Opportunities to improve diabetes care in the hemodialysis unit: A cohort study in Ontario, Canada

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Key Points:

- Little is known about diabetes care gaps and predictors in patients using in-centre hemodialysis.
- In Ontario, almost half of patients with diabetes on hemodialysis have diabetes care gaps; most commonly, suboptimal retinopathy screening.
- Significant predictors of care gaps include younger age, female sex, shorter duration of diabetes, dementia, and fewer physician visits.

Abstract

Background: Patients with diabetes receiving chronic in-centre hemodialysis face healthcare challenges. We examined the prevalence of gaps in their diabetes care, explored regional differences, and determined predictors of care gaps.

Methods: We conducted a population-based retrospective study between January 1 2016 and January 1 2018 in Ontario Canada. We included adults with prevalent diabetes mellitus receiving in-centre hemodialysis as of January 1 2018 and examined the proportion with 1) insufficient or excessive glycemic monitoring, 2) suboptimal screening for diabetes-related complications (retinopathy and cardiovascular screening), 3) hospital encounters for hypo- or hyperglycemia, and 4) hospital encounters for hypertension in the 2 years prior (January 1 2016-January 1 2018). We then identified patient, provider and health system factors associated with >1 care gap and used multivariable logistic regression to determine predictors. Further, we used Geographic Information Systems to explore spatial variation in gaps.

Results: There were 4,173 patients with diabetes receiving in-centre hemodialysis. Mean age was 67 years, 39% were women and the majority were of lower socioeconomic status.
Approximately 42% of patients had >1 diabetes care gap, the most common being suboptimal retinopathy screening (53%). Significant predictors of more than one gap included younger age, female sex, shorter duration of diabetes, dementia, fewer specialist visits and not seeing a physician for diabetes. There was evidence of spatial variation in care gaps across our region.

**Conclusions:** There are opportunities to improve diabetes care in patients receiving in-centre hemodialysis, particularly screening for retinopathy. Focused efforts to bring diabetes support to high-risk individuals might improve their care and outcomes.
**Introduction**

Approximately 11,000 patients with diabetes receive dialysis treatment for end-stage kidney disease across Canada. These individuals experience numerous health and healthcare challenges. Patients on hemodialysis are among the highest at risk of diabetes-related complications including hypoglycemia, cardiovascular disease, retinopathy, and amputation. They have a high burden of medical appointments and diagnostic tests, and juggle health care visits with dialysis treatments three-times per week. They are frequently hospitalized, take many medications, have difficulty with adherence, and often feel poorly. With lower levels of education and income, they frequently struggle with diabetes self-management. These individuals are at risk of gaps in their diabetes healthcare.

Although diabetes care gaps have been examined in the general chronic kidney disease (CKD) population and small studies have investigated glycemic control in those using hemodialysis, there has yet to be a comprehensive examination of diabetes care gaps in in-centre hemodialysis patients with publicly funded healthcare. Knowledge of care gaps in this unique, high-risk population can support the creation of targeted interventions to improve patient care and outcomes. For example, if gaps in hypoglycemia are identified, patients might receive targeted education and self-management support about hypoglycemia avoidance. If it is observed that patients are not receiving diabetes-related laboratory testing, best practices might be reviewed with care professionals who manage this patient population. If patients using dialysis are not visiting physicians for diabetes care, outreach opportunities might be explored (e.g. remote diabetes support).
In this study, we examined diabetes care gaps in patients receiving chronic in-centre hemodialysis in Canada’s most populous province (Ontario, Canada), and identified modifiable predictors of care gaps. We hypothesized that patients receiving in-centre hemodialysis would experience gaps in their diabetes care, and that those with sociodemographic challenges and less frequent healthcare might be at higher risk of gaps.

**Materials and Methods**

*Design and setting*

We conducted a population-based retrospective study in Ontario Canada between January 1 2016 and January 1 2018. Ontario has over 14 million residents who have universal access to hospital and physician services. Those 65 years and older have universal access to medications covered by the Ontario Drug Benefits (ODB) Program. Information on their use of health services is held in secure administrative databases available for access at ICES.

ICES is an independent, non-profit research institute whose legal status under Ontario’s Information and Privacy Commissioner allows it to collect and analyze healthcare and demographic data without individual-level patient consent for health system evaluation and improvement. The use of data in this project was authorized under section 45 of Ontario’s Personal Health Information Protection Act, which does not require review by a Research Ethics Board. Our study followed the Reporting of studies Conducted using the Observational Routinely-collected Data (RECORD) Statement (Table 1 of the Supplemental Material). (13)

*Patients*
We identified adults age 18 years or older with prevalent diabetes who were receiving in-centre hemodialysis on our index date (Jan 1 2018). We excluded non-Ontario residents, those older than 105 years, and those who had evidence of death, withdrawal from dialysis or transplant before the index date. To facilitate a 2-year lookback for care gaps, we also excluded those with a diabetes diagnosis less than 2 years and those who used in-centre hemodialysis for less than 2 years from the index date.

Data sources

We used databases available at ICES to conduct our study. These datasets were linked using unique encoded identifiers and analyzed at ICES. We captured vital statistics and demographics from the Registered Persons Database (RPDB) of Ontario. This database contains information for all those issued an Ontario health card. Diabetes status was ascertained from the Ontario Diabetes Database (ODD) which defines diabetes by receipt of two outpatient diagnostic codes for diabetes, one drug claim for a diabetes medication, or one hospitalization with diabetes within a one-year period.(14) Compared with medical chart review, this algorithm has a sensitivity of 90%, and specificity of 98% in adults.(15) We used the Ontario Renal Reporting System (ORRS) to capture use of in-centre hemodialysis and the characteristics of patients using dialysis. In Ontario, all dialysis providers submit activity data on the use of acute and chronic dialysis services to the ORRS to improve health system quality, performance and planning.(16)

We captured additional descriptors from the Ontario Marginalization Index (ON-MARG) database, a geographically-based index that quantifies degrees of marginalization. Measures include residential instability (e.g. living alone, multi-unit housing), material deprivation (e.g. low income, unemployment) dependency (e.g. age ≥65 years), and ethnic concentration (e.g.
recent immigrant, visible minority).(17,18) We used the Canadian Institute for Health Information’s Discharge Abstract Database (CIHI-DAD) and the National Ambulatory Care Reporting System Database (NACRS) for medical diagnoses and receipt of procedures during inpatient and emergency department (ED) visits respectively (via International Classification of Disease 10th Revision codes and Canadian Classification of Health Intervention Codes).

We also used datasets derived from validated case definitions of comorbidities including the ICES Congestive Heart Failure,(19) Chronic Obstructive Pulmonary Disease (COPD),(20) Hypertension (21), and Dementia datasets.(22,23) We used the Canadian Organ Replacement Registry (CORR) to determine the transplant status of patients.

To present health services use, we used the Ontario Health Insurance Plan (OHIP) database, a collection of physician diagnostic and billing codes. For visits to physicians and family physician roster status (i.e. registration status with a family physician for the provision of health services), we used the ICES Physician’s Database, Corporate Provider Database (CPDB) and the Client Agency Program Enrollment (CAPE) Database. We used the Ontario Laboratories Information System Database for laboratory data including hemoglobin A1c levels (HbA1c).(24) For those 65 years and older, we also used the Ontario Drug Benefits (ODB) Database and the Drug Identification Number (DIN) database for prescription medications. A list of study variables, related administrative codes, and originating data sources is included in Table 2 of the Supplemental Material.

*Primary Outcome*

We captured measurable, intervenable diabetes care gaps in the 2 years prior to January 1 2018 (i.e. January 1 2016 to January 1 2018). While we recognize that best diabetes practices in
patients using hemodialysis is controversial, we drew upon clinical practice guidelines, (25–27) previous care quality assessments, (28, 29) and clinical expertise to define gaps. We structured gaps around Donabedian’s framework (structure, process and outcomes). (30). We chose a “look-back” rather than a “look-forward” period to define gaps, as we felt this to be most clinically relevant (care providers inquire about past diabetes screening and management during patient encounters).

We examined the following gaps over the 2-year period: 1) no evidence of at least annual HbA1c testing, 2) more than 8 HbA1c tests (excessive monitoring), 3) no evidence of at least one diabetes eye exam, 4) no evidence of at least one electrocardiogram or cardiac stress test, 5) hospital encounter with hypoglycemia, 6) hospital encounter with hyperglycemia, and 7) hospital encounter with hypertension. We defined hospital encounters as ED visits or hospitalizations where the outcome was captured as the primary diagnosis and we used validated coding algorithms where possible (Table 3 of the Supplemental Material). (31, 32) Although examined as a baseline measure, we did not include HbA1C value in our care gap analysis as most guidelines suggest individualized glycemic targets, particularly in vulnerable populations. (33, 34) We also did not include use of medications or glucose test strips, as this information was only available for a subpopulation (i.e. 65 years and older).

To facilitate our predictive analysis, we then calculated a care gap “score” for each patient. We did this by summing the total number of care gaps per person, over the 2-year period (Table 3 of the Supplemental Material). A higher gap score equated to lower quality of care.
Secondary Outcomes

As secondary outcomes, we identified predictors of diabetes care gaps. We focused on patient (age, sex, residential status, income, comorbidities, duration of diabetes), provider (type of physician seen for diabetes), and health system factors (roster status with family physician, visits to specialists and family doctors, diabetes-related visits with physicians). (30) We examined predictors in the one year prior to the care gap period. We also examined for spatial distribution in care gaps, aggregated to Local Health Integration Network or LHIN. Over the study period, LHINs were the geographical units used to plan, organize and integrate health services in our province. (35)

Statistical analysis

We present the characteristics of included patients descriptively using means (standard deviations), medians (interquartile ranges), numbers and percentages. We report individual diabetes care gaps using numbers and percentages. We describe the characteristics of those with care gap scores greater than and ≤ the median, and compared groups using standardized differences (differences >10% considered meaningful). (36) We used Poisson regression to determine predictors of a gap score above the median and present relative risks (RR) and 95% confidence intervals (CIs).

For our spatial analysis, we examined rates of care gap scores above the median by geographical location. Crude rates were obtained by dividing the number of patients with gap scores above the median by the total eligible study population as of January 1, 2018. Due to low counts (particularly in those younger than 49 years), there was instability in age-adjusted gap rates. As
such, we display gaps by age category (18-49, 50-65, 66-74, ≥75 years). Maps were created using ArcGIS software (version 10.3). All other analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC, USA).

**Results**

There were 4,173 patients included in the study (flow diagram in Figure 1 of the Supplemental Material). Baseline characteristics are detailed in Table 1. Mean (standard deviation) age was 67 ± 13 years and 39% were women. Patients received hemodialysis across 26 programs.

Over half of patients were in the lowest two income quintiles and had high levels of instability, deprivation, and dependency. In addition to using hemodialysis, patients had many other medical comorbidities including coronary artery disease and heart failure. Mean duration of diabetes was 17.6 ± 7.4 years. Mean HbA1c was 6.9 ±1.6% and the proportion with a mean HbA1c ≤7% was 51%.

We found that 42% of patients had >1 diabetes care gap evident (Table 2). The most common gap was suboptimal retinopathy screening (53%), followed by suboptimal glycemic monitoring as defined by at least annual HbA1c test (34% had no evidence of an annual HbA1c). Suboptimal glycemic monitoring was also observed by use of glucose test strips in a subpopulation of older adults (1,115/2,337 or 48% did not have at least an annual prescription for glucose test strips over 2 years). 308 or 7.4% of patients had no stress test or EKG in the 2 years prior. Only a small proportion of patients had hospital encounters for hypertension, hyperglycemia, or hypoglycemia (5.2%, 0.4% and 4.4% respectively).
The characteristics of patients by care gap score are shown in Table 3. There were 1,775 (42.5%) with a gap score above the median (i.e. 1) and 2,398 (57.5%) with a score ≤ median (i.e. ≤1).

Compared with those with a gap score ≤1, patients with a score >1 were more often not rostered to a family physician, had a shorter duration of diabetes and fewer comorbidities and hospitalizations. They also had fewer diabetes-related healthcare visits.

Significant predictors of more than one diabetes care gap are shown in Table 4. These included younger age (RR=0.997, 95% CI 0.994 to 0.999), female sex (1.084, 95% CI 1.011 to 1.163), shorter duration of diabetes (RR 0.985, 95% CI 0.981 to 0.990), dementia (RR 1.206, 95% CI 1.056 to 1.377), fewer specialist visits (RR 0.986, 95% CI 0.982 to 0.989) and no diabetes-related visit with a physician (RR 1.138, 95% CI 1.012 to 1.281). We note regional variation in gaps; across most age groups, Southern and Northern areas of our province appeared vulnerable. There was less geographic variation in care gaps in younger individuals, but in this group, overall gap rates were high (Figure 1).

**Discussion**

In this large population-based cohort study of patients with diabetes receiving in-centre hemodialysis in Ontario, we note opportunities to improve diabetes care. There is special need to improve retinopathy screening, which has also been described in the general diabetes population.(37,38) Efforts might also be made to improve glycemic monitoring. Further, there may be a need to “loosen” glycemic control given our cohort had a mean HbA1c of 6.9 ±1.6%, and the majority had an HbA1c ≤7%. It is generally recommended that tight control is avoided in
those with functional limitation and significant comorbidities, (27,39) due to a heightened risk of hypoglycemia.

There have been limited studies to examine diabetes gaps in the hemodialysis population. In a small study (n=100) in Southeastern Ontario Canada in 2006, >50% of patients had “suboptimal” glycemic control, at that time defined as a HbA1c of >7%. (12) In a study of patients with diabetes and CKD in Australia (20% receiving dialysis), patients self-reported suboptimal use of statins, out-of-target blood pressures, and low rates of retinopathy screening. (40) In a 2018 United States Renal Data System report, 17% of patients with diabetes and end-staged kidney disease had not had an annual HbA1c, and 53% did not have a diabetes eye exam. (29)

Reasons for diabetes care gaps in hemodialysis are likely multifactorial and related to patient, provider, and health system factors. Low eye screening might relate to the need to schedule and attend separate outpatient appointments, lack of awareness of the need for eye screening, lower socioeconomic status, behavioral and cultural factors, or geographic barriers. (38,41,42) Suboptimal eye screening is concerning given those on dialysis are at very high risk of vision-threatening retinopathy. (43,44) Early detection and appropriate treatment can reduce vision impairment. (45)

Suboptimal glycemic monitoring may have been due to limitations in diabetes self-management skills or competing medical appointments making it difficult to attend the laboratory for testing. While we recognize that use of HbA1c for glycemic monitoring in CKD is controversial. (46) HbA1c remains a common clinical tool to assess glycemic control in this population. We also
observed a similar monitoring gap with use of glucose test strips. Glycemic monitoring is
important in diabetes to capture and act upon hyper and hypoglycemia. Hypoglycemia is
particularly common in patients on dialysis.(3)

In terms of predictors of care gaps, younger individuals, females, and those with a shorter
duration of diabetes had more gaps. Gaps in younger patients may have been due to suboptimal
education, personal/social influences, or treatment inertia in younger, more recently diagnosed
patients.(40,47) Sex disparities in both CKD,(48,49) and diabetes management have been
described previously.(50–52) The gaps observed in patients with dementia might have been due
to cognitive limitations or suboptimal access to care. We also found that patients who saw fewer
specialists or who did not have diabetes care visits faced more gaps. The importance of routine
diabetes follow-up and specialist care in diabetes has been described previously.(42,53)

Like our study, studies of other diabetes cohorts have noted spatial variation in care quality.
(54,55) A Canadian study of patients with diabetes and CKD in Alberta, found that remote
dwellers were less likely to have an HbA1c and urinary albumin-to-creatinine ratio measured,
and less likely to receive an angiotensin-converting-enzyme inhibitor, angiotensin-receptor
blocker or statin than those who lived closer to a nephrologist.(56) Geographic variation in care
gaps might be related to physician volumes in particular regions, lack of specialists, or the health
behaviours, beliefs, and socioeconomic characteristics of the populations who live in the
area.(54,56–59) It also remains possible that Northern and Southern residents of our province
might seek and receive care in other provinces or states, precluding full capture of healthcare
utilization.(60)
Our study has clinical and research implications. Where suboptimal diabetes healthcare has been linked with adverse outcomes for patients with CKD, (61) this study might inform targeted efforts to improve the care of this high-risk population. Interventions to improve rates of eye screening (e.g. patient education, assistance with appointment scheduling, ocular telemedicine strategies) might be helpful. (62,63) To support glycemic control, self-management and monitoring, there may be value in outreach diabetes support in the hemodialysis unit, or interdisciplinary care clinics.(64)

Our study has many strengths. We captured care gaps across several hemodialysis units across the province rather than focusing on a single centre. We conducted a comprehensive gap analysis, focusing upon those which are modifiable and targetable for intervention. Instead of relying upon patient self-report, we used healthcare data captured in administrative databases. In terms of limitations, care gaps had to be measurable using administrative data. As such, we could not examine for adequate foot screening or blood pressure control. However we did examine hospitalizations for hypertension in our gap analysis. Further, administrative codes can be limited in sensitivity,(31) and as such we missed outcome events that did not lead to hospital presentation (e.g. events which prompted emergency medical services only). We defined suboptimal glycemic monitoring using HbA1c tests, which is controversial given its measure can be influenced by uremia, anemia, and use of erythropoietic stimulating agents. (65) However we also examined monitoring by use of glucose test strips and noted consistent results. We could only examine prescription medications in those 65 years or older and did not incorporate into our care gap analysis. Further, guidelines for diabetes management in hemodialysis are sparse, necessitating use of other general CKD/diabetes guidelines and clinical expertise for our
analysis. Finally, our results are only fully generalizable to those receiving in-center hemodialysis in the province of Ontario.

In conclusion, there are opportunities to improve diabetes care in chronic in-centre hemodialysis patients. Focused efforts to increase patients’ access to diabetes health services might be considered to improve outcomes.

**Disclosures**

K. Clemens received a diabetes research award sponsored by Astra Zeneca. She has attended Merck sponsored conferences. She has received honoraria for delivering certified Continuing Medical Education talks from Sutherland Global Services Canada ULC and the Canadian Medical and Surgical Knowledge Translation Research Group. A. Garg reports Research Funding: Astellas; Scientific Advisor or Membership: Currently on the Editorial Boards of Kidney Int and AJKD; Other Interests/Relationships: Serve on the Data Safety and Monitoring Board for an Investigator Initiated Trial Program Funded by Glaxo Smith Kline, Medical Lead Role to Improve Access to Kidney Transplantation and Living Kidney Donation for the Ontario Renal Network (government funded agency located within Ontario Health). S. Silver reports Honoraria: Sanofi, Baxter; Scientific Advisor or Membership: Editorial board Canadian Journal of Kidney Health and Disease. All remaining authors have nothing to disclose.

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Author contributions

K. Clemens conceptualized the study, drafted the protocol, interpreted results, and drafted the manuscript. A. Ouedraogo acquired study data, performed the analysis, interpreted results, and reviewed the manuscript critically. A. Garg conceptualized the study, reviewed the protocol, interpreted the results, and reviewed the manuscript. S. Silver reviewed the protocol, interpreted
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Table 1. Characteristics of 4,173 patients with prevalent diabetes receiving chronic in-centre hemodialysis in Ontario, Canada on January 1 2018

| Demographics                        |       |
|-------------------------------------|-------|
| Age, years                          | 67 ± 13 |
| Mean ± SD                           |       |
| Median (IQR)                        | 68 (59-77) |
| 18 to 49                            | 413 (9.9%) |
| 50 to 65                            | 1,308 (31.3%) |
| 66 to 74                            | 1,127 (27.0%) |
| ≥75                                 | 1,325 (31.8%) |
| Women                               | 1,627 (39.0%) |
| Race                                |       |
| Caucasian                           | 2,401 (57.5%) |
| Black/African origin                | 438 (10.5%) |
| Other                               | 1,320 (31.6%) |
| Missing                             | 14 (0.3%) |
| Family physician roster status a    |       |
| Not rostered                        | 293 (7.0%) |
| Rostered                            | 3,202 (76.7%) |
| Virtually rostered                  | 678 (16.2%) |
| Income quintile b                   |       |
| 1 (lowest)                          | 1,362 (32.6%) |
| 2                                   | 981 (23.5%) |
| 3                                   | 772 (18.5%) |
| 4                                   | 588 (14.1%) |
| 5 (highest)                         | 470 (11.3%) |
| Distance from primary residence to dialysis centre (km) c |       |
| Mean ± SD                           | 18.9 ± 64.2 |
| Median (IQR)                        | 6.3 (3.3-13.1) |
| Marginalization index          |       |
|-------------------------------|-------|
| **Instability Quintile**      |       |
| 1 - lowest instability        | 626 (15.0%) |
| 2                             | 595 (14.3%) |
| 3                             | 688 (16.5%) |
| 4                             | 819 (19.6%) |
| 5 - highest instability       | 1,359 (32.6%) |
| Missing                       | 86 (2.1%) |
| **Deprivation Quintile**      |       |
| 1 - lowest deprivation        | 533 (12.8%) |
| 2                             | 657 (15.7%) |
| 3                             | 724 (17.3%) |
| 4                             | 923 (22.1%) |
| 5 - highest deprivation       | 1,250 (30.0%) |
| Missing                       | 86 (2.1%) |
| **Dependency Quintile**       |       |
| 1 - lowest dependency         | 808 (19.4%) |
| 2                             | 716 (17.2%) |
| 3                             | 696 (16.7%) |
| 4                             | 750 (18.0%) |
| 5 - highest dependency        | 1,117 (26.8%) |
| Missing                       | 86 (2.1%) |
| **Ethnic Concentration Quintile** |       |
| 1 - lowest ethnic concentration | 632 (15.1%) |
| 2                             | 621 (14.9%) |
| 3                             | 652 (15.6%) |
| 4                             | 758 (18.2%) |
| 5 - highest ethnic concentration | 1,424 (34.1%) |
| Missing                       | 86 (2.1%) |
| **Long term care**            |       |
| b,d                           |        |
| Rural location                | 263 (6.3%) |
| Missing                       | 446 (10.7%) |
| **Duration of diabetes prior to index date, years** |       |
| Mean ± SD                     | 17.6 ± 7.4 |
| Median (IQR)                  | 19.0 (11.9-24.5) |
| **Duration of ESKD prior to index date, years** |       |
| Mean ± SD                     | 5.4 ± 5.2 |
| Median (IQR)                  | 3.8 (2.4-6.6) |
| **Comorbidities**             |       |
| Chronic obstructive pulmonary disease | 1,275 (30.6%) |
| Congestive heart failure      | 2,298 (55.1%) |
| Dementia                      | 379 (9.1%) |
| Condition                                      | Count   | Percentage |
|-----------------------------------------------|---------|------------|
| Coronary artery disease                       | 2,595   | (62.2%)    |
| Stroke                                        | 583     | (14.0%)    |
| Foot ulcer                                    | 489     | (11.7%)    |
| Amputation                                    | 294     | (7.0%)     |
| Retinopathy                                   | 473     | (11.3%)    |
| Depression and anxiety                        | 374     | (9.0%)     |
| Hospital encounter with hypoglycemia          | 472     | (11.3%)    |
| Hospital encounter with hyperglycemia         | 18      | (0.4%)     |
| Cancer                                        | 618     | (14.8%)    |
| Chronic liver disease                        | 608     | (14.6%)    |

**Charlson score**

| Category | Count | Percentage |
|----------|-------|------------|
| Mean ± SD| 4.9 ± 1.9 |           |
| Median (IQR) | 5.0 (4.0-6.00) | |
| 0        | 27 (0.6%) | |
| 1        | 26 (0.6%) | |
| 2        | 413 (9.9%) | |
| 3        | 268 (6.4%) | |
| 4+       | 3,363 (80.6) | |
| Missing  | 76 (1.8%) | |

**Healthcare utilization in the prior year**

**Number of specialist visits**

| Category | Count | Percentage |
|----------|-------|------------|
| Mean ± SD| 17.2 ± 14.0 | |
| Median (IQR) | 14.0 (7.0-24.0) | |
| 0        | 135 (3.2%) | |
| 1 to 2   | 222 (5.3%) | |
| 3 to 5   | 450 (10.8%) | |
| 6 to 11  | 885 (21.2%) | |
| 12+      | 2,481 (59.5%) | |

**Number of primary care visits**

| Category | Count | Percentage |
|----------|-------|------------|
| Mean ± SD| 8.5 ± 11.9 | |
| Median (IQR) | 6.0 (2.0-11.0) | |
| 0        | 524 (12.6%) | |
| 1 to 2   | 687 (16.5%) | |
| 3 to 5   | 842 (20.2%) | |
| 6+       | 2,120 (50.8%) | |

**At least one outpatient visit for diabetes**

| Category | Count | Percentage |
|----------|-------|------------|
| Mean ± SD| 2.66 ± 4.35 | |
| Median (IQR) | 1.00 (0.00-4.00) | |
| 0        | 1,824 (43.7%) | |
| 1 to 2   | 839 (20.1%) | |
| 3 to 5   | 817 (19.6%) | |
| 6+       | 693 (16.6%) | |
| Physician seen for diabetes care | f,h |
|----------------------------------|-----|
| Family physician                 | 1,291 (30.9%) |
| Internal medicine                | 326 (7.8%)   |
| Endocrinology                    | 719 (17.2%)  |
| Other                            | 13 (0.3%)    |
| No visit for diabetes            | 1,824 (43.7%)|
| **Number of unique physician visits** |     |
| Mean ± SD                        | 38.7 ± 25.0  |
| Median (IQR)                     | 33.0 (21.0-51.0) |
| **All cause emergency department visits** |     |
| Mean ± SD                        | 3.1 ± 5.0    |
| Median (IQR)                     | 2.0 (1.0-4.0) |
| **All cause hospitalizations**   |     |
| Mean ± SD                        | 3.1 ± 3.1    |
| Median (IQR)                     | 2.0 (1.0-4.0) |
| **At least one HbA1c value**     | 3,454 (82.8%)|
| HbA1c value                      |     |
| Mean ± SD                        | 6.9 ± 1.6    |
| ≤7%                              | 2,136 (51.2%)|
| >7%                              | 1,318 (31.6%)|
| **Medications (≥66 years, n= 2452)** |     |
| Insulin or oral antihyperglycemic medication | 1,460 (59.5%) |
| Insulin                          | 1,168 (47.6%) |
| Oral antihyperglycemic medication | 564 (23.0%)  |
| Acarbose                         | 0           |
| Other sulphonylurea              | 0           |
| Gliclazide                       | 207 (8.4%)  |
| Glyburide                        | <=5         |
| Metformin                        | 25 (1.0%)   |
| Thiazolidinedione                | <=5         |
| Sodium glucose co-transporter 2 inhibitor | <=5 |
| Other diabetes medication        | 422 (17.2%) |
| Glucose test strips              | 1,197 (48.8%)|
| **Last prescriber of diabetes medication** |     |
| Family physician                 | 777 (31.7%) |
| Internal medicine                | 186 (7.6%)  |
| Endocrinology                    | 180 (7.3%)  |
| Nephrology                       | 246 (10.0%) |
| Other specialty                  | 71 (2.9%)   |
| ACE/ARB                          | 1,080 (44.0%)|
| Statin                           | 1,782 (72.7%)|
| Other lipid medication           | 203 (8.3%)  |
Table 2. Two-year diabetes care gaps in 4,173 patients using chronic in-centre hemodialysis in Ontario, Canada as of January 1 2018

| Description                                                                 | Count (Percentage) |
|----------------------------------------------------------------------------|--------------------|
| No evidence of at least annual HbA1c                                       | 1410 (33.8%)       |
| >8 HbA1c tests                                                             | 1278 (30.6%)       |
| No evidence of retinopathy screening                                        | 2201 (52.7%)       |
| No electrocardiogram or cardiac stress test                                | 308 (7.4%)         |
| Hospitalization for hyperglycemia a                                        | 18 (0.4%)          |
| Hospitalization for hypoglycemia a                                         | 182 (4.4%)         |
| Hospitalization for hypertension a                                         | 217 (5.2%)         |
| Age 67+ with no evidence of annual test strip prescription (n=2,334) b     | 1115 (47.7%)       |

a Recorded as main diagnosis
b Only patients aged 67+ were included to facilitate a 2-year look back for use of medications.

Patient rostering is a process by which patients register with a family practice, family physician, or team. It defines the population for which the primary care organization or provider is responsible. (66)

To avoid small cells from being re-calculated, missing income quintiles was recoded as ‘3’. Missing rural was also recoded as ‘no’ (urban)

distance from primary residence to dialysis centre was calculated using great circle distances (in km) based on latitudes and longitudes. Equations were obtained from Statistics Canada.

Rural definition was based on Statistics Canada definition (communities <10,000 population).

Outpatient visit for diabetes was defined by receipt of Ontario Health Insurance Plan (OHIP) diagnostic code 250 during an outpatient clinical encounter with a physician.

Physician seen for diabetes care was defined as the physician who billed OHIP code 250 during an outpatient physician encounter.

'Specialist visits’ include: dermatology, general surgery, neurosurgery, community medicine, orthopaedic surgery, geriatrics, plastic surgery, cardiothoracic surgery, emergency medicine, internal medicine, endocrinology, nephrology, vascular surgery, neurology, psychiatry, ob/gyn, gynaecology, genetics, ophthalmology, otolaryngology, physical medicine, urology, gastroenterology, medical oncology, infectious disease, respiratory disease, rheumatology, optometrists, osteopaths, chiropractors, cardiologist, cardiology, haematology, clinical immunology, nuclear medicine, thoracic surgery

Physicians seen for diabetes visits include internists, nephrologists, endocrinologists, general practitioners, geriatricians
Table 3. Characteristics of patients with diabetes using in-centre hemodialysis with a care gap score above and below the median as of Jan 1 2018

|                      | Gap score >1 | Gap score ≤1 | Standardized difference |
|----------------------|--------------|--------------|-------------------------|
|                      | N=1,775      | N=2,398      |                         |
| Age (years)          |              |              |                         |
| Mean ± SD            | 66.83 ± 14.16| 67.54 ± 12.31| 0.05                    |
| Median (IQR)         | 68.00 (57.00-77.00) | 68.00 (59.00-77.00) | 0.02                    |
| 18-49 yrs.           | 213 (12.0%)  | 200 (8.3%)   | 0.12                    |
| 50 to 65 yrs.        | 541 (30.5%)  | 767 (32.0%)  | 0.03                    |
| 66 to 74             | 430 (24.2%)  | 697 (29.1%)  | 0.11                    |
| 75 and over          | 591 (33.3%)  | 734 (30.6%)  | 0.06                    |
| Sex - females        |              |              | 0.1                     |
| Caucasian            | 1,050 (59.2%)| 1,351 (56.3%)| 0.06                    |
| Black/African origin | 192 (10.8%)  | 246 (10.3%)  | 0.02                    |
| Other                | 526 (29.6%)  | 794 (33.1%)  | 0.07                    |
| Missing              | 7 (0.4%)     | 7 (0.3%)     | 0.02                    |
| Rostered to family doctor |          |              |                         |
| 0 - not rostered     | 153 (8.6%)   | 140 (5.8%)   | 0.11                    |
| 1 - rostered         | 1,361 (76.7%)| 1,841 (76.8%)| 0                       |
| 2 - virtually rostered| 261 (14.7%)  | 417 (17.4%)  | 0.07                    |
| Income quintile a    |              |              |                         |
| 1 (lowest)           | 577 (32.5%)  | 785 (32.7%)  | 0                       |
| 2                    | 427 (24.1%)  | 554 (23.1%)  | 0.02                    |
| 3                    | 326 (18.4%)  | 446 (18.6%)  | 0.01                    |
| 4                    | 238 (13.4%)  | 350 (14.6%)  | 0.03                    |
| 5 (highest)          | 207 (11.7%)  | 263 (11.0%)  | 0.02                    |
| Distance to dialysis center (km) |          |              |                         |
| Mean ± SD            | 17.85 ± 49.93| 19.63 ± 72.92| 0.03                    |
| Median (IQR)         | 6.53 (3.21-13.87) | 6.21 (3.28-12.57) | 0.03                   |
| Marginalization index|              |              |                         |
| Instability Quintile |              |              |                         |
| 1 - lowest instability| 265 (14.9%)  | 361 (15.1%)  | 0                       |
| 2                    | 269 (15.2%)  | 326 (13.6%)  | 0.04                    |
| 3                    | 308 (17.4%)  | 380 (15.8%)  | 0.04                    |
| 4                    | 348 (19.6%)  | 471 (19.6%)  | 0                       |
| 5 - highest instability| 552 (31.1%)  | 807 (33.7%)  | 0.05                    |
| Missing              | 33 (1.9%)    | 53 (2.2%)    | 0.02                    |
| Deprivation Quintile |              |              |                         |
| 1 - lowest deprivation| 218 (12.3%)  | 315 (13.1%)  | 0.03                    |
| Dependency Quintile | 1 - lowest dependency | 2 | 3 | 4 | 5 - highest deprivation | Missing |
|---------------------|----------------------|---|---|---|------------------------|--------|
| 2                   | 274 (15.4%)          | 306 (17.2%) | 405 (22.8%) | 539 (30.4%) | 33 (1.9%)  | 0.01   |
| 3                   | 306 (17.2%)          | 418 (17.4%) | 518 (21.6%) | 711 (29.6%) | 53 (2.2%)  | 0.03   |
| 4                   | 405 (22.8%)          | 417 (17.4%) | 420 (17.5%) | 633 (26.4%) | 53 (2.2%)  | 0.02   |
| 5 - highest deprivation | 539 (30.4%)          | 711 (29.6%) | 633 (26.4%) | 711 (29.6%) | 53 (2.2%)  | 0.02   |
| Missing             | 33 (1.9%)            | 53 (2.2%)  | 53 (2.2%)  | 53 (2.2%)  | 53 (2.2%)  | 0.02   |

| Ethnic Concentration Quintile | 1 - lowest concentration | 2 | 3 | 4 | 5 - highest concentration | Missing |
|-------------------------------|--------------------------|---|---|---|--------------------------|--------|
| 1                             | 273 (15.4%)              | 311 (17.5%) | 279 (15.7%) | 330 (18.6%) | 484 (27.3%) | 33 (1.9%) |
| 2                             | 311 (17.5%)              | 405 (16.9%) | 417 (17.4%) | 420 (17.5%) | 633 (26.4%) | 53 (2.2%) |
| 3                             | 279 (15.7%)              | 417 (17.4%) | 420 (17.5%) | 633 (26.4%) | 53 (2.2%)  | 0.02   |
| 4                             | 330 (18.6%)              | 420 (17.5%) | 633 (26.4%) | 53 (2.2%)  | 0.02       |
| 5 - highest concentration     | 484 (27.3%)              | 633 (26.4%) | 53 (2.2%)  | 0.02       |
| Missing                       | 33 (1.9%)                | 53 (2.2%)  | 53 (2.2%)  | 53 (2.2%)  | 53 (2.2%)  | 0.02   |

| Long term care               | 131 (7.4%)              | 132 (5.5%) | 132 (5.5%) | 132 (5.5%) | 132 (5.5%) | 0.08   |
| Rural locationa              | 204 (11.5%)             | 242 (10.1%) | 242 (10.1%) | 242 (10.1%) | 242 (10.1%) | 0.05   |
| Duration of diabetes (years) | Mean ± SD               | 16.5 ± 7.7 | 18.4 ± 7.0 | 20.0 (13.7-24.8) | 0.26   |
|                              | Median (IQR)            | 17.2 (10.2-23.9) | 20.0 (13.7-24.8) | 0.24   |

**Comorbidities**

| COPD      | 539 (30.4%) | 736 (30.7%) | 0.01 |
|-----------|-------------|-------------|------|
| CHF       | 930 (52.4%) | 1,368 (57.0%) | 0.09 |
| Dementia  | 169 (9.5%)  | 210 (8.8%)  | 0.03 |
| CAD       | 1,016 (57.2%) | 1,579 (65.8%) | 0.18 |
| Stroke    | 225 (12.7%) | 358 (14.9%) | 0.07 |
| Foot ulcer| 163 (9.2%)  | 326 (13.6%) | 0.14 |
| Amputation| 95 (5.4%)   | 199 (8.3%)  | 0.12 |
| Depression and anxiety | 158 (8.9%) | 216 (9.0%) | 0 |
| Hypoglycemia | 209 (11.8%) | 263 (11.0%) | 0.03 |
| Hyperglycemia | 9 (0.5%) | 9 (0.4%) | 0.02 |
| Retinopathy | 118 (6.6%) | 355 (14.8%) | 0.27 |
| Cancer    | 238 (13.4%) | 380 (15.8%) | 0.07 |
| Liver     | 242 (13.6%) | 366 (15.3%) | 0.05 |
| Charlson score |           |             |      |
| Healthcare utilization in the prior year | | | |
|---|---|---|---|
| **Mean ± SD** | 4.8 ± 2.0 | 5.1 ± 1.9 | 0.15 |
| **Median (IQR)** | 5.0 (4.0-6.0) | 5.0 (4.0-6.0) | 0.15 |
| 0 | 16 (0.9%) | 11 (0.5%) | 0.05 |
| 1 | 8 (0.5%) | 18 (0.8%) | 0.04 |
| 2 | 223 (12.6%) | 190 (7.9%) | 0.15 |
| 3 | 126 (7.1%) | 142 (5.9%) | 0.05 |
| 4+ | 1,344 (75.7%) | 2,019 (84.2%) | 0.21 |
| Missing | 58 (3.3%) | 18 (0.8%) | 0.18 |

**Number of specialist visits**

| **Mean ± SD** | 13.5 ± 12.1 | 20.1 ± 14.7 | 0.48 |
| **Median (IQR)** | 11.0 (5.0-19.0) | 17.0 (10.0-27.0) | 0.55 |
| 0 | 116 (6.5%) | 19 (0.8%) | 0.31 |
| 1 to 2 | 152 (8.6%) | 70 (2.9%) | 0.24 |
| 3 to 5 | 258 (14.5%) | 192 (8.0%) | 0.21 |
| 6 to 11 | 422 (23.8%) | 463 (19.3%) | 0.11 |
| 12+ | 827 (46.6%) | 1,654 (69.0%) | 0.47 |

**Number of primary care visits**

| **Mean ± SD** | 8.1 ± 12.4 | 8.7 ± 11.5 | 0.06 |
| **Median (IQR)** | 5.0 (2.0-11.0) | 6.0 (2.0-11.0) | 0.13 |
| 0 | 261 (14.7%) | 263 (11.0%) | 0.11 |
| 1 to 2 | 311 (17.5%) | 376 (15.7%) | 0.05 |
| 3 to 5 | 366 (20.6%) | 476 (19.8%) | 0.02 |
| 6+ | 837 (47.2%) | 1,283 (53.5%) | 0.13 |

**At least one diabetes visit**

| **Mean ± SD** | 2.3 ± 4.3 | 2.9 ± 4.4 | 0.13 |
| **Median (IQR)** | 0.0 (0.0-3.0) | 1.0 (0.0-4.0) | 0.24 |
| 0 | 910 (51.3%) | 914 (38.1%) | 0.27 |
| 1 to 2 | 311 (17.5%) | 528 (22.0%) | 0.11 |
| 3 to 5 | 294 (16.6%) | 523 (21.8%) | 0.13 |
| 6+ | 260 (14.6%) | 433 (18.1%) | 0.09 |

**Physician seen for diabetes**

| **General practitioner** | 496 (27.9%) | 795 (33.2%) | 0.11 |
| **Internal medicine** | 112 (6.3%) | 214 (8.9%) | 0.1 |
| **Endocrinology** | 248 (14.0%) | 456 (19.0%) | 0.14 |
| **Other** | ≤5 | ≤5 | 0.01 |
| **No visits** | 910 (51.3%) | 914 (38.1%) | 0.27 |

**Number of unique physician visits**

| **Mean ± SD** | 35.5 ± 25.2 | 41.0 ± 24.5 | 0.22 |
### Median (IQR)

|                      | 29.0 (17.0-48.0) | 36.0 (23.0-53.0) | 0.29 |
|----------------------|------------------|------------------|------|
| All cause ED visits  |                  |                  |      |
| Mean ± SD            | 3.2 ± 5.6        | 3.1 ± 4.5        | 0.02 |
| Median (IQR)         | 2.0 (0.0-4.0)    | 2.0 (1.0-4.0)    | 0.02 |
| All cause hospitalization |            |                  |      |
| Mean ± SD            | 2.9 ± 3.2        | 3.3 ± 3.0        | 0.15 |
| Median (IQR)         | 2.0 (1.0-4.0)    | 3.0 (1.0-5.0)    | 0.23 |

### Labs

|                             | 1,272 (71.7%) | 2,182 (91.0%) | 0.51 |
|-----------------------------|--------------|--------------|------|
| At least one A1c            |              |              |      |
| A1c value (%)               | 6.8 ± 1.6    | 6.9 ± 1.6    | 0.08 |
| Median (IQR)                | 6.5 (5.6-7.7)| 6.6 (5.8-7.8)| 0.11 |
| ≤7%                         | 820 (46.2%)  | 1,316 (54.9%)| 0.17 |
| >7%                         | 452 (25.5%)  | 866 (36.1%)  | 0.23 |
| Missing                     | 503 (28.3%)  | 216 (9.0%)   | 0.51 |

Cell sizes <6 suppressed for patient privacy, as per ICES privacy policies

a Fewer than 3% of patients had missing data. To avoid small cells from being re-calculated, missing income quintiles was recoded as ‘3’. Missing rural was also recoded as ‘no’ (urban)

b Selected specialties in ‘specialist visits’ include: dermatology, dermatology, general surgery, neurosurgery, community medicine, orthopaedic surgery, geriatrics, plastic surgery, cardiothoracic surgery, emergency medicine, internal medicine, endocrinology, nephrology, vascular surgery, neurology, psychiatry, obstetrics and gynecology, genetics, ophthalmology, otolaryngology, physical medicine, urology, gastroenterology, medical oncology, infectious disease, respiratory disease, rheumatology, optometrists, osteopaths, chiropractors, cardiology, hematology, clinical immunology, nuclear medicine, thoracic surgery

c Physicians seen for ‘diabetes visits’ include internists, nephrologists, endocrinologists, general practitioners, geriatricians

Abbreviations: ESKD, end-staged kidney disease; IQR, interquartile range; SD, standard deviation
Table 4. Predictors of >1 diabetes care gap in patients using chronic in-centre hemodialysis in Ontario, Canada

| Predictor                                | Relative risk | Lower confidence interval | Upper confidence interval | P-value |
|------------------------------------------|---------------|---------------------------|---------------------------|---------|
| Age, years                               | 0.997         | 0.994                     | 0.999                     | 0.018   |
| Sex - Female                             | 1.084         | 1.011                     | 1.163                     | 0.023   |
| Rostered to family doctor                |               |                           |                           |         |
| 0 - not rostered                         | 1.132         | 1.000                     | 1.281                     | 0.051   |
| 1 - rostered                             | REF           | REF                       | REF                       |         |
| 2 - virtually rostered                   | 0.951         | 0.862                     | 1.049                     | 0.315   |
| Income quintilea                         |               |                           |                           |         |
| 1 - Lowest                               | 0.950         | 0.845                     | 1.069                     | 0.396   |
| 2                                        | 0.981         | 0.868                     | 1.110                     | 0.764   |
| 3                                        | 0.987         | 0.869                     | 1.122                     | 0.842   |
| 4                                        | 0.897         | 0.780                     | 1.030                     | 0.124   |
| 5 - Highest                              | REF           | REF                       | REF                       |         |
| Rural location                           | 1.086         | 0.979                     | 1.206                     | 0.119   |
| Duration of diabetes                     | 0.985         | 0.981                     | 0.990                     | <0.001  |
| Congestive heart failure                 | 0.988         | 0.914                     | 1.067                     | 0.754   |
| Chronic obstructive pulmonary disease    | 1.034         | 0.954                     | 1.121                     | 0.416   |
| Dementia                                 | 1.206         | 1.056                     | 1.377                     | 0.006   |
| Coronary artery disease                  | 0.967         | 0.898                     | 1.040                     | 0.361   |
| Stroke                                   | 1.005         | 0.896                     | 1.129                     | 0.927   |
| Amputation                               | 0.912         | 0.750                     | 1.109                     | 0.354   |
| Anxiety/Depression                       | 1.016         | 0.892                     | 1.157                     | 0.812   |
| Cancer                                   | 1.054         | 0.950                     | 1.169                     | 0.320   |
| Liver                                    | 0.926         | 0.829                     | 1.035                     | 0.176   |
| Charlson score                           |               |                           |                           |         |
| 0 or no hospitalizations                 | REF           | REF                       | REF                       |         |
| 1                                        | 0.660         | 0.353                     | 1.236                     | 0.194   |
| 2                                        | 1.072         | 0.882                     | 1.304                     | 0.484   |
| 3                                        | 1.005         | 0.809                     | 1.250                     | 0.961   |
| 4+                                       | 0.938         | 0.778                     | 1.130                     | 0.501   |
| Specialist visits                        | 0.986         | 0.982                     | 0.989                     | <0.001  |
| Primary care visits                      | 1.001         | 0.997                     | 1.004                     | 0.751   |
| Diabetic visits | 1.010 | 1.000 | 1.020 | 0.063 |
|-----------------|-------|-------|-------|-------|
| Physician seen for diabetes |       |       |       |       |
| General/family physician | 0.950 | 0.847 | 1.064 | 0.373 |
| Internal medicine | 0.880 | 0.744 | 1.040 | 0.134 |
| Endocrinology | REF | REF | REF |       |
| Other* | 0.933 | 0.586 | 1.488 | 0.772 |
| No visits | **1.138** | **1.012** | **1.281** | **0.032** |

* Other physician included nephrologist, geriatrician
Figure 1. Geographic variation in diabetes gap scores over 1, by age group. Care gaps included: 1) insufficient or excessive glycemic monitoring, 2) suboptimal screening for diabetes-related complications (retinopathy and cardiovascular screening), and 3) hospitalizations for hypoglycemia, hyperglycemia, and hypertension. Results were sex-adjusted proportions per 1,000, aggregated to Local Health Integration Network.
