Nephrol Dial Transplant (2013) 0: 1–8
doi: 10.1093/ndt/gft284

ndt
Nephrology Dialysis Transplantation

Full Review

Using linked administrative data to study periprocedural mortality in obesity and chronic kidney disease (CKD)

Aminu Bello[1],
Raj Padwal[1],
Anita Lloyd[1],
Brenda Hemmelgarn[2,3],
Scott Klarenbach[1,4],
Braden Manns[2,3]
and Marcello Tonelli[1,4,]
for the Alberta Kidney Disease Network

Correspondence and offprint requests to: Marcello Tonelli; E-mail: mtonelli-admin@med.ualberta.ca

[1]Department of Medicine, University of Alberta, Edmonton, Canada, [2]Department of Medicine, University of Calgary, Calgary, Canada, [3]Department of Community Health Sciences, University of Calgary, Calgary, Canada and [4]Department of Public Health Sciences, University of Alberta, Edmonton, Canada

Keywords: CKD, obesity, mortality, administrative databases, AKDN

ABSTRACT

Both obesity and chronic kidney disease (CKD) are associated with adverse periprocedural outcomes, but it is unknown how these two common conditions interact to influence risk. We examined the feasibility of combining a new procedure-related, obesity-specific flag with administrative and laboratory data and assessed the joint association between obesity and CKD with mortality. Since 2007, Alberta physicians may claim a fee supplement for performing eligible surgical and non-surgical procedures on patients with documented BMI $\geq$ 35 kg/m^2. We linked this information to the Alberta Kidney Disease Network registry. Participants were classified into four mutually exclusive groups based on the presence/absence of both obesity (BMI $\geq$ 35 kg/m^2) and CKD (eGFR < 60 mL/min/1.73 m^2). Mortality was assessed at 30 days following the index procedure. Of 393 659 participants, 9% were obese. Overall, 8% had obesity only, 78% neither obesity nor CKD, 13% CKD only and 1% both obesity and CKD. Unadjusted risks of mortality at 30 days were 0.3, 0.4, 2.0 and 2.1%, respectively—but decreased to 0.1, 0.2, 0.3 and 0.3%, respectively, after adjustment for age, sex, socioeconomic status, procedure type and other comorbidities. Administrative data can be feasibly combined with disease registries to study obesity-related outcomes. Results from the linked dataset demonstrated face validity—subjects with both obesity and CKD were at increased risk of periprocedural mortality, and this was driven in part by differences in age and comorbidity.

BACKGROUND

Obesity affects 24% of adult Canadians [1] and 500 million people globally [2] and causes substantial morbidity, [3–5] premature mortality [6, 7] and impaired quality of life [8–10]. Obesity is defined according to the body mass index (BMI), with BMI levels of 30–34.9, 35–39.9 and over 40 kg/m^2 corresponding to Class I, II and III obesity, respectively (BMI levels of 18.5–24.9 kg/m^2 are considered normal) [11]. Obesity is associated with severe consequences in terms of attendant comorbidities and associated healthcare costs [12]. Obesity has been estimated to account for between 0.7 and 2.8% of total healthcare expenditures [13]—estimated at $3.9 billion (~2.7% of total health expenditures) in Canada alone for 2006 [14]. Thus, obesity has become a central focus for clinicians, policymakers, health care administrators, regional health authorities [15] and health care funders [16, 17].

Extreme obesity (Classes II and III or BMI ≥ 35 kg/m^2) is associated with severe healthcare consequences, affects 9% of Canadians and is the fastest growing obesity subclass, having tripled in prevalence from 1978–79 to 2007–09 [1, 18]. Extreme obesity results in an ≥8-fold increased risk of type 2 diabetes compared with normal-weight participants [4], shortens life expectancy [10] by 5–13 years [7, 19], increases health care costs by 50–200% [20] and dramatically reduces the quality of life [8], work productivity [21] and likelihood of employment [12].

Obesity is recognized as one of the major drivers of the current epidemic of chronic kidney disease (CKD) worldwide [22]. Although both obesity and CKD are associated with adverse periprocedural outcomes [23, 24], it is unknown how these two common conditions interact to influence periprocedural risk—in part because most administrative and laboratory data do not include data on body weight or BMI [25].

We studied the risk of all-cause mortality at 30 days after surgical, endoscopic or obstetrical procedures in relationship to obesity status (defined by BMI ≥ 35 kg/m^2) and CKD [defined by the estimated glomerular filtration rate (eGFR) < 60 mL/min/1.73 m^2] at the time of the procedure. In addition to evaluating this specific issue, our overarching goal was to show the feasibility of using administrative data to evaluate the adverse consequences of obesity in patients with CKD.

FULL REVIEW

METHODS

Population and data sources

This study used the Alberta Kidney Disease Network (AKDN) database, which incorporates linked administrative data from Alberta Health (AH; the provincial health ministry), the Northern and Southern Alberta Renal Programs (NARP and SARP) and the clinical laboratories in Alberta [26]. All people registered with AH were eligible for inclusion. All Alberta residents are eligible for insurance coverage by AH and >99% participate in coverage. The database (Figure 1) was used to assemble a cohort of adults aged ≥18 years who resided in Alberta, Canada, between July 2007 and October 2009. The focus of this study was on non-dialysis-dependent CKD, and so we excluded participants with end-stage renal disease (ESRD, defined as documented chronic dialysis; or prior kidney transplant) at baseline. All files were linked using the personal health number, a unique identifier from AH.

Classification of obesity status

Since 2007, the Alberta health ministry has supplemented physician procedure fees by 25% when surgical, obstetrical or endoscopic procedures are performed on patients with BMI ≥ 35 kg/m^2 [27]. Claims for this fee supplement must be supported by documentation of height and weight on the patient's medical record; a list of eligible procedures is given in Table 1. As for all physician billings in Alberta, claims are subject to audit, and penalties for inappropriate use can be severe. We used health service codes [28] from the physician claims data to identify procedures performed by the physician. Procedures were classified as surgical, endoscopic or obstetrical (eligible procedures are shown in Table 1). We subclassified surgical procedures as general surgery, orthopedic, gynecological, neurological, cardiac/vascular, urological, ophthalmic or other; endoscopic procedures as gastrointestinal, bronchoscopy or other and obstetrical procedures as delivery or non-delivery related. Physicians were eligible to bill the supplementary code as of 1 July 2007. Thus, any patient undergoing an eligible procedure on or after 1 July 2007 was included in the cohort and classified as obese (BMI ≥ 35) or non-obese (BMI < 35) based on the presence or absence of fee modification codes [27] in the physician claims file.

Some participants had multiple procedures during follow-up. For participants who were classified as non-obese at the time of their first procedure and were subsequently classified as obese, the date of the first procedure where the participant was classified as obese was chosen as the index date. For all other participants, the date of the first eligible procedure was used as the index date. If multiple procedures were performed on the same index date, we classified the procedure type using the following order of priority: surgical over obstetrical over endoscopic procedure. The end of study date was 31 October 2009; all participants were followed for 30 days. Participants who could not be followed for 30 days were excluded (i.e. participants with an index date after 1 October 2009 or participants who moved out of province before 30 days of follow-up). Mortality within 30 days of the procedure was assessed by linkage to the Alberta Health Vital Statistics file.

Classification of baseline kidney function

From the source cohort, a subset of participants with available data on serum creatinine (sCr) were obtained, using the closest outpatient sCr measurement within 6 months on or before the index date. The eGFR was estimated using the CKD Epidemiology Collaboration (CKD-EPI) equation [29]. The baseline eGFR was categorized as ≥60, 45–59.9, 30–44.9, 15–29.9, <15 mL/min/1.73 m^2 and baseline albuminuria (median value within 6 months of the index date) was categorized as none [album in:creatinine ratio (ACR) < 30 mg/g or urine dipstick negative], mild (ACR 30–300 or urine dipstick trace or 1+) and heavy (ACR > 300 or urine dipstick 2+ or 3+). For purposes of this analysis, only participants with eGFR < 60 mL/min/1.73 m^2 were considered to have CKD.

Other covariates

Information on demographics [age, sex, aboriginal status (registered First Nations or recognized Inuit)] and socioeconomic status was collected for all individuals in the study. Validated algorithms were used to define Charlson's comorbidities [30], diabetes [31] and hypertension [32] at baseline using physician claims, and hospitalization data.

Statistical analyses

We did analyses with Stata/MP 11.2 (www.stata.com) and reported baseline descriptive statistics as percentages, or means and standard deviations, as appropriate. The primary analysis used logistic regression to calculate both unadjusted and adjusted odds ratios of mortality within 30 days of the index date for the four mutually exclusive groups resulting

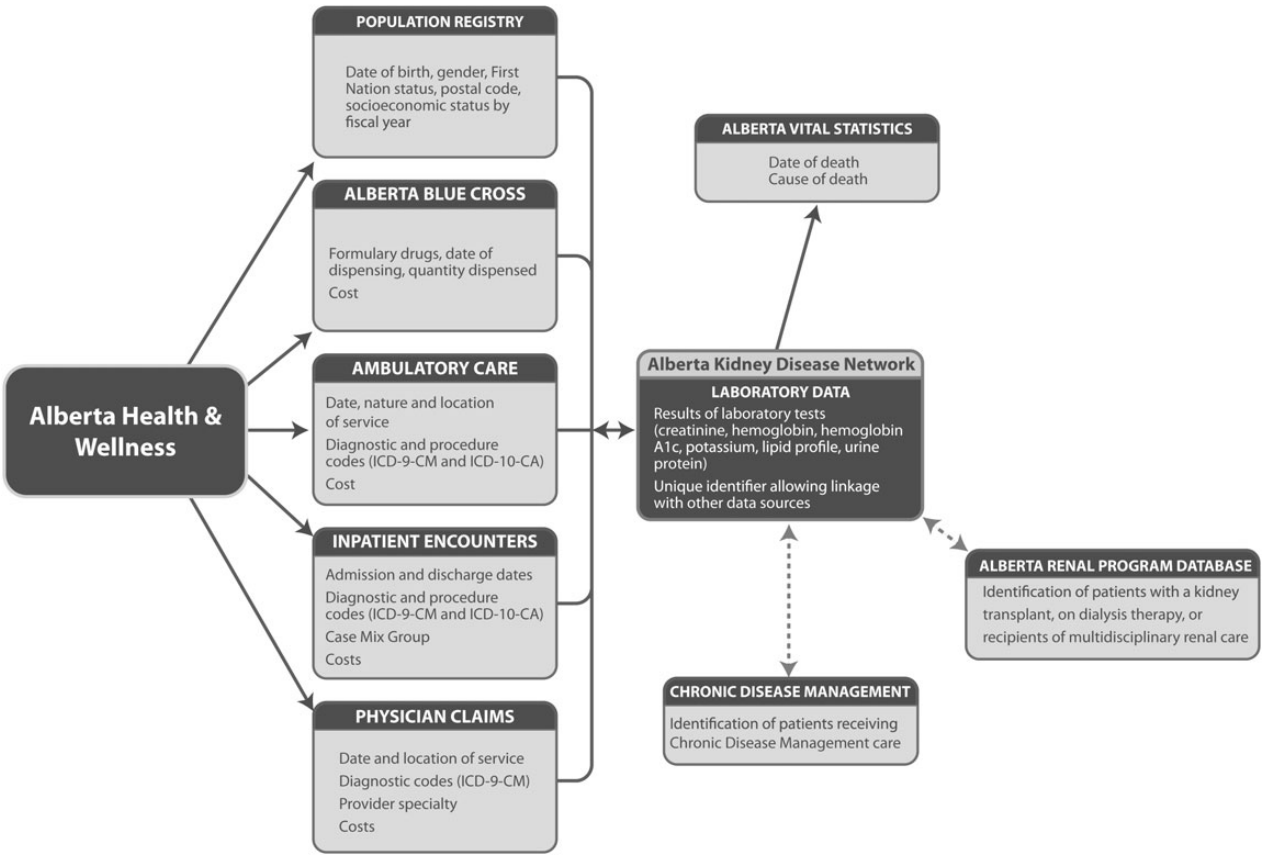

FIGURE 1: AKDN database. Information from the physician claims file is used to classify patients undergoing an eligible surgical, endoscopic or obstetrical procedure as obese (BMI ≥ 35) or non-obese (BMI < 35).

from the intersection of BMI indicator and CKD status (i.e. 'obese' and 'no CKD'; 'non-obese' and 'no CKD'; 'non-obese' and 'CKD'; 'obese' and 'CKD'). To allow for the association between the obesity status and the outcome to be modified by CKD status (and vice versa), a two-way interaction term was included. A likelihood ratio test was used to evaluate the significance of the interaction term; since the test was statistically significant for the adjusted model, all analyses were done with the interaction term included. Odds ratios were calculated using 'non-obese' and 'no CKD' as the referent category. The fully adjusted logistic models included baseline age, sex, diabetes, hypertension, albuminuria, aboriginal status, socioeconomic status, procedure type and Charlson's comorbidities. To assess agreement of obesity status between procedures, we used a kappa statistic [33]. The institutional review board at the University of Alberta approved the study.

RESULTS

Characteristics of study participants

Overall, 3 254 714 eligible people were included in the AKDN database (Figure 2). Of those, 1 052 600 underwent an eligible procedure and were classified for the presence or absence of obesity. Of these, 393 659 had sCr measurements and could be followed for 30 days, so were included in the final cohort.

We classified participants into four mutually exclusive groups based on the presence or absence of obesity and CKD. The characteristics of these four groups are shown in Table 2. Overall, 9.1% of eligible participants had BMI ≥ 35 kg/m^2. Of the 85 117 participants who underwent at least two procedures on the same date, agreement of obesity status as classified at the first versus second procedure was excellent as reflected by the kappa statistic ($\kappa = 0.77$). Within this subgroup, kappa progressively increased over time (κ for calendar years 2007, 08 and 09 was 0.70, 0.77 and 0.79), likely reflecting increasing familiarity with this billing code among potentially eligible physicians.

Participants with CKD were older, more often male, and were more likely to have diabetes, hypertension and albuminuria. Participants with obesity were more often female. The subset of those with both obesity and CKD were more likely to have diabetes, hypertension, Charlson's comorbidities and albuminuria.

Most participants underwent a surgical procedure; details of the types of procedures received by participants are shown in Table 1. Unadjusted mortality at 30 days is shown in Table 2. Unadjusted risks of mortality at 30 days were 0.3, 0.4, 2.0 and 2.1% for those with obesity only, neither obesity nor CKD, CKD only, and both obesity and CKD, respectively.

The proportion of participants undergoing each type of procedure differed between obese and non-obese participants (Figure 3). After adjustment for age, sex, aboriginal status,

Table 1. Demographic and clinical characteristics of participants

	+Obesity −CKD	−Obesity −CKD	−Obesity +CKD	+Obesity +CKD
N	31 075	308 181	49 733	4670
Age, year[a]	50.4 (15.2)	53.3 (16.2)	75.2 (11.3)	69.2 (10.5)
Female	69	57	55	64
Aboriginal	4	2	1	2
Low income	13	11	13	22
Social assistance	6	4	2	4
Diabetes	24	13	30	48
Hypertension	49	34	81	89
Charlson's comorbidities				
Cancer	13	10	19	21
CVD	3	3	12	11
CHF	5	3	20	24
Chronic lung disease	24	16	25	33
Dementia	1	1	8	4
Metastatic solid tumor	2	2	3	4
Myocardial infarction	4	3	12	14
Mild liver disease	2	2	2	2
Moderate/severe liver disease	0	0	1	1
Paraplegia	1	1	1	1
Peptic ulcer disease	3	3	5	5
Peripheral vascular disease	3	2	10	11
Rheumatic disease	3	3	5	5
eGFR, mL/min/1.73 m^2				
<15	0	0	2	2
15–29.9	0	0	9	8
30–59.9	0	0	90	90
60–89.9	46	53	0	0
≥90	54	47	0	0
Albuminuria[b]				
None	80	87	70	63
Mild	17	11	22	24
Heavy	3	2	9	12
30-day mortality	0.3	0.4	2	2
Procedure type				
Surgical	80	73	78	85
Endoscopic	13	24	22	14
Obstetrical	7	3	0.05	0.1

Continued

Table 1. Continued

	+Obesity −CKD	−Obesity −CKD	−Obesity +CKD	+Obesity +CKD
Procedure type—detailed				
Surgical				
Cardiac/vascular	5	6	11	12
General surgery	25	15	12	21
Gynecological	15	11	2	6
Neurological	12	4	2	3
Ophthalmic	4	9	21	11
Orthopedic	26	15	17	32
Other	8	35	29	7
Urological	6	5	5	8
Endoscopic				
Gastrointestinal scope	92	63	60	88
Bronchoscopy	1	25	17	1
Other	7	13	23	11
Obstetrical				
Delivery	4	9	4	0
Non-delivery	96	91	96	100

Data expressed as percentage, except [a]mean (standard deviation).
Obesity was defined as BMI ≥ 35 kg/m^2. Albuminuria defined as: none (ACR < 30 mg/g or urine dipstick negative), mild (ACR 30–300 mg/g or urine dipstick trace or 1+), heavy (ACR > 300 mg/g or urine dipstick 2+). Participants with an eGFR of <60 mL/min/1.73 m^2 were considered to have CKD. For purposes of this analysis, those with albuminuria only were not considered to have CKD. Low socioeconomic status was defined by annual family income <$39 250 CAD, and receiving social assistance was based on the government of Alberta health care insurance records.
ACR, albumin:creatinine ratio; CKD, chronic kidney disease; CVD, cerebrovascular disease; CHF, congestive heart failure; eGFR, estimated glomerular filtration rate.
[a]Mean (standard deviation).
[b]*N* = 276 421 (70%) participants had an albuminuria measurement.

socioeconomic status, comorbidity, albuminuria and type of procedure, the adjusted proportion of death was highest in patients with both CKD and obesity (OR 1.49, 95% CI 1.18, 1.87), intermediate in those with neither obesity nor CKD, or with CKD only, and lowest in those with obesity but no CKD. Fully adjusted risks of mortality at 30 days were 0.1, 0.2, 0.3 and 0.3% for those with obesity only, neither obesity nor CKD, CKD only, and both obesity and CKD, respectively.

DISCUSSION

The epidemic of obesity is arguably the greatest challenge facing health systems worldwide [34]. As for any other health condition, epidemiological data are prerequisite to formulating an effective clinical and policy response to the rising burden of obesity [35]. There is a tremendous quantity of literature documenting the burden of obesity in terms of related comorbidities and associated healthcare costs— mostly based on surveys, disease registries, *ad hoc* studies and reviews [7, 10]. These studies are often limited by small sample sizes, short follow-up period and limited statistical power. Administrative data can be used to mitigate some of these, but are seldom applied in studies linking obesity and adverse outcomes [36] because most administrative data sources lack data on BMI or body weight. This constitutes a missed opportunity to track how obesity influences patterns of care and clinical outcomes in the real world. Similarly, most administrative data do not include laboratory results, meaning that conditions like CKD (which are diagnosed based on abnormal laboratory measurements) are often misclassified [25].

We took advantage of a new billing code introduced in a single Canadian province to identify people with obesity (as defined by BMI ≥ 35 kg/m^2), and assess their mortality at 30 days following a variety of surgical and non-surgical related procedures. Further, we were able to subclassify people with or

without obesity on the basis of CKD status (defined by eGFR < 60 mL/min/1.73 m^2) by linking to laboratory data. We found a graded and independent risk of mortality in association with the presence and absence of these two chronic conditions (obesity and CKD). People with both obesity and CKD were at highest risk, followed by those with CKD only and then those with neither obesity nor CKD. Somewhat surprisingly, those with obesity only were at lowest risk of mortality overall. The latter finding may be confounded by inclusion of people with cachexia in the referent group, and perhaps by the so-called 'obesity paradox' [37].

Our findings suggest that people with obesity and CKD constitute a high-risk group for adverse outcomes following surgical and non-surgical procedures—and (given the substantial attenuation in risk following adjustment for covariates) that much but not all of the excess risk is mediated by age and comorbidity. Although these findings are interesting on their own, in our opinion its major value lies in proof of concept for using administrative data as a potential surveillance tool for the obesity epidemic.

This study has several strengths that include a large sample size and number of procedures that defined obesity with reasonable face validity. Of 3 254 714 patients included in our database, 1 052 600 underwent an eligible procedure and thus could be classified as obese or non-obese during the study period (although only 393 659 of these had serum creatinine measured). Although we did not have access to a gold standard measure of obesity to validate this measure, the proportion of

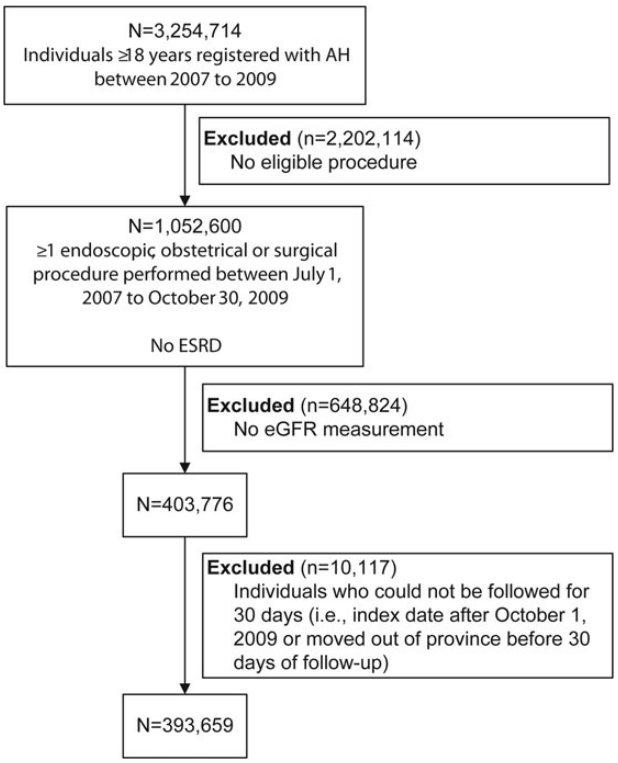

FIGURE 2: Participant flow. AH, Alberta Health; ESRD, end-stage renal disease, eGFR, estimated glomerular filtration rate using the CKD Epidemiology Collaboration formula.

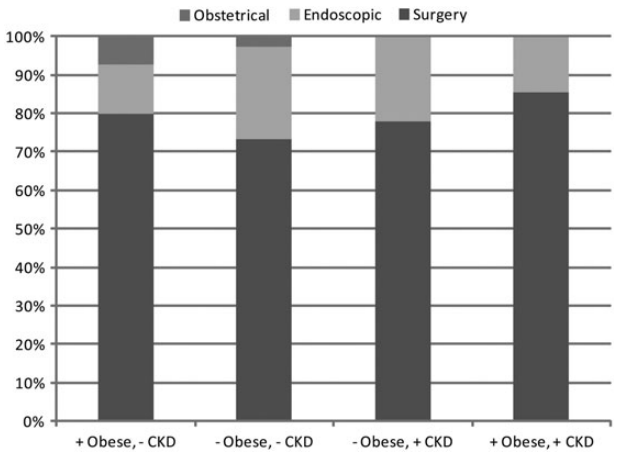

FIGURE 3: Stacked bar graph of procedure types by obesity status.

Table 2. Unadjusted and fully adjusted odds ratios (95% CI) of mortality at 30 days following an eligible procedure

	Obese	CKD	*N*	Number of events	Unadjusted	Fully adjusted
Obese, no CKD	+	–	31 075	95	0.79 (0.64, 0.97)	0.77 (0.62, 0.95)
Non-obese, no CKD	–	–	308 181	1194	1	1
Non-obese, CKD	–	+	49 733	1016	5.36 (4.93, 5.83)	1.36 (1.23, 1.51)
Obese, CKD	+	+	4670	98	5.51 (4.48, 6.79)	1.49 (1.18, 1.87)

Obesity was defined as BMI ≥ 35 kg/m^2. Participants with an eGFR of <60 mL/min/1.73 m^2 were considered to have CKD. For purposes of this analysis, those with albuminuria only were not considered to have CKD. Referent category is 'non-obese and no CKD.' Adjusted for age, sex, diabetes, hypertension, albuminuria, procedure type (surgical, endoscopic/obstetrical), aboriginal status, socioeconomic status, Charlson's comorbidities (cancer, cerebrovascular disease, congestive heart failure, chronic pulmonary disease, dementia, metastatic solid tumor, myocardial infarction, liver disease, paraplegia, peptic ulcer disease, peripheral vascular disease and rheumatic disease).
Albuminuria defined as: none (ACR < 30 mg/g or urine dipstick negative), mild (ACR 30–300 mg/g or urine dipstick trace or 1+), heavy (ACR > 300 mg/g or urine dipstick 2+) and not measured.
CI, confidence interval; CKD, chronic kidney disease.

participants with BMI ≥ 35 kg/m^2 is consistent with that observed in population-based surveys of middle-aged people [1, 34]. Second, the excellent agreement between assessments for participants who had multiple procedures on the same date during the study provides face validity for this method of classification.

Another limitation is the restriction of the evaluation to a single periprocedural outcome. However, once a given participant is classified as obese or non-obese, it would be possible to assess his or her outcomes and care patterns associated with an unrelated condition – and present these in aggregate after stratification on obesity status. A second limitation of this study is that we could only assess participants undergoing an eligible procedure – and of these, have focused on those with an available sCr measurement. This limits our ability to generalize the current findings to the general population. However, since our focus was to demonstrate the feasibility and face validity of administrative data for assessing the burden of obesity and a selected comorbidity (CKD) on health services, we do not believe that this is a major limitation. A third limitation is our inability to identify participants with less severe increases in BMI (such as those with BMI 30–34.9 kg/m^2). It is unlikely that the provincial government will create a billing code that increases reimbursement for this group, given the high prevalence of this characteristic in the general population.

What are the implications of our findings? Accurate information on temporal trends in the incidence and prevalence of obesity will be critical for effectively (re)-structuring health care systems to deal with the rising disease burden and the attendant consequences. Additional information on laboratory-based comorbidity (such as CKD) or other types of comorbidity that can be assessed by claims data (such as the conditions from the Charlson index that are included in Table 1) will also be useful, as well information on how patients with obesity are clinically managed and the costs that they incur. Collectively, these data will help clinicians and policymakers to identify care gaps in the care of patients with obesity (whether as an index condition, a comorbidity or multimorbidity), organize care delivery to optimally address identified gaps and ensuring that health care budgets include adequate funds to pay for the infrastructure and personnel needed to manage obesity and its consequences.

In conclusion, our findings suggest that administrative databases may be a useful tool for surveillance of the obesity epidemic. However, it is striking that routinely collected administrative health data do not often include information on measures of body weight (BMI, waist circumference, etc.), tobacco use and blood pressure [38, 39]. Perhaps, it is time to reconsider the potential benefits that might accrue from routinely collecting data on these three characteristics at the point of health care delivery.

ACKNOWLEDGEMENTS

This work was supported by a team grant to the Interdisciplinary Chronic Disease Collaboration from the Alberta Heritage Foundation for Medical Research (AHFMR), and the Canadian Institutes for Health Research. M.T. is supported by an AHFMR Population Health Scholar award and a Government of Canada Research Chair in the optimal care of people with chronic kidney disease. This study is based in part on data provided by Alberta Health and Alberta Health Services. The interpretation and conclusions are those of the researchers and do not represent the views of the Government of Alberta.

CONFLICT OF INTEREST STATEMENT

None declared.

REFERENCES

1. Shields M, Carroll MD, Ogden CL. Adult obesity prevalence in Canada and the United States. NCHS Data Brief 2011; 56: 1–8
2. World Health Organization. Obesity and Overweight Fact Sheet. http://www.who.int/mediacentre/factsheets/fs311/en/ (1 March 2013, date last accessed) [cited]
3. Guh DP, Zhang W, Bansback N *et al.* The incidence of co-morbidities related to obesity and overweight: a systematic review and meta-analysis. BMC Public Health 2009; 9: 88
4. Must A, Spadano J, Coakley EH *et al.* The disease burden associated with overweight and obesity. JAMA 1999; 282: 1523–1529
5. Feller S, Boeing H, Pischon T. Body mass index, waist circumference, and the risk of type 2 diabetes mellitus: implications for routine clinical practice. Dtsch Arztebl Int 2010; 107: 470–476
6. Allison DB, Fontaine KR, Manson JE *et al.* Annual deaths attributable to obesity in the United States. JAMA 1999; 282: 1530–1538
7. Flegal KM, Kit BK, Orpana H *et al.* Association of all-cause mortality with overweight and obesity using standard body mass index categories: a systematic review and meta-analysis. JAMA 2013; 309: 71–82
8. Jia H, Lubetkin EI. The impact of obesity on health-related quality-of-life in the general adult US population. J Public Health (Oxf) 2005; 27: 156–164
9. Keating CL, Peeters A, Swinburn BA *et al.* Utility-based quality of life associated with overweight and obesity: the Australian diabetes, obesity, and lifestyle study. Obesity (Silver Spring) 2013; 21: 652–655
10. Ul-Haq Z, Mackay DF, Fenwick E *et al.* Meta-analysis of the association between body mass index and health-related quality of life among adults, assessed by the SF-36. Obesity (Silver Spring) 2013; 21: E322–E327
11. World Health Organization. Expert Committee on Physical Status. Physical status: the use and interpretation of anthropometry. Geneva, Switzerland, WHO, 1995. (WHO Technical Report Series No. 854).
12. Hensrud DD, Klein S. Extreme obesity: a new medical crisis in the United States. Mayo Clin Proc 2006; 81: S5–10
13. Withrow D, Alter DA. The economic burden of obesity worldwide: a systematic review of the direct costs of obesity. Obes Rev 2011; 12: 131–141

14. Anis AH, Zhang W, Bansback N *et al.* Obesity and overweight in Canada: an updated cost-of-illness study. Obes Rev 2010; 11: 31–40
15. Alberta Health Services. Alberta Health Services Launches Obesity Initiative. http://www.albertahealthservices.ca/5670.asp (13 September 2011, date last accessed) [cited]
16. Canadian Institute for Health Research and the Canadian Obesity Network. Developing a research agenda to support bariatric care in Canada. http://www.cihr-irsc.gc.ca/e/documents/INMD-CON_BariatricCareWorkshopReport_e.pdf (14 October 2011, date last accessed) [cited]
17. Moyer VA, Force USPST, LeFevre ML, Siu AL *et al.* Screening for and management of obesity in adults: US Preventive Services Task Force recommendation statement. Ann Intern Med 2012; 157: 373–378
18. Tjepkema M. Measured Obesity Adult obesity in Canada: Measured height and weight. In Nutrition: Findings from the Canadian Community Health Survey; 2004
19. Peeters A, Barendregt JJ, Willekens F *et al.* Obesity in adulthood and its consequences for life expectancy: a life-table analysis. Ann Intern Med 2003; 138: 24–32
20. Andreyeva T, Sturm R, Ringel JS. Moderate and severe obesity have large differences in health care costs. Obes Res 2004; 12: 1936–1943
21. Klarenbach S, Padwal R, Chuck A *et al.* Population-based analysis of obesity and workforce participation. Obesity (Silver Spring) 2006; 14: 920–927
22. Chertow GM, Hsu C-y, Johansen KL. The enlarging body of evidence: obesity and chronic kidney disease. J Am Soc Nephrol 2006; 17: 1501–1502
23. Gaber A, Moore L, Aloia T *et al.* Cross-sectional and case–control analyses of the association of kidney function staging with adverse postoperative outcomes in general and vascular surgery. Ann Surg 2013; [Epub ahead of print]
24. Zrim S, Furlong T, Grace BS *et al.* Body mass index and postoperative complications in kidney transplant recipients. Nephrology (Carlton) 2012; 17: 582–587
25. Bello A, Hemmelgarn B, Manns B *et al.* Alberta Kidney Disease N. Use of administrative databases for health-care planning in CKD. Nephrol Dial Transplant 2012; 27: iii12–iii8
26. Hemmelgarn BR, Clement F, Manns BJ *et al.* Overview of the Alberta Kidney Disease Network. BMC Nephrol 2009; 10: 30
27. Alberta Health. Alberta Health Care Insurance Plan: Fee Modifier Definitions as of 01 April 2013. 2013 http://www.health.alberta.ca/documents/SOMB-Fee-Modifiers-2013-04.pdf [cited]
28. Alberta Health. Alberta Health Care Insurance Plan: Medical Procedure List as of 01 April 2012. 2012 http://www.health.alberta.ca/documents/SOMB-Medical-Procedures-2012-04.pdf [cited]
29. Levin A, Hemmelgarn B, Culleton B *et al.* Guidelines for the management of chronic kidney disease. CMAJ 2008; 179: 1154–1162
30. Quan H, Sundararajan V, Halfon P *et al.* Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. Med Care 2005; 43: 1130–1139
31. Hux JE, Ivis F, Flintoft V *et al.* Diabetes in Ontario: determination of prevalence and incidence using a validated administrative data algorithm. Diabetes Care 2002; 25: 512–516
32. Quan H, Khan N, Hemmelgarn BR *et al.* Validation of a case definition to define hypertension using administrative data. Hypertension 2009; 54: 1423–1428
33. Fleiss J, Nee J, Landis J. Large sample variance of kappa in the case of different sets of raters. Psychol Bull 1979; 86: 974–977
34. OECD. Overweight and Obesity. OECD Factbook 2013: Economic, Environmental and Social Statistics: OECD Publishing, 2013; http://dx.doi.org/10.1787/factbook-2013-100-en (4 June 2013, date last accessed)
35. Friel S, Chopra M, Satcher D. Unequal weight: equity oriented policy responses to the global obesity epidemic. BMJ 2007; 335: 1241–1243
36. Virnig BA, McBean M. Administrative data for public health surveillance and planning. Annu Rev Public Health 2001; 22: 213–230
37. Banack HR, Kaufman JS. The "obesity paradox" explained. Epidemiology 2013; 24: 461–462
38. Iezzoni LI. Assessing quality using administrative data. Ann Intern Med 1997; 127: 666–674
39. Emerging Risk Factors CollaborationWormser D, Kaptoge S, Di Angelantonio E *et al.* Separate and combined associations of body-mass index and abdominal adiposity with cardiovascular disease: collaborative analysis of 58 prospective studies. Lancet 2011; 377: 1085–1095

Received for publication: 8.5.2013; Accepted in revised form: 18.5.2013