes in an understudied, vulnerable segment of the population.

We recognise that we will not capture cases who do not present to hospital (ie, those who do not present at all or who present to an outpatient laboratory instead), or those who present to hospital but fail to have the appropriate tests. Nonetheless, we will capture a substantial number of important severe lab-based outcomes that if anything, will underestimate the true incidence. These

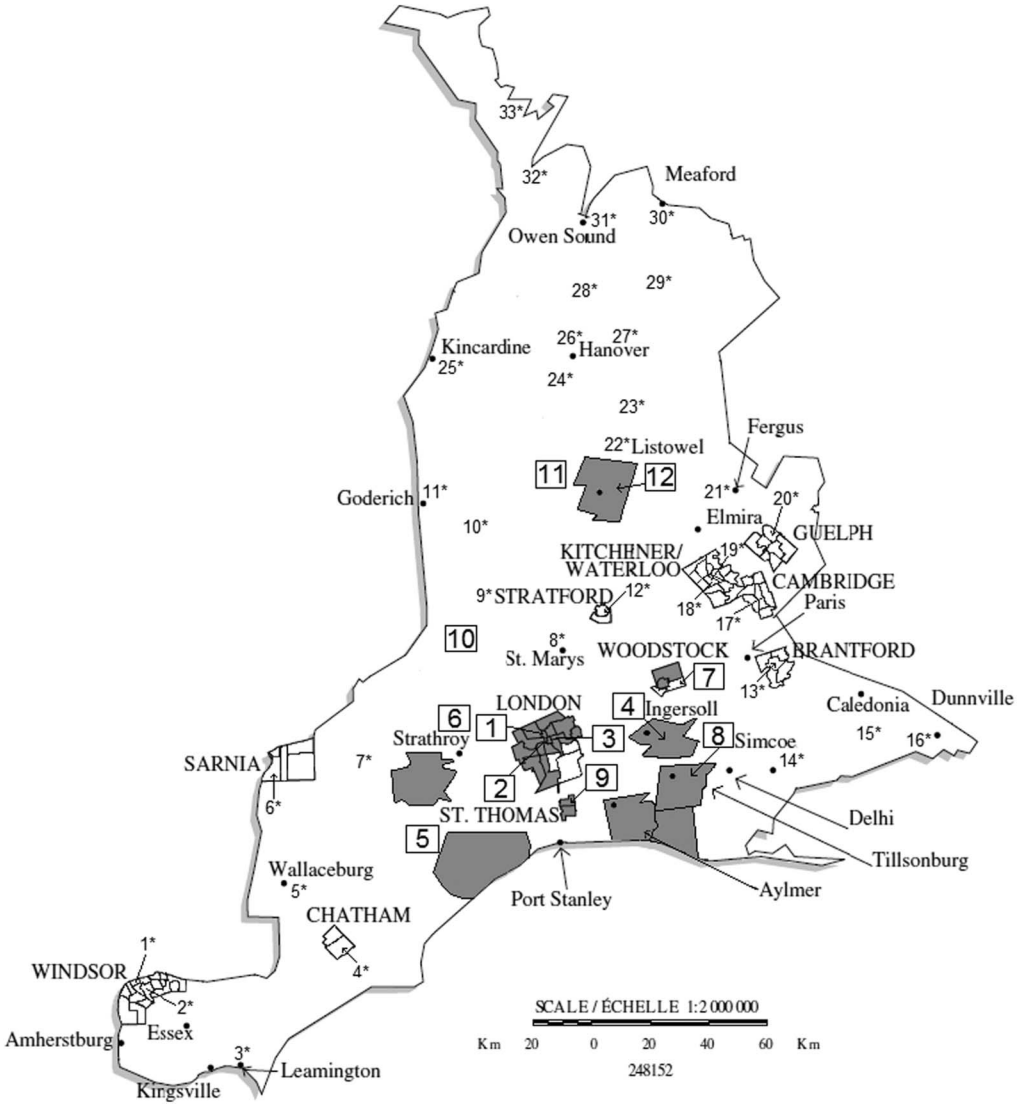


Figure 2 Locations of eligible regions (shaded) in Southwestern Ontario as of 2009. Boxed numbers represent laboratory-linked hospitals and starred numbers represent non-laboratory-linked hospitals. See online supplementary appendix 2 legend for further details.

Table 1 Comparison of catchment area and Ontario populations*

	Catchment area	Ontario
FSA characteristics		
N	25	509
Rural, N (%)	2 (8.0)	55 (10.8)
Patient characteristics		
N	80000	1649055
Age, N (%)		
65–69	21455 (26.8)	466295 (28.3)
70–74	18760 (23.5)	401890 (24.4)
75–79	16480 (20.6)	338825 (20.5)
80–84	13085 (16.4)	250250 (15.2)
85+	10220 (12.8)	191795 (11.6)
Women, N (%)	46150 (57.7)	931580 (56.5)

*2006 Census counts were applied to the 2009 catchment area.

studies will allow us to generate new information to guide optimal medication use.

We also understand that because our strict inclusion criteria has defined a population representing only 5% of Ontario's elderly residents, findings that arise from this catchment area may not fully generalise to the entire province. With respect to age, sex and rural living, the catchment area was similar in make-up to the Ontario population. Nonetheless, studies using this area will have lower sample sizes as compared with the entire province. Depending on the number of medication users and expected event rate, this may challenge the feasibility of some studies. For this reason, it may be prudent to conduct separate analyses examining diagnostic codes first (for all of Ontario) and then lab results (for the catchment area). Observing concordant signals across these two sets of analyses would strengthen inferences about the associations under study.

Implementation

We are now using this catchment area to define hospital-based laboratory outcomes in Canadian Institutes of Health Research-funded drug safety studies. Outcomes of interest include hospitalisation with hyponatremia, hyperkalemia and acute kidney injury. For research that examines lab-based disorders from medication use, both diagnostic codes and lab data are being used to define a particular outcome in separate related analyses. Preliminary work confirms that approximately 5% of elderly medication users in Ontario are being assessed in our catchment area.

CONCLUSION

Medication-related lab-based outcomes can be accurately identified at the population level using hospital-based laboratory data. A catchment area for those regions serviced by laboratory-linked hospitals can be used in future analyses. By capturing serious events that would otherwise go undetected by diagnostic codes, researchers may better inform health policy decision-makers about potential risks of common medications in routine practice. The new knowledge created can be translated and integrated into clinical practice (eg, routine measurements of serum electrolytes after certain drugs are prescribed) so that adverse events can be mitigated or even avoided.

Acknowledgements We acknowledge Tara Gomes and Karen Aubin for their contributions. This study was supported by the Institute for Clinical Evaluative Sciences (ICES), which is funded by an annual grant from the Ontario Ministry of Health and Long-Term Care (MOHLTC). 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. We thank the team at London Health Sciences Centre, St Joseph's Health Care and the Thames Valley Hospitals for providing access to the Cerner laboratory data.

Contributors SG participated in the data acquisition and linkage, coordination of the study, study design, provided interpretation of study results, and drafted the manuscript. SZS participated in the study design, performed the analysis and provided interpretation of study results. MMB, TH and GK participated in the data acquisition and linkage. MAW participated in the study design and provided feedback on the manuscript. AXG conceived of the study, participated in its design and provided feedback on the manuscript. All authors read and approved the final manuscript.

Funding SG was supported by a Canadian Institutes of Health Research Drug Safety and Effectiveness Cross-Disciplinary Training Programme Award. AXG was supported by a Clinician Scientist Award from the Canadian Institutes of Health Research.

Competing interests None

Ethics approval Sunnybrook Health Sciences Centre.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement There are no additional data available.

REFERENCES

1. Goel V, Williams JI, Anderson GM, Blackstien-Hirsch P, Fooks C, Naylor CD (eds). Appendix – a summary of studies on the quality of health care administrative databases in Canada. *Patterns of Health Care in Ontario. The ICES Practice Atlas. 2nd edition* (Ottawa: Canadian Medical Association, 1996) 339–46.
2. Suissa S, Garbe E. Primer: administrative health databases in observational studies of drug effects—advantages and disadvantages. *Nat Clin Prac Rheumatol* 2007;3:725–32.
3. Park-Wyllie LY, Juurlink DN, Kopp A, *et al*. Outpatient gatifloxacin therapy and dysglycemia in older adults. *N Engl J Med* 2006;354:1352–61.
4. Park-Wyllie LY, Mamdani MM, Juurlink DN, *et al*. Bisphosphonate use and the risk of subtrochanteric or femoral shaft fractures in older women. *JAMA* 2011;305:783–9.
5. Weir MA, Juurlink DN, Gomes T, *et al*. Beta-blockers, trimethoprim-sulfamethoxazole, and the risk of hyperkalemia requiring hospitalization in the elderly: a nested case-control study. *Clin J Am Soc Nephrol* 2010;5:1544–51.
6. Cheng RM, Mamdani M, Jackevicius CA, *et al*. Association between ACE inhibitors and acute pancreatitis in the elderly. *Ann Pharmacother* 2003;37:994–8.
7. Juurlink D, Preyra C, Croxford R, Chong A, Austin P, Tu J, Laupacis A. Canadian Institute for Health Information Discharge Abstract Database: A Validation Study. Toronto: Institute for Clinical Evaluative Sciences; 2006.
8. Movig KL, Leufkens HG, Lenderink AW, *et al*. Validity of hospital discharge International Classification of Diseases (ICD) codes for identifying patients with hyponatremia. *J Clin Epidemiol* 2003;56:530–5.
9. Shea AM, Curtis LH, Szczech LA, *et al*. Sensitivity of International Classification of Diseases codes for hyponatremia among commercially insured outpatients in the United States. *BMC Nephrol* 2008;9:5.
10. Gandhi S, Shariff SZ, Fleet JL, *et al*. Validity of the International Classification of Diseases 10th revision code for hospitalisation with hyponatraemia in elderly patients. *BMJ Open* (In press).
11. Statistics Canada: age pyramid of Ontario's population, 2010 and 2036. http://www.fin.gov.on.ca/en/economy/demographics/projections/ (accessed 5 Apr 2012).
12. Von Elm E, Altman DG, Egger M, *et al*. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *Ann Intern Med* 2007;147:573–7.
13. Canada Post: Householder counts and maps. http://www.canadapost.ca/cpc2/addrm/hh/maps/FSA/ON22.pdf (accessed 31 Mar 2012).
14. Ontario Ministry of Health and Long-Term Care: Health Care Options Directory. http://www.hco-on.ca/English/Search/ (accessed 31 Mar 2012).
15. Statistics Canada: Forward sortation area. http://www12.statcan.ca/census-recensement/2006/ref/notes/FSA-RTR-eng.cfm (accessed 1 Apr 2012).
16. Canada Post: Addressing Guidelines, Forward sortation areas—The first segment of the postal code. http://www.canadapost.ca/tools/pg/manual/PGaddress-e.asp#1383055 (accessed 11 Oct 2012).
17. Cerner. http://www.cerner.com/solutions/Hospitals_and_Health_Systems/Laboratory/ (accessed 18 Apr 2012).

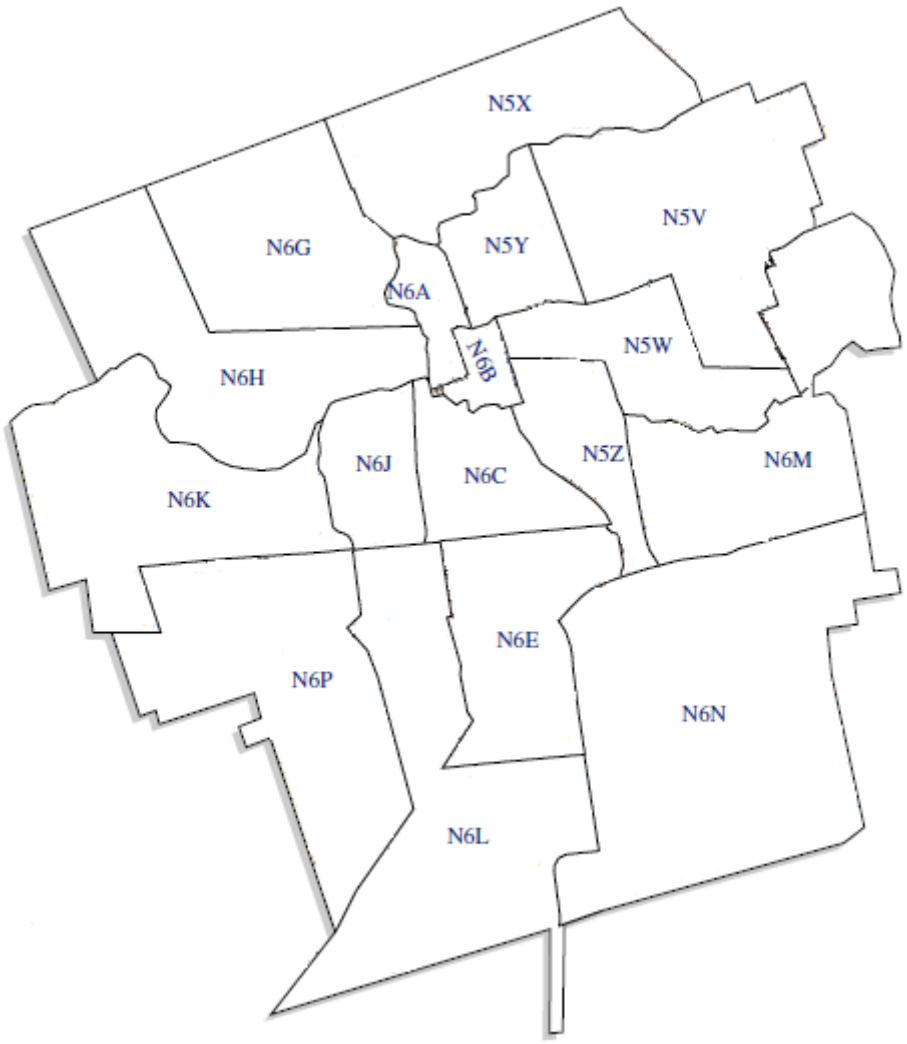
Appendix 1. STROBE Checklist

	Item No	Recommendation	Reported
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	abstract
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	abstract
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	introduction
Objectives	3	State specific objectives, including any prespecified hypotheses	introduction
Methods			
Study design	4	Present key elements of study design early in the paper	methods
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	methods
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	methods
		(b) For matched studies, give matching criteria and number of exposed and unexposed	n/a
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	methods
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	methods
Bias	9	Describe any efforts to address potential sources of bias	discussion
Study size	10	Explain how the study size was arrived at	methods, based on availability of the data
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	methods
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	methods
		(b) Describe any methods used to examine subgroups and interactions	n/a , no subgroups
		(c) Explain how missing data were addressed	n/a, data complete
		(d) If applicable, explain how loss to follow-up was addressed	n/a
		(e) Describe any sensitivity analyses	n/a
Results			
Participants	13	(a) Report numbers of individuals at each stage of study—e.g. 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	methods, Figure 1
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14	(a) Give characteristics of study participants (e.g. demographic, clinical, social) and information on exposures and potential confounders	table 1
		(b) Indicate number of participants with missing data for each variable of interest	n/a
		(c) Summarise follow-up time (e.g. average and total amount)	n/a
Outcome data	15	Report numbers of outcome events or summary measures over time	results
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g. 95% confidence interval). Make clear which confounders were adjusted for and why they were included	n/a
		(b) Report category boundaries when continuous variables were categorized	n/a
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—e.g. analyses of subgroups and interactions, and sensitivity analyses	n/a

Discussion			
Key results	18	Summarise key results with reference to study objectives	discussion, Figure 2
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	discussion
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	discussion
Generalisability	21	Discuss the generalisability (external validity) of the study results	discussion
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	cover page

Appendix 2, Figure 1. Hospitals with emergency departments in Southwestern Ontario as of 2009. See legend for further details.

Appendix 3. Graphical presentation of FSAs



Appendix 4

Table 1. Hospitals with linked laboratory data*							
Hospital	**Year**						
	2003	2004	2005	2006	2007	2008	2009
University Hospital, London	√	√	√	√	√	√	√
Victoria Hospital, London[£]	√	√	√	√	√	√	√
St. Joseph's Healthcare, London[€]	√	√	√	√	√	√	√
Alexandra Hospital, Ingersoll			√	√	√	√	√
Four Counties Health Services, Newbury			√	√	√	√	√
Strathroy Middlesex General Hospital, Strathroy			√	√	√	√	√
Woodstock General Hospital, Woodstock				√	√	√	√
Tillsonburg District Memorial Hospital, Tillsonburg				√	√	√	√
St. Thomas Elgin General Hospital, St. Thomas				√	√	√	√
South Huron Hospital, Exeter					√	√	√
Wingham and District Hospital, Wingham							√
Listowel Memorial Hospital, Listowel							√

*Catchment area methodology was applied to each hospital, for each fiscal year of interest.

[£]Prior to June 2005, Victoria Hospital (VH) only had a pediatric emergency department. South Street Hospital (SSH) had an adult emergency department until 2005 when VH opened a separate adult department [1]. This did not affect the lab data as SSH was a part of the VH umbrella. For computational purposes, aminst and NACRS information was obtained for SSH for fiscal years 2003 to 2005, until the VH ED was operational.

[€]St. Joseph's Healthcare (SJHC) in London had an emergency department until February 2005 when an urgent care centre opened up in its place [2]. Although records indicate that emergency department lab tests were being recorded in the system as of 2003, NACRS data for SJHC did not begin until February of 2005. Therefore for this hospital, we were unable to apply the catchment area methodology for the 2003/2004, and much of the 2004/2005 fiscal years. In the interest of not losing valuable information, this hospital was still considered to be a lab linked hospital for these years.

1. **London Health Sciences Centre: Countdown Begins to Emergency Department Changes.** [http://www.lhsc.on.ca/About_Us/LHSC/Media_Room/Media_Releases/2005/february7.htm]
2. **London Health Sciences Centre: South Street Hospital Transfer Complete.** [http://www.lhsc.on.ca/About_Us/LHSC/Media_Room/Media_Releases/2005/june12_2.htm]

Appendix 5

Table 2. FSAs to be included in the catchment area							
FSA	**Period of Interest**						
	2003	2004	2005	2006	2007	2008	2009
N5W	√	√	√	√	√	√	√
N5X	√	√	√	√	√	√	√
N5Y	√	√	√	√	√	√	√
N5Z	√	√	√	√	√	√	√
N6B	√	√	√	√	√	√	√
N6C	√	√	√	√	√	√	√
N6H	√	√	√	√	√	√	√
N6J	√	√	√	√	√	√	√
N6K	√	√	√	√	√	√	√
N6L	√	√	√	√	√	√	√
N6P	√	√	√	√	√	√	√
N5V	√	√	√	√	√	√	√
N7G			√	√	√	√	√
N5C			√	√	√	√	√
N6A			√	√	√	√	√
N6G				√	√	√	√
N5P				√	√	√	√
N5R				√	√	√	√
N4S				√	√	√	√
N4T				√	√	√	√
N4G				√	√	√	√
N5H				√	√	√	√
N0J				√	√	√	√
N0L				√	√	√	√
N4W							√

Legend: [ ] = laboratory linked hospitals; * = non-laboratory linked hospitals		
1 University Hospital, London	5 Four Counties Hospital, Newbury	9 Saint Thomas Elgin Hospital, Saint Thomas
2 Victoria Hospital, London	6 Strathroy Middlesex General Hospital, Strathroy	10 South Huron Hospital, Exeter
3 St. Joseph's Healthcare Centre, London	7 Woodstock Hospital, Woodstock	11 Wingham and District Hospital, Wingham
4 Alexandra Hospital, Ingersoll	8 Tillsonburg District Memorial Hospital, Tillsonburg	12 Listowel Memorial Hospital, Listowel
1* Hotel-Dieu Grace Hospital, Windsor	12* Stratford General Hospital, Stratford	23* North Wellington Health Care – Louise Marshall Hospital, Mount Forest
2* Windsor Regional Hospital – Metropolitan Campus, Windsor	13* Brantford General Hospital, Brantford	24* Walkerton County of Bruce Hospital Site – South Bruce Grey Health Centre, Walkerton
3* Leamington District Memorial Hospital, Leamington	14* Norfolk General Hospital, Simcoe	25* Kincardine & District Hospital Site – South Bruce Grey Health Centre, Kincardine
4* Public General Hospital Society of Chatham, Chatham	15* West Haldimand General, Haldimand County	26* Hanover and District Hospital, Hanover
5* Chatham-Kent Health Alliance – Syndenham Campus, Wallaceburg	16* Haldimand War Memorial Hospital, Dunnville	27* Durham Memorial Hospital Site – South Bruce Grey Health Centre, Durham
6* Bluewater Health – Norman Site, Sarnia	17* Cambridge Memorial Hospital, Cambridge	28* Chesley & District Hospital Site – South Bruce Grey Health Centre, Chesley
7* Bluewater Health – Charlotte Eleanor Englehart Hospital Site, Petrolia	18* St. Mary's General Hospital, Kitchener	29* Grey Bruce Health Services – Markdale Hospital, Markdale
8* St. Marys Memorial Hospital, St. Marys	19* Grand River Hospital – Kitchener-Waterloo Site, Kitchener	30* Grey Bruce Health Services – Meaford Hospital, Meaford

9* Seaforth Community Hospital, Seaforth	20* Guelph General Hospital, Guelph	31* Grey Bruce Health Services – Owen Sound Hospital, Owen Sound
10* Clinton Public Hospital, Clinton	21* Groves Memorial Community Hospital, Fergus	32* Grey Bruce Health Services – Wiarton Hospital, Wiarton
11* Alexandra Marine & General Hospital, Goderich	22* North Wellington Health Care – Palmerston and District Hospital Site, Palmerston	33* Grey Bruce Health Services – Lion's Head Hospital, Lion's Head