Validity of Administrative Data Claim-based Methods for Identifying Individuals with Diabetes at a Population Level

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ABSTRACT

Objectives: This study assessed the validity of a widely-accepted administrative data surveillance methodology for identifying individuals with diabetes relative to three laboratory data reference standard definitions for diabetes.

Methods: We used a combination of linked regional data (hospital discharge abstracts and physician data) and laboratory data to test the validity of administrative data surveillance definitions for diabetes relative to a laboratory data reference standard. The administrative discharge data methodology includes two definitions for diabetes: a strict administrative data definition of one hospitalization code or two physician claims indicating diabetes; and a more liberal definition of one hospitalization code or a single physician claim. The laboratory data, meanwhile, produced three reference standard definitions based on glucose levels +/- HbA1c levels.

Results: Sensitivities ranged from 68.4% to 86.9% for the administrative data definitions tested relative to the three laboratory data reference standards. Sensitivities were higher for the more liberal administrative data definition. Positive predictive values (PPV), meanwhile, ranged from 53.0% to 88.3%, with the liberal administrative data definition producing lower PPVs.

Conclusions: These findings demonstrate the trade-offs of sensitivity and PPV for selecting diabetes surveillance definitions. Centralized laboratory data may be of value to future surveillance initiatives that use combined data sources to optimize case detection.

Key words: Predictive value of tests; patient selection; health services research; diabetes mellitus; sensitivity; validation studies; surveillance

La traduction du résumé se trouve à la fin de l'article.

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Public health surveillance is of great importance to the planning and evaluation of treatment and prevention programs for chronic diseases such as diabetes.[1-3] However, the optimal methodology for identifying individuals with diabetes in a population has yet to be determined. Currently in Canada, the National Diabetes Surveillance System (NDSS),[4] based on administrative health data, is used to disseminate comparative data on rates of diabetes across provinces and territories. The NDSS is a collaborative initiative that focuses on using administrative databases to identify individuals with diabetes [4,5] NDSS definitions have been in use for several years now, but their validity is only partially characterized.[6] One of the potential limitations of diabetes surveillance definitions that are based on administrative data claims is that they require the explicit documentation of diabetes by both physicians and health record coders. As a result, the NDSS methodology may be prone to underestimate the prevalence and incidence of diabetes. In contrast, archived laboratory test data have potential value in disease surveillance because they do not require the explicit medical record documentation of diabetes status. Although not formally tested in surveillance research, it has been demonstrated by Pine et al. that laboratory data can be linked to traditional administrative data to enhance health services analyses focusing on mortality rates.[7]

Canada's single payer health system facilitates surveillance systems because it mandates the collection of the hospital stay and physician claims data needed to implement the NDSS. This is indeed the case in the Calgary zone of Alberta Health Services, a large publicly-funded regional health system that oversees the health and health care of over 1.2 million people in the province of Alberta. Among its many data assets, the health region archives administrative data records for all inpatient hospital separations that occur in the region's acute-care hospitals, physician billing claims for all inpatient and outpatient contacts (the latter are obtained periodically from the provincial Ministry of Health), and laboratory test data for all inpatient and outpatient tests that occur in the region in a given year.

This rich combination of data sources provides us with the opportunity to study diabetes surveillance case definitions to build on existing knowledge of validity of these definitions.[6,8,9] For the study presented here, we specifically sought 1) to identify individuals with diabetes using a centralized laboratory database based on the presence of laboratory test results that indicate presence of diabetes; and 2) to assess the sensitivity of the currently accepted administrative data methodology for identifying individuals with diabetes relative to the reference standard of people with diabetes defined by laboratory data.

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Conflict of Interest: None to declare.

Table 1. Laboratory Data Definitions

A) the first is referred to as our "laboratory-CDA definition" (Canadian Diabetes Association definition) with
   1. a fasting blood glucose ≥ 7 mmol/L (126 mg/dL) or
   2. a random glucose ≥ 11.1 mmol/L (200 mg/dL) or
   3. a 2-hour glucose (post-prandial or part of an oral glucose tolerance test (OGTT)) ≥ 11.1 mmol/L (200 mg/dL)

B) the second is referred to as our "laboratory 0.067 definition" with
   1. a fasting blood glucose ≥ 7 mmol/L (126 mg/dL) or
   2. a random glucose ≥ 11.1 mmol/L (200 mg/dL) or
   3. a 2-hour glucose ≥ 11.1 mmol/L (200 mg/dL) or
   4. a HbA_{1c} >0.067

C) the third is referred to as our "laboratory 0.061 definition" with
   1. a fasting blood glucose ≥ 7 mmol/L (126 mg/dL) or
   2. a random glucose ≥ 11.1 mmol/L (200 mg/dL) or
   3. a 2-hour glucose ≥ 11.1 mmol/L (200 mg/dL) or
   4. a HbA_{1c} >0.061

Table 2. Administrative Data Definitions

1) For the "strict administrative data definition" (used in the NDSS)
   - a person with diabetes is identified as such when they have either one hospitalization where they are coded as having diabetes (ICD-9-CM codes 250.0- 250.9 or ICD-10-CA codes E10.x, E11.x, E13.0, E13.1, E14.0, E14.1) OR
   - two separate ambulatory physician claims within 730 days of each other where they are coded as having diabetes (ICD-9-CM 250.x).

2) The "liberal administrative data definition" is a broadened version definition
   - classifying an individual as having diabetes if they have one hospitalization OR
   - any single ambulatory physician claim with a recorded diabetes diagnosis code.

Table 3. Date Ranges for Administrative Data Definitions

a) Using diagnosis data only from July 1st, 2000 through June 30th, 2002 to classify the population as having diabetes or not using the administrative data definitions described in Table 2.

b) Using diagnosis data from July 1st, 1998 through June 30th, 2002 to classify the population as having diabetes or not, only if they are designated as such post July 1st, 2000. The extended date range here is to permit a person whose first physician claim occurred prior to the time window to be included in the diabetes cohort as per NDSS recommendation when they have a second defining diagnosis claim that occurs within the desired timeframe. (Note: this extended date range is applied to the NDSS administrative definition only.)

c) Using the entire data sample of administrative data from fiscal year 1994 onward to June 30th, 2002 to include anyone who has diabetes according to the NDSS definition. Unlike the preceding two date ranges, this longer time period includes all individuals who were classified as having diabetes prior to July 1st, 2000, were anchored as such, and continued to be active in the region.

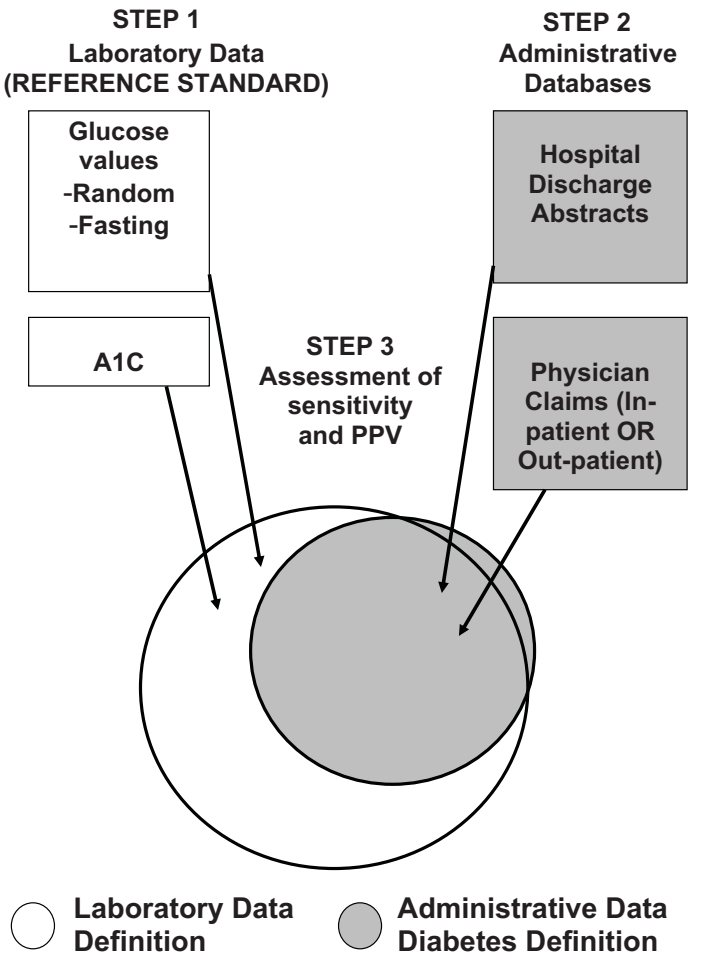
MATERIALS AND METHODS

Laboratory Data Definitions

Laboratory data for this study were provided by Calgary Laboratory Services (CLS). We focused on individual patient laboratory tests for fasting blood glucose, random blood glucose, 2 hour glucose tolerance test, and haemoglobin A1C (HbA_{1c}). We proceeded to query laboratory data from July 1, 2000 through June 30, 2002 to create three different diabetes definitions from laboratory data (see Table 1).

Each successive definition presented in Table 1 encompasses the previous one(s), with the third definition being the broadest because of the lower cut-point for HbA_{1c} judged to be indicative of diabetes. The use of HbA_{1c} to make the clinical diagnosis of diabetes has not been widely accepted for a variety of reasons, and most formal definitions of diabetes (such as the Canadian Diabetes Association (CDA) definition) have been confined to blood glucose parameters. However, the incorporation of HbA_{1c} cut-offs into surveillance definitions was felt promising because many patients who have established diabetes are likely to have HbA_{1c} measured to assess control (and at a frequency of 2-4 times per year). Furthermore, there are data demonstrating that HbA_{1c} cut-points of 0.061 and 0.067 can be informative for judging presence or absence of diabetes (with the former being more sensitive and the latter more specific).[10-12]

Figure 1. Overview of the methodology used to assess sensitivity of administrative data diabetes surveillance definitions relative to laboratory data reference standards



PPV = positive predictive value

Administrative data definitions

Administrative hospital discharge data and physician claims data were used to determine diabetes status according to more traditional administrative data surveillance definitions. All individuals living in the study region with any diabetes code recorded in these data sources from fiscal year 1994 through fiscal year 2002 could be identified and extracted, and the NDSS diabetes definition thus applied. For the purposes of this study, we evaluated two administrative data definitions for diabetes: the NDSS definition and a more liberal administrative data definition. These definitions are described in detail in Table 2.

We used three different date range queries for implementing these two administrative data definitions. These different date ranges are presented and explained in Table 3.

Analysis

Figure 1 schematically summarizes our research process of compiling and comparing laboratory and administrative data definitions for diabetes. Given our focus on studying the validity of existing

Table 4. Comparison of Laboratory and Administrative Data Definitions for Defining Diabetes

Comparison Administrative Data and Relevant Data Years	Gold Standard	Sensitivity: P(Admin+|Gold+) %	95% CI for Sensitivity	PPV: P(Gold+|Admin+) %	95% CI for PPV
NDSS Data Definition (Two claims or one hospitalization)					
1994-2002	Laboratory-CDA (N=25,419)	78.5	78.3, 78.8	69.2	68.9, 69.5
	Laboratory 0.067 (N=27,381)	79.1	78.9, 79.4	75.1	74.8, 75.3
	Laboratory 0.061 (N=29,143)	77.1	76.9, 77.4	77.9	77.6, 78.1
1998-2002	Laboratory-CDA (N=25,419)	73.5	73.2, 73.8	78.0	77.8, 78.3
	Laboratory 0.067 (N=27,381)	73.7	73.4, 74.0	84.3	84.1, 84.5
	Laboratory 0.061 (N=29,143)	71.4	71.1, 71.7	86.9	86.7, 87.1
2000-2002	Laboratory-CDA (N=25,419)	70.8	70.5, 71.0	79.6	79.3, 79.8
	Laboratory 0.067 (N=27,381)	70.8	70.5, 71.1	85.8	85.6, 86.0
	Laboratory 0.061 (N=29,143)	68.4	68.2, 68.7	88.3	88.1, 88.4
Liberal Admin Data Definition (One claim or one hospitalization)					
1994-2002	Laboratory-CDA (N=25,419)	86.4	86.2, 86.7	53.0	52.7, 53.3
	Laboratory 0.067 (N=27,381)	86.9	86.7, 87.1	57.4	57.1, 57.7
	Laboratory 0.061 (N=29,143)	85.2	85.0, 85.4	59.9	59.6, 60.2
2000-2002	Laboratory-CDA (N=25,419)	81.6	81.4, 81.9	69.3	69.0, 69.6
	Laboratory 0.067 (N=27,381)	81.7	81.5, 82.0	74.7	74.4, 75.0
	Laboratory 0.061 (N=29,143)	79.5	79.3, 79.7	77.3	77.1, 77.6

CDA = Canadian Diabetes Association; NDSS = National Diabetes Surveillance System; PPV = Positive Predictive Value
P(Admin+|Gold+) = Probability(positive through administrative data/positive through laboratory data) – i.e., the sensitivity
P(Gold+| Admin+) = Probability(positive through laboratory data/positive through administrative data) – i.e., the PPV

administrative data approaches to defining diabetes, laboratory data definitions served as the reference standards in our analysis, against which the administrative data definitions were tested. Using the registry file of all Calgary area residents receiving provincial health insurance, we linked the laboratory data to confine our analyses to individuals who resided continuously in the study region. A total of 6 comparisons were then made: The NDSS data definition was compared to each of a) the laboratory-CDA definition, b) the laboratory 0.067 definition, and c) the laboratory 0.061 definition. The liberal administrative data definition was then compared to these same three laboratory data definitions.

For each comparison, we determined the sensitivity (and binomial 95% confidence intervals) as our primary measure of validity of the administrative data surveillance definitions. We also assessed the positive predictive value (PPV) as a secondary measure of interest.

RESULTS

A total of 25,419 individuals were identified as having diabetes using the Laboratory-CDA definition, 27,381 using the Laboratory 0.067 definition, and 29,143 using the Laboratory 0.061 definition. The sensitivities and PPV for the administrative data vs. laboratory data comparisons made are presented in Table 4.

The comparison of the NDSS definition and the liberal definition to the various laboratory data definitions that we studied yields sensitivities ranging from 68.4% to 79.1%, depending on the laboratory reference standard used, and the time interval used to define presence of diabetes. In general, the administrative data definitions were more sensitive when a longer time period of data was queried to determine presence/absence of diabetes (i.e., sensitivities ranging from 77.1% to 79.1% when 1994-2002 data were queried vs. only 68.4% to 70.8% when only two years of data were queried). We also found that the liberal administrative data definition produced higher sensitivities than did the NDSS definition, with the liberal definition's sensitivities ranging from 79.5% to 86.9%, depending on the time interval and laboratory reference standard used. Interestingly, the choice of laboratory reference standard (i.e., laboratory CDA vs. laboratory 0.067 vs. laboratory 0.061) did not significantly influence the administrative data sensitivity estimates, though there is a pattern of slightly lower sensitivities for the broadest laboratory definition that includes a haemoglobin A1C threshold of only ≥0.061.

The PPV estimates, meanwhile, demonstrate a different pattern that reflects the typical trade-offs of optimizing sensitivity at the expense of PPV (and specificity). The PPV was highest for the NDSS administrative data definition applied to the shortest time window of data, and dropped as the time period of data queried increased. The PPV also dropped when the more liberal administrative data definition was applied to each of the laboratory definitions for both the 2-year time window and also the longer 8-year time window.

DISCUSSION

Our study findings are important in providing two key insights regarding Canada's important NDSS initiative.[13] First, our results reveal sensitivity values around 80% for the currently used NDSS administrative data definition, compared to the definitions we developed from the laboratory data. This general result underlines the fact that current surveillance definitions are underestimating the burden of *diagnosed* diabetes at a population level, even if we set aside consideration of *undiagnosed* diabetes. In the absence of improved disease surveillance systems and definitions, the underestimation of diabetes prevalence is an interpretive caveat to existing diabetes surveillance estimates.

The second key insight from our results is that the currently-used NDSS definition has modest performance on validity testing, and that there are potential ways of enhancing its performance. Three prior validation studies from Nova Scotia, Ontario, and Prince Edward Island have used narrower scopes of data to partially assess the validity of the NDSS diabetes surveillance definition.[6,8-10,14] Like our study, these revealed sensitivity measures ranging from 69% to 86%, with the gold standards being a combination of provincial health surveys, diabetes registries, and/or medical charts.[3-6,8] In the Ontario study,[3] researchers compared the NDSS algorithm to primary care medical chart data as the reference standard for determining presence/absence of diabetes. They found that the NDSS data definition yielded a sensitivity of 85%, and that the liberal administrative definition yielded a sensitivity of 90%.[3]

Our range of administrative data sensitivities (68% to 87%) is generally comparable to prior validity estimates from the above-mentioned studies. However, our reported sensitivities are lower than those reported in the above-mentioned Ontario study.[3] We suspect that this relates partially to the fact that the methodology used in that study is prone to find higher sensitivities, because diabetes explicitly recorded by a physician in the written medical record is more likely to also be coded (because coding is itself a direct result of what actually gets recorded in a medical chart). Laboratory data, meanwhile, permits us to test the performance of administrative data surveillance definitions against a reference standard that is not directly linked to what actually gets documented in the written medical record (i.e., perhaps a 'tougher' test of validity). Subtle differences aside, these studies testing the validity of administrative data surveillance definitions highlight that there is a need to explore improved surveillance definitions.

There is promise in the potential *dual use* of coded administrative data with linked laboratory data to detect diabetes using a Boolean "or" operator (i.e., judging diabetes to be present when it is recorded in either the administrative data records or in linked laboratory data). This approach to using two data sources represents a form of capture-recapture methodology for case detection.[15] Similar potential exists with the use of prescription claims data, which could likewise be used to enhance surveillance definitions. Such combined surveillance definitions would almost certainly be more sensitive in capturing diagnosed diabetes at a population level, but would continue to be limited in their ability to detect individuals with undiagnosed diabetes.

Beyond comparisons between data sources, our study provides insights into the choice of strict vs. liberal administrative data definitions for diabetes. We have shown that the liberal administrative data definition improved sensitivity relative to the NDSS definition, but at the cost of a lower positive predictive value (and by extension, probably also specificity). We recognize that the PPV results need to be interpreted with some caution since our PPV estimates are likely to be affected by the fact that a proportion of patients with diabetes may not have laboratory tests performed and so will be missed from the denominator. The ultimate choice of surveillance definitions depends on user needs. In some instances (e.g., estimating diabetes prevalence), a higher sensitivity may be desirable. For other goals and situations (e.g., detecting diabetes cases for contact), a higher PPV may be desirable.

Such choices notwithstanding, our study demonstrates the potential role of population-based laboratory data in surveillance to improve upon the limitations of existing diabetes surveillance algorithms that produce underestimates of the true burden of diagnosed diabetes. Future chronic disease surveillance systems are likely to benefit from the use of centralized laboratory data such as those used in this study.

REFERENCES

1. Delich S, Carter AO. Public health surveillance: Historical origins, methods and evaluation. *Bull WHO* 1994;72:285-304.
2. Tan H, MacLean DR. Epidemiology of diabetes mellitus in Canada. *Clin Invest Med* 1995;18:240-46.
3. NIH. *Diabetes in America,* 2nd ed. Washington, DC: National Diabetes Data Group, National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health, 1995.
4. Clottey C, Mo F, LeBrun B, Mickelson P, Niles J, Robbins G. The development of the National Diabetes Surveillance System (NDSS) in Canada. *Chron Dis Can* 2001;22(2):67-69.
5. Blanchard JF, Ludwig S, Wajda A, Dean H, Andreson K. Incidence and prevalence of diabetes in Manitoba, 1986-1991. *Diabetes Care* 1996;19:807-11.
6. Hux JE. Using administrative data to define the prevalence of diabetes mellitus in Ontario. Report to NDSS Validation Working Group. Toronto: ICES, March 1999.
7. Pine M, Norussis M, Jones B, Rosenthal GE. Predictions of hospital mortality rates: A comparison of data sources. *Ann Intern Med* 1997;126:347-54.
8. LeBlanc J, Kephart G. Assessment of the sensitivity and specificity of Nova Scotia administrative databases for detecting diabetes mellitus. Report to NDSS Validation Working Group. Halifax: Population Health Research Unit, January 1998.
9. Van Til L. PEI Diabetes Validation Project, Report to NDSS Validation Working Group. Charlottetown: Document Publishing Centre, March 2001. Responding to the Challenge of Diabetes in Canada: First Report of the National Diabetes Surveillance System (NDSS), 2003.
10. McCance DR, Hanson RL, Charles MA, Jacobsson LT, Pettitt DJ, Bennett PH, et al. Comparison of tests for glycated hemoglobin and fasting and two hour plasma glucose concentrations as diagnostic methods for diabetes. *BMJ* 1994;308:1323-28.
11. Engelgau MM, Thompson TJ, Herman WH, Boyle JP, Aubert RE, Kenny SJ, et al. Comparison of fasting and 2-hour glucose and HbA1c levels for diagnosing diabetes. Diagnostic criteria and performance revisited. *Diabetes Care* 1997;20(5):785-91.
12. Rohlfing CL, Little RR, Wiedmeyer HM, England JD, Madsen R, Harris MI, et al. Use of GHb (HbA1c) in screening for undiagnosed diabetes in the U.S. population. *Diabetes Care* 2000;23(2):187-91.
13. National Diabetes Surveillance System, 2006. Available at: http://www.phac-aspc.gc.ca/ccdpc-cpcmc/ndss-snsd/english/index_e.html (Accessed January 15, 2008).
14. Hux JE, Ivis F, Flintoft V, Bica A. Diabetes in Ontario: Determination of prevalence and incidence using a validated administrative data algorithm. *Diabetes Care* 2002;25(3):512-16.
15. Harvey JN, Craney L, Kelly D. Estimation of the prevalence of diagnosed diabetes from primary care and secondary care source data: Comparison of record linkage with capture-recapture analysis. *J Epidemiol Community Health* 2002;56:18-23.

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RÉSUMÉ

Contexte : Cette étude a évalué la validité d'une méthode de surveillance basée sur des données administratives pour identifier des sujets diabétiques selon trois définitions du diabète constituant un étalon de référence pour les données de laboratoire.

Méthode : Nous avons utilisé une combinaison de données régionales liées (registres des sorties des hôpitaux et demandes de paiement des médecins) et de données de laboratoire pour évaluer la validité de définitions administratives de la surveillance du diabète par rapport à un étalon de référence pour les données de laboratoire. Les données administratives sur les sorties utilisent deux définitions pour le diabète : une définition stricte (un code d'hospitalisation ou deux demandes de paiement de médecins indiquant le diabète) et une définition plus large (un code d'hospitalisation ou une seule demande de paiement de médecin). Les données de laboratoire, par contre, ont trois définitions, fondées sur les niveaux de glycémie +/- les niveaux de HbA1c.

Résultats : La sensibilité des définitions administratives variait entre 68,4 % et 86,9 % par rapport aux trois définitions utilisées pour les données de laboratoire. La sensibilité était plus élevée pour la définition administrative la plus large. Les valeurs prédictives positives (VPP) variaient quant à elles entre 53,0 % et 88,3 %, la définition administrative la plus large produisant des VPP plus faibles.

Interprétation : Ces résultats montrent qu'il y a un compromis à faire entre une sensibilité optimale et la VPP lorsqu'on veut employer les meilleures définitions de surveillance du diabète. Les données centralisées en laboratoire peuvent être utiles pour les futures initiatives de surveillance, qui pourraient utiliser des sources de données combinées pour optimiser la détection des cas.

Mots clés : valeur prédictive des tests; sélection des patients; évaluation résultats et méthodes (soins); diabète de type 1; sensibilité et spécificité; études de validité; surveillance épidémiologique