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Abstract

Objectives

This article describes an algorithm to classify respondents to cycle 1.1 (2000/2001) of the Canadian Community Health Survey (CCHS) according to whether they have type 1, type 2 or gestational diabetes.

Data source

The data are from the chronic disease module and the drug module of cycle 1.1 of the CCHS.

Analytical techniques

A total of 6,361 respondents to cycle 1.1 of the CCHS reported that a health care professional had diagnosed them as having diabetes. The Ng-Dasgupta-Johnson algorithm classifies this group according to whether they have type 1, type 2 or gestational diabetes, based on their answers to CCHS questions about diabetes during pregnancy, use of oral medications to control diabetes, use of insulin, timing of initiation of insulin treatment, and age at diagnosis.

Main results

Application of an earlier algorithm to CCHS cycle 1.1 results in a 10%-90% split for type 1 and type 2 diabetes. By contrast, the Ng-Dasgupta-Johnson algorithm yields a 5%-95% split. This is not unreasonable, given the rapid rise in obesity, a major risk factor for type 2 diabetes, in Canada.

Keywords

Chronic disease, classification, data collection, health surveys, insulin

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Diabetes is a serious chronic condition characterized by high levels of glucose, the body's primary fuel. Normally, glucose is transferred from the circulation system into tissue cells through the action of insulin, a hormone produced by the pancreas. In patients with type 1 diabetes, high glucose levels result from a lack of insulin production. For patients with type 2 or gestational diabetes, glucose levels rise because of resistance to the action of insulin. Although gestational diabetes may resolve post-partum, women with this condition are at increased risk of developing type 2.[1]

Very high glucose levels can cause fatigue, dehydration, and even death. More moderate but long-term elevations of glucose levels can contribute to injury of blood vessels, which, in turn, can result in complications such as blindness, kidney injury, heart disease and stroke.[2-5] Because of its adverse health effects and the associated economic burden on the health care system,[6,7] diabetes is a major public health problem.

Recent literature suggests that the prevalence of diabetes is rising, not only in Canada, but worldwide.[8,9] It is likely that this increase is due primarily to the growing number of people with type 2 diabetes.[8,9] The insulin resistance that leads to type 2 diabetes results from a combination of excess body weight, physical inactivity, and genetic factors. Tellingly, the increasing prevalence of type 2 diabetes has paralleled the rise in obesity, which is a risk factor.

Because of differences in etiology, associated risk factors, costs, and prevention strategies for type 1 and type 2 diabetes, it is important for public health surveillance to be able to track their prevalence.[10] Data on diabetes are collected by Statistics Canada's Canadian Community Health Survey (CCHS). The CCHS is a nationally representative population survey that contains questions about a host of chronic conditions and a comprehensive array of demographic, socio-economic, health and lifestyle variables. Thus, potentially, the CCHS can be used to monitor the prevalence of diabetes in Canada and to study associations with risk factors. A major limitation of these data, however, is that the survey does not directly ask respondents about diabetes type.

This article describes a new algorithm based on cycle 1.1 (2000/2001) of the CCHS, which is designed to identify respondents according to whether they have type 1, type 2 or gestational diabetes.

Diabetes questions in the Canadian Community Health Survey

The CCHS covers the population aged 12 or older living in private households. It does not include people on Indian reserves, on Canadian Forces bases, or in some remote areas. The first cycle (1.1) was conducted from September 2000 through October 2001. The overall response rate for cycle 1.1 was 85%; the total sample size was 131,535.

The chronic disease module of the CCHS contains six questions that deal specifically with diabetes:

CCCA_101	Do you have diabetes?
CCCA_102	How old were you when this was first diagnosed?
CCCA_10A	Were you pregnant when you were first diagnosed with diabetes? (asked of women aged 15 or older)
CCCA_10B	Other than during pregnancy, has a health professional ever told you that you have diabetes? (asked of women who had diabetes during pregnancy)
CCCA_10C	When you were first diagnosed with diabetes, how long was it before you were started on insulin? Less than 1 month 1 month to less than 2 months 2 months to less than 6 months 6 months to less than 1 year 1 year or more Never
CCCA_105	Do you currently take insulin for your diabetes?

As well, the drug module of the CCHS contains questions about diabetes medications:

In the past month, that is, from (date one month ago) to yesterday, did you take:

DRGA_1N	. . . insulin?
DRGA_1O	. . . pills to control diabetes?

Creating an algorithm

To create an algorithm to classify CCHS respondents who report diabetes as being type 1, type 2 or gestational cases, it is necessary to understand the nature of these forms of the disease and differences in they way they are treated. Type 1 and type 2, in particular, differ not only in etiology, but also in treatment.

People with type 1 diabetes produce little or no insulin. In type 1, the pancreas cannot produce insulin, so it must be replaced. Therefore, treatement for type 1 invariably requires insulin injections. Type 1 usually develops during childhood or adolescence.[3]

In type 2 diabetes, the pancreas continues to produce insulin, but the body develops resistance to its effects, resulting in a relative insulin deficiency. Glucose control in type 2 diabetes may be achieved with weight reduction, exercise, and oral medications, although insulin production may become impaired over time, and many patients eventually require insulin treatment.[11-13] Type 2 typically occurs in adulthood after age 30,[12] and becomes progressively more common with

advancing age. However, rates of type 2 among children and adolescents are rising, largely as a result of the increasing prevalence of obesity.[14,15]

Gestational diabetes occurs in about 4% of all pregnancies.[16] Identifying gestational diabetes from the CCHS is relatively simple; the principal challenge is differentiating between types 1 and 2.

Given the differences in age of onset and treatment, it is possible to classify CCHS respondents as having type 1 or type 2 diabetes, based on their answers to questions about these factors. For example, age of diagnosis before 30 might be used to identify type 1 patients. Based on this criterion, close to 10% of the CCHS sample who reported diabetes would be classified as type 1 (n=608), a proportion consistent with previous studies.[3] However, responses to questions about medication use indicate that approximately half of these respondents started insulin treatment six months or more after they had been diagnosed, even though type 1 patients generally require insulin treatment within six months of diagnosis.[17] This suggests that some of the patients identified as type 1 based on the age 30 criterion would be misclassified. This possibility is bolstered by the increasingly younger age at which type 2 diabetes is being diagnosed.[14,15] As well, using insulin cannot definitively categorize patients as type 1 or type 2, given that insulin use is not confined to type 1 patients. Therefore, a combination of age and medication use criteria is needed to distinguish between types 1 and 2.

The Maddigan-Johnson algorithm

An algorithm to classify CCHS respondents as having type 1 or type 2 diabetes was developed by Maddigan-Johnson (MJ) in 2006.[18] This algorithm (Figure 1) employs six CCHS questions: 1. has diabetes; 2. use of insulin; 3. age at first diagnosis; 4. timing of insulin treatment; 5. age of respondent; and 6. use of oral medications.

The MJ algorithm classifies the 6,361respondents reporting diabetes who used an oral medication as type 2, regardless of insulin use. Respondents using neither oral medications nor insulin are also classified as type 2. Those not using an oral medication, but using insulin, and who were younger than age 30 at

Figure 1
Maddigan-Johnson algorithm

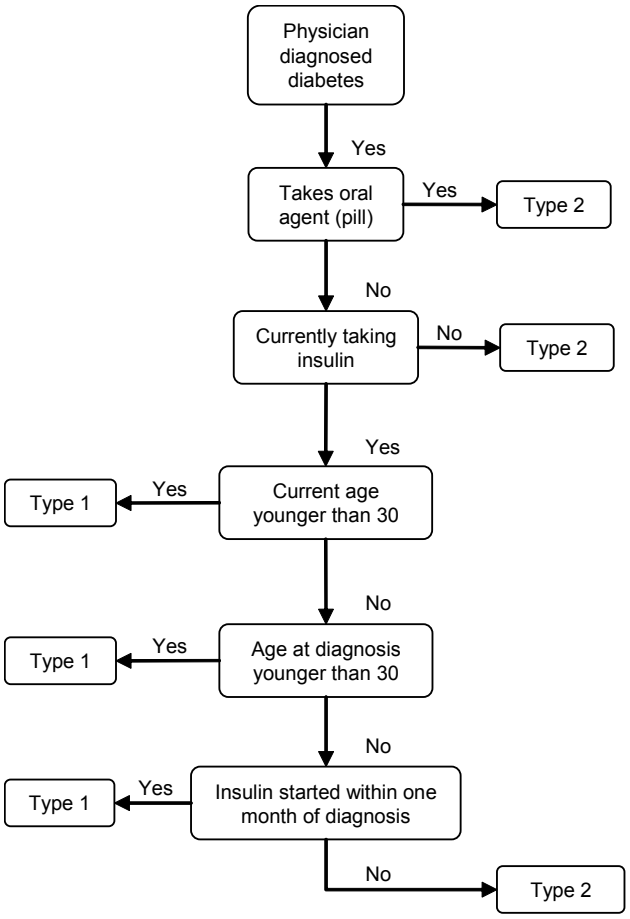
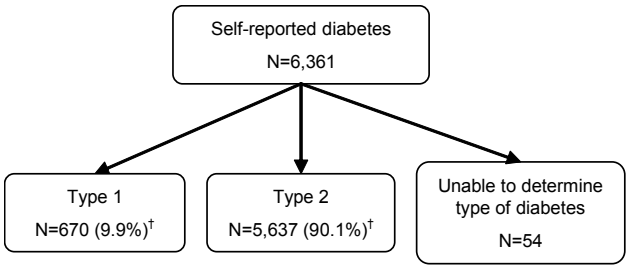


Figure 2
Survey sample, analysis sample and missing data for diabetic population based on Maddigan-Johnson algorithm



† Percentage represents weighted population percentage based on respondents who could be categorized as having type 1 or type 2 diabetes.
Source: 2000/2001 Canadian Community Health Survey, cycle 1.1.

the time of diagnosis or at the time of the interview, or who had started insulin therapy within one month of diagnosis, are classified as type 1. According to the MJ algorithm, the type1–type 2 split was 10%–90% (Figure 2). However, 54 diabetic respondents were not classified, because they did not answer any of the six questions used in the algorithm.

While the MJ algorithm is an important first step in distinguishing between type 1 and type 2 diabetes, it has some limitations. First, it is not explicit in how missing information (refusal, don't know, etc.) should be treated. Second, some people with type 1 diabetes may not start insulin therapy within a month of diagnosis if they have some response to oral medications (although all will require insulin within six months). And third, it is not clear how women with gestational diabetes are classified in the MJ algorithm.

The Ng-Dasgupta-Johnson algorithm

The proposed Ng-Dasgupta-Johnson (NDJ) aims to overcome the limitations of the MJ algorithm. It makes explicit the decisions with regard to dealing with missing information. It also uses the gestational diabetes question in the diabetes module, in which female respondents who report diabetes are asked if this had been only during pregnancy. Those who answer "yes" (that is, they had only gestational diabetes) skip out of the diabetes module to the questions in the next chronic disease module, and thus, cannot be classified by the MJ algorithm. The 54 cases of unknown type identified by the MJ algorithm may all be "gestational diabetes."

The NDJ algorithm requires seven steps to identify respondents to cycle 1.1 of the CCHS as having type 1, type 2 or gestational diabetes (Figure 3):

Step 1. Target population: Respondents who replied "yes" to having diabetes (CCCA_101=1) (n=6,361). These 6,361 respondents constitute the diabetes cohort. Those who did not know, refused to answer or did not respond were excluded (87).

Step 2. Gestational diabetes: If the respondents were women who said that they had not been diagnosed with diabetes at any time other than when they were pregnant (CCCA_10B=2) and the age of diagnosis was 15 to 49 (childbearing age range), they were considered to be cases of gestational diabetes.
Screening forward: Respondents in the diabetes cohort not asked this question (males; females younger than 15), women who reported being diagnosed with diabetes during pregnancy and at another time ("yes" to CCCA_10B), and those who did not answer were moved forward.

Step 3. If respondents reported taking an oral medication (DRGA_1O=1), they were assigned type 2 diabetes.
Screening forward: If the response was "no," "not applicable," "don't know" or "not stated," they were moved forward. (The question about oral medications was asked of about 24% of all respondents in cycle 1.1, as only selected health authorities in Ontario used this question.)

Step 4. If the respondents were not currently taking insulin (CCCA_105=2), they were assigned type 2 diabetes.
Screening forward: If the response was "yes," "not applicable" or "don't know," they were moved forward.

Step 5. If the respondents were younger than 30 and began taking insulin within 6 months of being diagnosed, they were assigned type 1 diabetes.
Screening forward: If the respondents were 30 or older or began taking insulin 6 or more months after being diagnosed, they were moved forward.

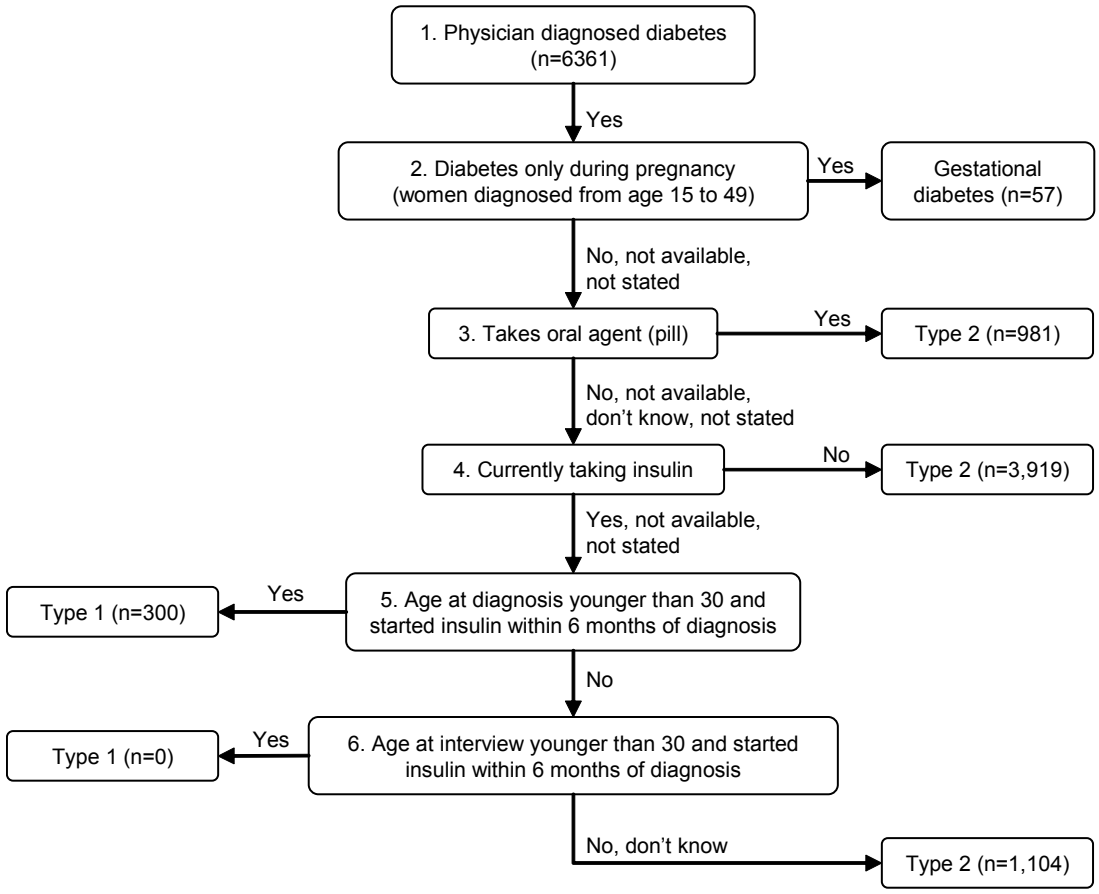
Step 6. If the respondents' age of diagnosis was younger than 30 and they began taking insulin within 6 months of being diagnosed, they were assigned type 1 diabetes.
Screening forward: If the respondents' age of diagnosis was 30 or older or if they did not know or refused to answer this question, or if they had started taking insulin more than 6 months after being diagnosed, they were moved forward.

Step 7. All the remaining respondents were assigned type 2 diabetes, regardless of when they started taking insulin.

The MJ algorithm used the timing of the start of insulin treatment to assign some of the Step 7 respondents to type 1; specifically, those who began taking insulin within one month of diagnosis. However, about half of them were aged 50 or older when they were diagnosed, and so are far more likely to be type 2.

Table 1 contains the variable names, description, code, sample size, and frequency of the above-

Figure 3
Ng-Dasgupta-Johnson algorithm



Notes: Sample size is listed in parenthesis. In CCHS cycle 1.1, the question about oral agents was asked only in selected Health Authorities in Ontario; thus, just 31,187 respondents, or 24% of the overall sample, were asked this question.
Source: 2000/2001 Canadian Community Health Survey, cycle 1.1.

mentioned variables for all CCHS respondents. Table 2 contains the same information for respondents who reported that they had been diagnosed with diabetes by a health professional.

Results

The main difference between the MJ and NDJ algorithms is the shift in the proportions classified as type 1 and type 2 diabetes. While the MJ algorithm results in a 10%–90% split, the NDJ algorithm yields a 5%-–95% split (figure 4), which is not unreasonable, given the rapid rise in obesity[19,20] and type 2 diabetes in Canada and around the world.[2,21]

The characteristics of type 1 and type 2 diabetic respondents identified by the NDJ algorithm reflect the variables used to make this assignment (Table 3). By definition, all type 1 respondents were currently taking insulin and had been diagnosed when they were younger than 30. No type 1 respondents had taken oral anti-diabetic medications in the past month, whereas this was the case for 16% of those classified as type 2. However, 75% and 74% of type 1 and 2 respondents were not asked this question, as it was included only in the optional sub-module of CCHS cycle 1.1.

The timing of the start of insulin is used to differentiate between diabetes types at the end of the MJ algorithm, and to be classified as a type 1 case, respondents had to have begun insulin treatment within one month of diagnosis. The NDJ algorithm also uses this question, but broadens the

Table 1
Information used to determine diabetes type (types 1, 2 and gestational plus unable to determine), total sample, Canadian Community Health Survey, cycle 1.1, (n=131,535)

Variable name	Variable description		Response						
			Yes	Other	No	Not applicable	Don't know	Refusal	Not stated
CCCA_101	Has diabetes	Code	1	...	2	6	7	8	9
		Sample	6,361	...	125,087	...	61	1	25
CCCA_10B	Diagnosed other than when pregnant	Code	1	...	2	6	...	...	9
		Sample	143	...	58	131,262	...	...	72
DRGA_1O	Pills used in past month	Code	1	...	2	6	7	...	9
		Sample	998	...	30,136	100,348	23	...	30
CCCA_105	Currently taking insulin	Code	1	...	2	6	7	...	9
		Sample	1,530	...	4,766	125,145	7	...	87
DHHA_AGE	Current age	Code	12-102	...	...	...	...	...	...
		Sample	131,535	...	...	...	...	...	...
CCCA_102	Age at diagnosis	Code	0-92	...	...	996	997	998	999
		Sample	6,319	...	...	125,087	40	2	87
CCCA_10C	Time between diagnosis and starting insulin	Code	< 1 month	Other	Never	96	97	...	99
		Sample	915	943	4,413	125,145	32	...	87

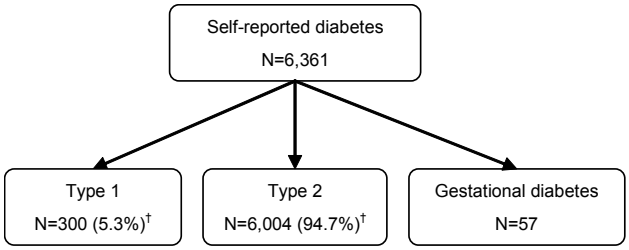
... not applicable
< less than
Source: 2000/2001 Canadian Community Health Survey, cycle 1.1.

Table 2
Information used to determine diabetes type (types 1, 2 and gestational plus unable to determine), diabetic sample, Canadian Community Health Survey, cycle 1.1, (n=6,361)

Variable name	Variable description		Response						
			Yes	Other	No	Not applicable	Don't know	Refusal	Not stated
CCCA_101	Has diabetes	Code	1	...	2	6	7	8	9
		Sample	6,361	...	...	...	...	...	...
CCCA_10B	Diagnosed other than when pregnant	Code	1	...	2	6	...	...	9
		Sample	143	...	58	6,134	...	...	26
DRGA_1O	Pills used in past month	Code	1	...	2	6	7	...	9
		Sample	984	...	646	4,729	1	...	1
CCCA_105	Currently taking insulin	Code	1	...	2	6	7	...	9
		Sample	1,530	...	4,766	58	7	...	...
DHHA_AGE	Current age	Code	< 30	...	≥ 30	...	...	...	...
		Sample	187	...	6,174	...	...	...	...
CCCA_102	Age at diagnosis	Code	< 30	...	≥ 30	996	997	998	999
		Sample	645	...	5,674	...	40	2	...
CCCA_10C	Time between diagnosis and starting insulin	Code	< 1 month	Other	Never	96	97	...	99
		Sample	915	943	4,413	58	32	...	...

... not applicable
< less than
≥ greater than or equal to
Source: 2000/2001 Canadian Community Health Survey, cycle 1.1.

Figure 4
Survey sample for diabetic population based on Ng-Dasgupta-Johnson algorithm



† Percentage represents weighted population percentage based on respondents who could be categorized as having type 1 or type 2 diabetes.
Source: 2000/2001 Canadian Community Health Survey, cycle 1.1.

Table 3
Characteristics of diabetes types 1 and 2 as assigned by Ng-Dasgupta-Johnson algorithm, Canadian Community Health Survey, cycle 1.1

	Type 1 (n=300)	Type 2 (n=6,004)
	% (unweighted)	
Has diabetes		
Yes	100	100
No	0	0
Diagnosed other than when pregnant		
Yes	5	2
No/Not applicable/Not stated	95	98
Pills used in past month		
Yes	0	16
No	25	9
Not asked	75	74
Currently taking insulin		
Yes	100	20
No/Not applicable/Not stated	0	80
Current age		
Less than 30	37	1
30 or older	63	99
Age at diagnosis		
Less than 30	100	5
30 or older/Not stated	0	95
Time between diagnosis and starting insulin		
Less than 1 month	94	11
1 to less than 2 months	2	1
2 to less than 6 months	4	1
6 months to less than 1 year	0	2
1 year or more	0	12
Never	0	74
Not applicable/Don't know	0	1

Source: 2000/2001 Canadian Community Health Survey, cycle 1.1.

interval between diagnosis and the start of insulin treatment to six months. Based on the NDJ algorithm, 94% of the newly assigned type 1 cases had started insulin within one month of diagnosis, compared with just 11% of the newly assigned type 2 cases. By design, none of the type 1 cases had started insulin more than 6 months after diagnosis, compared with 14% of type 2 cases.

About 5% of type 2 patients (308 respondents) identified by the NDJ algorithm had been diagnosed when they were younger than 30; in fact, 81 of them had been younger than 16. This raises the possibility that they were misclassified, and perhaps should be type 1. However, of these 308 cases, 41 were taking an oral anti-diabetic medication and 198 of the remaining 267 cases were not taking insulin, and so were more likely to have type 2 than type 1. Of the remaining 69 cases, only 19 had been diagnosed when they were younger than 16. Given the recent increases in type 2 diabetes in young adults and children,[14,15] it is reasonable to expect this number of younger respondents among those classified as type 2. Therefore, misclassification, if any, is not serious.

Beyond the type 1—type 2 distinction, other forms of diabetes are being recognized. As noted above, the NDJ algorithm takes account of the increase in "maturity onset diabetes of the young" (MODY), that is, a form of type 2 diabetes appearing in younger people. Other emerging forms include "latent autoimmune diabetes of adulthood" (LADA) and "latent autoimmune disease in youth" (LADY).[22] However, the prevalence of the last two conditions would be negligible in the population-based surveillance data that CCHS provides.

A potential criticism of the NDJ algorithm is that only 24% of cycle 1.1 respondents were asked about oral medications (Step 3). However, the question on the use of pills for diabetes control is no longer optional content, and was asked of everyone who reported diabetes in cycles 3.1 and 4.1. Application of the NDJ algorithm to cycle 3.1 yielded prevalence estimates of type 1 and type 2 similar to those derived from cycle 1.1.

The number of CCHS respondents reporting physician-diagnosed diabetes rose from 6,361 in

2000/2001 (CCHS 1.1) to 8,200 in 2005 (CCHS 3.1); the corresponding weighted estimates of the number of people with diabetes increased from 1,064,000 to 1,325,000. The distribution of these cases by type over this period varied little, with the proportion identified as type 1 fluctuating around 4% to 5%. Gestational diabetes consistently represented about 1% of cases

Conclusion

The Ng-Dasgupta-Johnson algorithm expands upon the Maddigan-Johnson algorithm in attempting to classify type 1, type 2 and gestational diabetes based on self-reported information from cycle 1.1 of the CCHS. While the NDJ algorithm was developed using cycle 1.1, it can be applied to other CCHS cycles. Although a potential for misclassification exists, this is likely minor, and is overshadowed by the benefits of classifying the majority of diabetic respondents in this nationally representative survey.

Nonetheless, further development and validation of the NDJ algorithm are needed. No external criteria exist, so sensitivity and specificity measures cannot be derived. A possible method of validation of the algorithm is against hospital discharge data, specifically, through the recently linked files of the CCHS and a person-oriented version of the CIHI Hospital Morbidity Database. This database contains ICD-10-CA diagnostic codes (E10-E14) that identify diabetes type.[23,24] Using the hospitalization record as a "gold standard," it may be possible to determine if CCHS respondents identified as having type 2 diabetes by the NDJ algorithm are similarly identified in hospital records.

Another possibility is to include a question about diabetes type in the CCHS itself. However, some people may not know what type of diabetes they have; type 2 patients taking insulin may believe they have type 1.

The new Canadian Health Measures Survey (CHMS), data from which will be available in 2010, contains a number of questions about diabetes. Respondents are directly asked about type of diabetes (type 1, type 2 or gestational), age at first diagnosis, and medication used. They also undergo blood tests which measure glycohaemoglobin (HbA1c), glucose (fasting or random), and fasting insulin. The CHMS results will offer an opportunity to determine if diabetic respondents can correctly identify the type of diabetes that they have. ●

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References

1. Hollander MH, Paarlberg KM, Huisje AJM. Gestational diabetes: Review of the current literature and guidelines. *Obstetrics & Gynecology Survey* 2007; 62(2): 125-35.
2. Englegau MM, Geiss LS, Saaddine JB, et al. The evolving diabetes burden in the United States. *Annals of Internal Medicine* 2004; 140: 945-50.
3. Daneman D. Type 1 diabetes. *Lancet* 2006; 367(9513): 847-58.
4. Murphy KA, Connor Gorber SK, O'Dwyer A for the Population Health Impact of Disease in Canada (PHI). *Health State Description for Canadians: Diabetes* (Catalogue 82-619-MIE2005002) Ottawa: Statistics Canada, 2005.
5. Sanmartin C, Gilmore J. *Smoking and Diabetes Care: Results from the CCHS Cycle 3.1 (2005*) (Catalogue 82-621-XIE) Ottawa: Statistics Canada, 2006.
6. Simpson SH, Jacobs P, Corabian P, Johnson JA. The cost of major comorbidity in people with diabetes mellitus. *Canadian Medical Association Journal* 2003; 168(13): 1661-7.
7. Ohinmaa A, Jacobs P, Simpson SH, Johnson JA. The projection of prevalence and cost of diabetes in Canada: 2000 to 2016. *Canadian Journal of Diabetes* 2004; 28(1): 116-23.
8. Wild S, Roglic G, Green A, et al. Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. *Diabetes Care* 2004; 27(5): 1047-53.
9. Johnson JA, Vermeulen SU. Chapter 2 - Epidemiological trends of diabetes in Alberta. In: *Alberta Diabetes Atlas 2007*. Edmonton: Institute of Health Economics, 2007: 11-24.
10. Johnson JA, Pohar, SL, Majumdar SR. Health care use and costs in the decade after identification of type 1 and type 2 diabetes: a population-based study. *Diabetes Care* 2006; 29: 2403-8.
11. Harris SB, Ekoe JM, Zdanowicz Y, Webster-Bogaert S. Glycemic control and morbidity in the Canadian primary care setting (results of the diabetes in Canada evaluation study). *Diabetes Research and Clinical Practice* 2005; 70(1): 90-7.
12. Stumvoll M, Goldstein BJ, van Haeften TW. Type 2 diabetes: principles of pathogenesis and therapy. *Lancet* 2005; 365(9467): 1333-46.
13. Johnson JA, Pohar SL, Secnik K, et al. Utilization of diabetes medication and cost of testing supplies in Saskatchewan, 2001: A population based study. *BMC Health Services Research* 2006; 6: 159.
14. Dean H. Type 2 diabetes in youth: a new epidemic. *Advances in Experimental Medicine and Biology* 2001; 498: 1-5.
15. Dean H, Sellers E, Birk P, et al. Children are not small adults. *Canadian Medical Association Journal.* 2003; 168(3): 255-6.
16. Dabelea D, Bischoff KJ, Snell-Bergeon JK, et al. Increasing prevalence of gestational diabetes mellitus (GDM) over time and by birth cohort. *Diabetes Care* 2005; 28: 579-84.
17. Steele C, Hagopian WA, Gitelman S, et al. Insulin secretion in type 1 diabetes. *Diabetes* 2004; 53: 426-33.
18. Maddigan SL, Feeny DH, Majumdar SR, et al. Understanding the determinants of health for people with type 2 diabetes. *American Journal of Public Health* 2006; 96(9): 1649-55.
19. Katzmarzyk PT, Ardern CI. Overweight and obesity mortality trends in Canada, 1985-2000. *Canadian Journal of Public Health* 2004; 95(1): 16-20.
20. Katzmarzyk PT, Mason C. Prevalence of class I, II and III obesity in Canada. *Canadian Medical Association Journal* 2006; 174(2): 156-7.
21. Lipscombe LL, Hux JE. Trends in diabetes prevalence, incidence, and mortality in Ontario, Canada 1995-2005: a population-based study. *Lancet* 2007; 369(9563): 750-6.
22. Wilkin TJ. Changing perspectives in diabetes: their impact on its classification. *Diabetologia* 2007; 50(8): 1587-92.
23. Canadian Institute of Health Information. Final Report: The Canadian Enhancement of ICD-10. Ottawa, *Canadian Institute of Health Information*, 2001.
24. Quan H, Sundararajan V, Halfon P, et al. Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. *Medical Care* 2005; 43: 1130-9.