

2-1-2015

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### Citation of this paper:

Rowe, Brian H.; Singh, Mira; Villa-Roel, Cristina; Leiter, Lawrence A.; Hramiak, Irene; Edmonds, Marcia L.; Lang, Eddy; Sivilotti, Marco; Scheuermeyer, Frank; Worster, Andrew; Riley, Jennifer; Afilalo, Marc; Stiell, Ian; Yale, Jean Francois; Woo, Vincent C.; and Campbell, Samuel, "Acute Management and Outcomes of Patients with Diabetes Mellitus Presenting to Canadian Emergency Departments with Hypoglycemia" (2015). *Paediatrics Publications*. 1202.  
<https://ir.lib.uwo.ca/paedpub/1202>

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Contents lists available at [ScienceDirect](#)

Canadian Journal of Diabetes

journal homepage:  
[www.canadianjournalofdiabetes.com](http://www.canadianjournalofdiabetes.com)

Original Research

## Acute Management and Outcomes of Patients with Diabetes Mellitus Presenting to Canadian Emergency Departments with Hypoglycemia



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## ARTICLE INFO

## Article history:

Received 4 January 2014

Received in revised form

29 March 2014

Accepted 1 April 2014

## Keywords:

diabetes mellitus  
emergency department  
hypoglycemia  
overcrowding

## ABSTRACT

**Objectives:** This retrospective chart audit examined the demographics, investigations, management and outcomes of adult patients with diabetes mellitus presenting to Canadian emergency departments (EDs). **Methods:** All sites conducted a search of their electronic medical records using International Classification of Diseases, Tenth Revision, codes to identify ED visits for hypoglycemia between 2008 and 2010. Patient characteristics, demographics, ED management, ED resources and outcome are reported.

**Results:** A total of 1039 patients over the age of 17 years were included in the study; 347 (33.4%) were classified as type 1 diabetes and 692 (66.6%) were classified as type 2 diabetes. Type 2 diabetes patients were significantly older (73 vs. 49 years;  $p < 0.0001$ ) and had more chronic conditions recorded on their chart (all  $p < 0.001$ ). Most subjects arrived by ambulance, and triage scores revealed severe presentations in 39% of cases. Treatments for hypoglycemia were common (75.7%) during prehospital transport; 38.5% received intravenous glucose and 40.1% received glucagon. Hypoglycemia treatments in the ED included oral (76.8%), intravenous (29.6%) and continuous infusion (27.7%) of glucose. Diagnostic testing (81.9%) commonly included electrocardiograms (51.9%), chest radiography (37.5%) and head computed tomography scans (14.5%). Most patients (73.5%) were discharged; however, more subjects with type 2 diabetes required admission (30.3 vs. 8.8%). Discharge instructions were documented in only 55.5% of patients, and referral to diabetes services occurred in fewer than 20% of cases. Considerable variation existed in the management of hypoglycemia across EDs.

**Conclusions:** Patients with diabetes presenting to an ED with hypoglycemia consume considerable healthcare resources, and practice variation exists. Emergency departments should develop protocols for the management of hypoglycemia, with attention to discharge planning to reduce recurrence.

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## R É S U M É

Mots clés :  
diabète sucré  
service des urgences  
hypoglycémie  
engorgement

**Objectifs :** Cette vérification rétrospective des dossiers a permis d'examiner les données démographiques, les examens, la prise en charge et les résultats des patients adultes souffrant de diabète sucré qui se sont présentés aux services des urgences (SU) au Canada.

**Méthodes :** Tous les sites ont mené une recherche dans leurs dossiers médicaux électroniques à l'aide des codes de la Classification internationale des maladies, dixième révision, pour relever les visites aux SU entre 2008 et 2010 qui étaient liées à l'hypoglycémie. Les caractéristiques des patients, les données démographiques, la prise en charge aux SU, les ressources des SU et les résultats sont rapportés.

**Résultats :** Un total de 1039 patients de plus de 17 ans ont été inclus dans l'étude; 347 (33,4 %) ont été classifiés comme étant des cas de diabète de type 1 et 692 (66,6 %) ont été classifiés comme étant des cas de diabète de type 2. Les patients souffrant du diabète de type 2 étaient beaucoup plus âgés (73 ans vs 49 ans;  $p < 0,0001$ ) et avaient plus d'affections chroniques inscrites à leur dossier (tous  $p < 0,001$ ). La plupart des sujets arrivaient par ambulance, et 39 % des cas montraient des scores de triage qui révélaient des tableaux cliniques graves. Les traitements contre l'hypoglycémie étaient fréquents (75,7 %) durant le transport préhospitalier; 38,5 % recevaient du glucose et 40,1 % recevaient du glucagon par voie intraveineuse. Les traitements administrés dans les SU contre l'hypoglycémie comprenaient le glucose par voie orale (76,8 %), le glucose par voie intraveineuse (29,6 %) et en perfusion continue (27,7 %). Les examens diagnostiques (81,9 %) comprenaient fréquemment les électrocardiogrammes (51,9 %), la radiographie thoracique (37,5 %) et la tomodensitométrie crânienne (14,5 %). La plupart des patients (73,5 %) recevaient leur congé. Cependant, plus de sujets souffrant du diabète de type 2 nécessitaient une admission (30,3 vs 8,8 %). Les instructions de congé étaient étayées seulement 55,5 % des patients, et l'orientation vers des services de diabète se rencontrait chez moins de 20 % des cas. Une variation considérable dans la prise en charge de l'hypoglycémie existait entre les SU.

**Conclusions :** Les patients souffrant de diabète qui se présentaient à un SU en raison d'une hypoglycémie consomment considérablement de ressources en soins de santé, puis une variation est observée dans la pratique. Les SU devraient élaborer des protocoles de prise en charge de l'hypoglycémie en portant une attention à la planification du congé pour réduire la récurrence.

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## Introduction

Hypoglycemia associated with diabetes mellitus is a state characterized by abnormally low levels of blood glucose and is defined by 1) the development of autonomic or neuroglycopenic symptoms; 2) low plasma glucose levels ( $< 4.0$  mmol/L for patients treated with insulin or an insulin secretagogue) and 3) symptoms responding to the administration of carbohydrate (1). Many people without diabetes can have glucose levels in the hypoglycemia range without symptoms or disease; however, for people with diabetes, the severity of hypoglycemia is based on the clinical manifestations of their episodes. The Endocrine Society recommends a diagnosis of hypoglycemia be based on the combination of a low glucose level and evidence of adverse effects (2).

Hypoglycemia can produce a variety of symptoms and effects; most important is the impairment of function due to inadequate supply of glucose to the brain, resulting in cognitive impairment that may be mild, transient and reversed with nothing more than minor oral supplementation. Conversely, it may lead to potentially significant complications (e.g. seizures, permanent neurological sequelae and coma) (3). Moderate and severe hypoglycemia occurs as a complication of treatment of diabetes with insulin or insulin secretagogues. Hypoglycemia has been associated with an increased risk of cardiovascular events; its role as a mediator or a marker for severity is still unresolved (4). Numerous hypoglycemia events over a person's life span can negatively affect quality of life and represent significant indirect and direct economic costs to the healthcare system (5,6).

Hypoglycemia often results in presentation to the emergency department (ED), where acute treatment approaches vary and the relapse rate can be high, particularly when the event is related to non-insulin antihyperglycemic agents. Little research describing these presentations and variation in clinical practice has been conducted in the ED setting, and none in Canada. MEDLINE searches in late 2012 identified 1 Canadian study (7) and several American studies,

including a multicentre chart review (8). The Canadian study was restricted to patients with type 1 diabetes, and in the American study, the investigators completed a 1-year chart review on consecutive hypoglycemia cases identified using the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes, not specific to diabetes. Limitations of this study are that presentations may be related to the United States (US) healthcare system of public and private health, and only 3 centres in 1 city were used.

The purpose of this study was to examine characteristics, resources and current protocols for hypoglycemia presentations across Canadian EDs, where care is transferable and universal for patients, and to describe the sociodemographic profile, investigations, management and outcomes of patients with diabetes presenting to EDs across Canada with hypoglycemia.

## Methods

### Study design

This medical record review study involved 11 adult community and teaching medical centres across 5 provinces in Canada between January 1, 2008, and December 31, 2010.

### Study setting

The study involved 11 ED sites in British Columbia (1 site), Alberta (2 sites), Ontario (6 sites), Quebec (1 site) and Nova Scotia (1 site). All sites were members of the Canadian Association of Emergency Physicians (CAEP) Research Consortium (RC) network, and represented both English and French language sites. One site gathered data from a pediatric ED, which was not included in this analysis; 2 sites from the same city were merged to represent 1 site. Research teams conducting the chart reviews at each site were composed of nurses, medical students and physicians. On average, these sites saw more than 60 000 patients a year.

## Definitions

### Hypoglycemia

The definition of hypoglycemia was based on the consensus recommendation of the Canadian Diabetes Association (9). Each team was trained using this formal diagnosis of hypoglycemia (2).

### Type 1 diabetes vs. type 2 diabetes

Individual emergency or consulting physicians' diagnosis was used to designate type 1 diabetes or 2 diabetes. If no designation was recorded in the chart, we assumed that patients receiving insulin only or with diabetes since childhood had type 1 disease. "Adult onset" and adults receiving 1 or more oral antihyperglycemic agents alone, in combination with insulin or insulin alone were assumed to have type 2 diabetes. In addition to a diagnosis of diabetes, the presentation must have had 1) a documented prehospital or ED glucose value (serum or capillary)  $\leq 3.9$  mmol/L, and 2) charted physician discharge diagnosis of hypoglycemia. A retrospective diagnostic approach was also used to confirm the diagnosis.

### Chart access

All sites conducted a search of their electronic medical records system for patients more than 17 years of age, presenting to the ED with a primary or secondary diagnosis of hypoglycemia. Specific ICD-10 codes (E1063, E110, E1163, E1463) were used to conduct the search for medical records over the study period. Contrary to other studies, only cases secondary to diabetes were included in this chart review (8).

### Inclusion/exclusion criteria

Hypoglycemia patients (first episode or recurrent paroxysmal) seen by an ED physician between 2008 and 2010 were included. Only the most recent visit was included for patients with multiple ED visits for hypoglycemia during the data collection period. Patients were excluded based on the following criteria: having no history of diabetes; recorded blood sugar levels  $> 3.9$  mmol/L; unclear physician diagnosis; symptoms of hypoglycemia clearly related to an existing comorbidity and not due to diabetes (e.g. presented in a nonhypoglycemic coma; directly admitted to hospital without being seen by an ED physician, or left without being seen by an ED physician or being treated in the ED).

### Data collection

Study data were abstracted from the ED records onto study-specific case report forms at all sites. All adult charts corresponded to patients who presented to participating EDs between 2008 and 2010. The study coordinator verified the accuracy of all data by reviewing copies of original health records (e.g. ED physician and nursing notes, discharge summaries and investigations) submitted from each site. The information recorded reflects the following categories: patient demographics and medical history; emergency medical services (EMS) and ED management, and patient disposition and final diagnosis. The first 5 case report forms from each site were approved by the national training site before additional cases could be reviewed. Data not present in the medical record were recorded as "not documented."

### Sample size

Overall, a goal of 100 charts per site for 11 adult EDs (1 ED having used 2 sites) were reviewed, with an achieved total of 1039 hypoglycemia patient charts. It was expected that this number of charts

would permit narrow confidence intervals ( $\pm 1\%$ ) around the primary outcomes (e.g. proportion of EMS arrivals, admissions) for the overall sample and provide reasonable confidence intervals ( $\pm 5\%$ ) around the site data. Moreover, it provided a balance of sites contributing to the overall epidemiology of hypoglycemia in Canada.

### Statistical analysis

Descriptive analyses included proportions for categorical variables and mean and standard deviation or median with interquartile range (IQR [25th and 75th percentiles]) for continuous variables. Bivariable analyses were performed using chi-square and Fisher's exact tests or *t* test and Mann-Whitney *U* test, where appropriate. Data analyses were performed using Stata Statistical Software, release 11.0 (Stata Corporation, College Station, Texas, US).

### Ethics

All sites obtained Research Ethics Board approval. Owing to the retrospective nature of the study and lack of inclusion of any patient identifiers, informed consent was not required from subjects. Physicians were unaware of the study at the time of the patient encounter.

## Results

### Sample

A total of 1039 adult patient charts were included in this study. There was a total of 550 exclusions from all sites, the most common reason (311; 56.5%) being the absence of documented blood glucose levels  $\leq 3.9$  at any time during the patient's acute healthcare (Figure 1). The remaining exclusions were due to the insensitive nature of the searches at one of the sites.

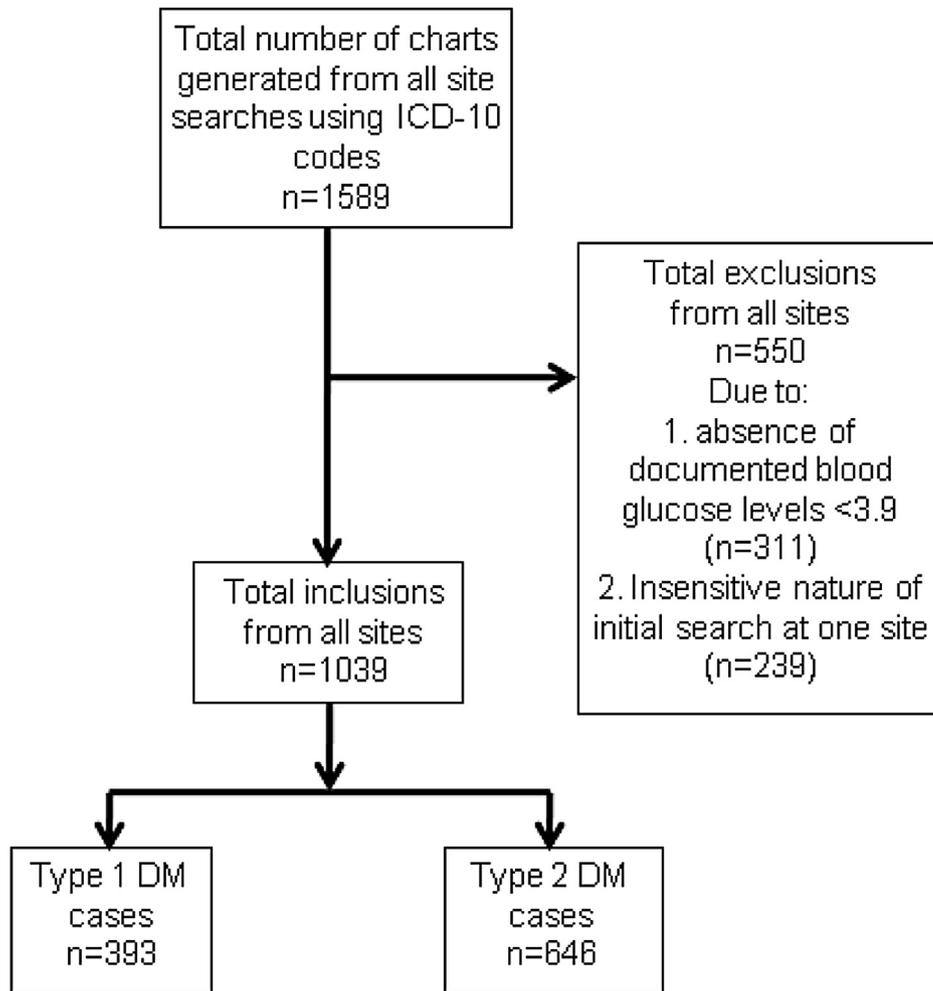
### Patient demographics

Of the 1039 adult patients included in this analysis, 579 (55.7%) were male; the median age was 68 years (IQR, 51–79). Overall, 899 subjects (86.5%) had a documented family physician. The vast majority of subjects (84.4%) required EMS transport to the hospital (Table 1).

### Patient comorbidities

Adult patients presented with a variety of comorbidities; subjects with type 2 vs. type 1 diabetes had a more frequently documented history of hypertension (75.4% vs. 43.5%;  $p < 0.001$ ), hyperlipidemia (52.2% vs. 26.8%;  $p < 0.001$ ), ischemic heart disease (36.6% vs. 18.4%;  $p < 0.001$ ) and peripheral vascular disease (15.6% vs. 5.5%;  $p < 0.001$ ) (Table 1).

Overall, approximately 94% of patients had documentation of their diabetes medication on the charts, the EMS records or the nursing notes (Table 2). Among all subjects with type 2 diabetes who were receiving medications for diabetes, 47.2% ( $n=299$ ) were only receiving non-insulin antihyperglycemic agents, 22.4% ( $n=142$ ) were receiving antihyperglycemic agents and insulin and 30.4% ( $n=193$ ) were receiving only insulin. The most common antihyperglycemic agent in patients with type 2 diabetes was metformin (75.9%), followed by the sulfonylureas (62.7%). Thiazolidinedione agents were reportedly used for 8.5% of patients, and the DPP4 inhibitors for less than 1% (Table 2). Hypoglycemia events were rare among patients with type 2 diabetes who were only receiving metformin (6.6%) or thiazolidinediones (0.3%). Hypoglycemia events were also rare among patients with type 2 diabetes



**Figure 1.** Canadian Association of Emergency Physicians Research Consortium hypoglycemia study flow. ICD-10, International Classification of Diseases, 10th revision; DM, diabetes mellitus.

who were receiving the combination of metformin and thiazolidinediones (0.4%).

#### Hypoglycemia presentation

Overall, approximately 31% of patients had a home reading of glucose demonstrating hypoglycemia. Of the patients transported by ambulance, 83.1% had a minimum of 1 glucose meter reading recorded at some time during care. In the ED, 98.2% of patients had a first glucose meter reading  $\leq 3.9$  mmol/L, and at discharge, glucose meter readings were above this level in all patients. The reason for presentation was most commonly hypoglycemia (68.0%) or decreased level of consciousness (12.3%). Other causes, including associated seizure (7.1%) and motor vehicle collision (1.5%), were less common. Unknown or nonspecific reasons (e.g. symptomatic [weakness, diaphoresis], behavioural [aggressiveness, confusion]) were documented in 33.3% of cases (Table 2). At presentation, most patients were afebrile with a normal pulse and respiratory rate and normal blood pressure (Table 3).

#### Emergency medical services interventions

In general, 75.7% of EMS calls recorded an intervention to treat the hypoglycemia; 52.2% received an intravenous line, 38.5% received intravenous glucose of approximately 50 cc 50% dextrose in water, oxygen was applied in 51.8% of cases and a small

percentage of patients required intubation (0.6%) (Table 3). Other treatments were documented in 67.2% of cases, and the most common other treatment was glucagon administration (40.1%).

#### ED management

At presentation to the ED, 39.3% of patients had a Canadian Triage Acuity Scale (CTAS) score of 1 or 2 (Table 3). The CTAS 1 and 2 patients were placed in a bed rapidly (20 minutes; IQR, 8–56.9 minutes) and seen by a physician within an hour (Table 3). Intravenous access was most commonly established or continued in the majority of patients. Emergency department hypoglycemia treatments included food or juice administration (76.8%), an intravenous glucose bolus (29.6%) or a continuous glucose infusion (27.7%); fewer than 1% of patients received glucagon. Oxygen was administered to 12.4% of patients and airway management, including noninvasive ventilation (0.2%) and intubation (1.1%), were rare.

#### ED investigations

Patients in the ED with hypoglycemia received a variety of laboratory investigations, including electrolytes (81.9%), complete blood count (81.4%), urinalysis (34.2%), cardiac enzymes (32.8%), venous blood gas (9.4%) and arterial blood gas (4.3%); serum testing was ordered more often in subjects with type 2 diabetes compared

**Table 1**

Demographics of 1039 patients with severe hypoglycemia severe hypoglycemia presenting to 10 Canadian emergency departments

Factor	All patients (n=1039)	Type 1 DM (n=347 [33.4%])	Type 2 DM (n=692 [66.6%])	p value
<b>Demographics</b>				
Male	579 (55.7)	207 (59.6)	372 (53.8)	0.071
Age, years	68 (51, 79)	49 (33, 67)	73 (62, 81)	<0.0001
Family physician documented	899 (86.5)	291 (84.1)	608 (87.2)	0.094
Active PHC number	1006 (96.8)	337 (97.1)	669 (96.7)	0.702
<b>Transportation</b>				
Arrival mode				0.670
Emergency medical services	877 (84.4)	288 (83.0)	589 (85.1)	
Self	159 (15.3)	58 (16.7)	101 (14.6)	
Not documented	3 (0.3)	1 (0.3)	2 (0.3)	
<b>Comorbidities</b>				
Hyperlipidemia	454 (43.7)	93 (26.8)	361 (52.2)	<0.001
Hypertension	673 (64.8)	151 (43.5)	522 (75.4)	<0.001
Ischemic heart disease	317 (30.5)	64 (18.4)	253 (36.6)	<0.001
Chronic renal failure	177 (17.0)	55 (15.8)	122 (17.6)	0.490
Peripheral vascular disease	127 (12.2)	19 (5.5)	108 (15.6)	<0.001
Asthma/COPD	132 (12.7)	28 (8.0)	104 (15.0)	0.002
Depression	102 (9.8)	36 (10.4)	66 (9.5)	0.225
Other	653 (62.8)	175 (50.4)	478 (69.1)	<0.001

COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; PHC, Provincial Health Care.

Values are n (%) or median (interquartile range).

with type 1 diabetes (Table 4). Although glycated hemoglobin was ordered infrequently (7.7%), it was more often ordered for patients with type 2 diabetes (8.8%) than type 1 diabetes (4.9%,  $p=0.024$ ). Electrocardiograms were obtained for 51.9% of the presentations and were ordered more commonly for type 2 diabetes (58.7%) than for type 1 diabetes (38.6%,  $p<0.001$ ). The most common radiograph investigation was chest radiography (37.6%); other advanced procedures, including computed tomography (most commonly of

the head), occurred in 14.5% of cases. Simple and advanced imaging was more frequent for patients with type 2 diabetes than for patients with type 1 diabetes.

#### Outcomes

Injuries occurred in 9.1% of cases, with the majority of these patients having a contusion or abrasion (56%) or laceration (24%)

**Table 2**

Treatment regimens, reasons for presentation and blood sugar documentation of patients with severe hypoglycemia presenting to 10 Canadian emergency departments

Factor	All patients (n=1039)	Type 1 DM (n=393)	Type 2 DM (n=646)	p value
<b>Diabetes medications</b>				
If yes, insulin	994 (95.7)	383 (97.4)	611 (94.6)	0.023
Short-acting	682 (65.6)	393 (100)	289 (44.7)	<0.001
Intermediate	355	224	131	
Long-acting	211	122	89	
Premix	151	105	46	
Premix	138	66	72	
If yes, oral hypoglycemics	469 (45.1)	46 (11.7)	423 (65.5)	<0.001
Metformin	356	32	324	
Sulfonylureas	294	12	282	
Glyburide	228	9	219	
Glicazide	62	3	59	
Other	6	0	6 (5.3)	
Thiazolidinedione	40	2	38	
Rosiglitazone	20	0	20	
Pioglitazone	20	2	18	
DPP4 inhibitor	3		2	
Sitagliptin	3		2	
<b>Hypoglycemia documentation</b>				
Glucose meter readings documented	1037 (99.8)	392 (99.7)	645 (99.8)	0.722
If yes, at home	320 (30.8)	133 (34.5)	187 (29.2)	
Home reading	2.5 (1.8, 3.3)	2.2 (1.6, 3.4)	2.7 (2.0, 3.3)	
If yes, by EMS	864 (83.1)	332 (84.7)	532 (82.5)	
EMS reading	2.3 (1.6, 3.4)	2.3 (1.6, 3.6)	2.3 (1.6, 3.3)	
If yes, in the ED	1018 (98.2)	388 (98.9)	630 (97.7)	
First ED reading	5.7 (3.5, 8.4)	6.2 (3.9, 8.8)	5.5 (3.4, 8.2)	
First normal ED reading	6.4 (5.2, 7.8)	6.6 (5.2, 8.1)	6.3 (5.2, 7.7)	
Last ED reading	8.9 (6.3, 12.2)	10.0 (7.2, 14.3)	8.3 (6.1, 11.5)	
<b>Reason for presentation*</b>				
Coma	128 (12.3)	49 (12.5)	79 (12.2)	0.917
Hypoglycemia alone	707 (68.0)	277 (70.5)	430 (66.6)	0.213
MVC	16 (1.5)	11 (2.8)	5 (0.8)	0.010
If MVC, drivers	14	11	3	
Associated seizure	74 (7.1)	43 (10.9)	31 (4.8)	<0.001
Other	357 (33.3)	122 (31.0)	235 (36.5)	0.073

DM, diabetes mellitus; ED, emergency department; EMS, emergency medical services; MVC, motor vehicle collision.

Values are n (%) or median (interquartile range).

\* Because of multiple complaints, number exceeds total number of all patients.

**Table 3**  
Prehospital and emergency department treatment of 1039 patients with severe hypoglycemia presenting to 10 Canadian emergency departments

Factor	All patients (n=1039)	Type 1 DM (n=393)	Type 2 DM (n=646)	p value
<b>EMS interventions</b>				
Hypoglycemia interventions	787 (75.7)	307 (78.1)	480 (74.3)	0.379
IV established	411 (52.2)	172 (56.0)	239 (49.8)	
If not established, no. attempts	0 (0, 2)	0 (0, 2)	0 (0, 2)	
IV glucose	303 (38.5)	126 (32.1)	177 (36.9)	
If yes, number cc D <sub>50</sub> W	50 (25, 50)	50 (25, 50)	50 (50, 50)	
Oxygen	408 (51.8)	157 (51.1)	251 (52.3)	
If yes, number L/min	10 (4, 12)	10 (4, 12)	10 (4, 12)	
Intubated	5 (0.6)	2 (0.6)	3 (0.6)	
IV fluids	224 (28.5)	102 (33.2)	122 (25.4)	
Other treatments	529 (67.2)	197 (64.2)	332 (69.2)	
Most common other treatment*	212 (40.1)	86 (43.6)	126 (37.9)	
<b>ED vital signs</b>				
Respiratory rate/min	18 (16, 20)	18 (16, 20)	18 (16, 19)	0.570
Pulse rate/min	80 (69, 91)	82 (71, 94)	78 (68, 89)	0.002
Temperature, °C	36.4 (36, 36.7)	36.4 (36.0, 36.7)	36.4 (36.0, 36.7)	0.339
Systolic blood pressure, mm Hg	139 (121, 157)	136 (121, 153)	140 (120, 159)	0.075
Diastolic blood pressure, mm Hg	75 (65, 84)	77 (68, 87)	73 (63, 83)	<0.001
Oxygen saturation by pulse, %	98 (96, 99)	98 (97, 100)	98 (96, 99)	<0.001
On room air	782 (75.3)	289 (73.5)	493 (76.3)	0.748
<b>CTAS score</b>				
1 and 2	408 (39.3)	152 (38.7)	256 (39.6)	0.786
3	573 (55.1)	220 (64.9)	353 (54.6)	
4	52 (5.0)	19 (5.6)	33 (5.1)	
Not documented	6 (0.6)	2 (0.6)	4 (0.6)	
<b>ED time metrics, minutes</b>				
From triage to bed placement	20.0 (8.0, 56.9)	17.0 (6.0, 43.2)	24.0 (9.9, 63.9)	<0.001
From triage to seeing physician	62.0 (31.9, 126.0)	54.0 (24.9, 114.0)	65.9 (38.9, 132.9)	0.002
<b>ED hypoglycemia interventions</b>				
Hypoglycemia interventions	896 (86.2)	325 (82.7)	571 (88.4)	0.001
IV established	505	167	338	
If not established, no. attempts	1 (1, 2)	2 (1, 4)	1 (1, 2)	
EMS IV continued in ED	306	115	191	
Food or juice given	688	252	436	
IV glucose bolus	265	91	174	
IV glucose infusion	248	57	191	
Glucagon	7	3	4	
Other	101	34	67	
Oxygen	111	32	79	
NIV/CPAP	2	1	1	
Intubated	10	3	7	
Associated injuries	94 (9.1)	38 (9.7)	56 (8.7)	0.577
Abrasion/contusion	53	18	35	
Laceration	23	11	12	
Other	20	9	11	
Fracture	6	2	4	
Dislocation	2	2	0	

CTAS, Canadian Triage and Acuity Scale; D<sub>50</sub> W, 50% dextrose in water; DM, diabetes mellitus; ED, emergency department; EMS, emergency medical services; IV, intravenous; NIV/CPAP, noninvasive ventilation/continuous positive airway pressure.

Values are n (%) or median (interquartile range).

\* Glucagon.

(Table 3). Of patients who had injuries, fractures were found in 6% and dislocations in 2%.

The majority of patients with hypoglycemia seen in the ED were discharged (73.5%) (Table 5) after a length of stay of 4.8 hours (IQR, 3.1–8.0 hours). Of cases that required admission, more patients with type 2 diabetes than with type 1 diabetes were admitted to the hospital (30.3% vs. 8.9%, respectively;  $p=0.001$ ). A small percentage (2.9%) left against medical advice. General internal medicine was the most frequently consulted inpatient service (67.6%), with the remainder distributed among other services (32.8%). Specialty consultations included endocrinology (10.3%), neurology (3.5%) and nephrology (5.3%). Consultations were higher for the type 2 diabetes cases than for type 1 diabetes (39.0% vs. 19.9%, respectively;  $p<0.001$ ) (Table 4).

Of diabetes patients admitted to hospital, 95.4% were admitted under a medical service, with 67.2% to general medicine and 7.9% to family medicine. Occasionally, other services admitted these patients; however, there were no documented admissions to an endocrinology service. Median times in ED for admitted patients were prolonged for both groups, varied across sites (16 hours; IQR, 9.2–22.5 hours) and

did not differ between diabetes types ( $p=0.0152$ ). Overall, 4 patients (1.7%) required admission to a surgical service, 7 (2.9%) went to an intensive care unit and 2 died (0.2%) (Table 5).

#### Post-ED follow up

There was some documentation of discharge instructions in 55.5% of cases (Table 5); however, this was more complete for type 1 diabetes subjects than for type 2 (63.4% vs. 51.6%, respectively;  $p<0.001$ ). Discharge instructions included action plan discussion (50.6%), medication change (47.3%), referral to primary care physician (49%) and dietary advice (30.9%). Referral to other types of services, apart from primary care, occurred in fewer than 20% of the cases.

#### Discussion

This study reviewed more 1000 patient encounters in 11 adult EDs across Canada and, combined with data from the site survey,

**Table 4**

Emergency department management of diabetic patients with severe hypoglycemia presenting to 10 Canadian emergency departments

Emergency department investigations	All patients (n=1039)	Type 1 DM (n=393)	Type 2 DM (n=646)	p value
Chest radiograph	391 (37.6)	104 (26.5)	287 (44.4)	<0.001
Other plain radiography	71 (6.8)	19 (4.8)	52 (8.0)	0.046
Limbs	15	4	11	
Spine	8	2	6	
Pelvis	5	2	3	
Other	40	9	31	
Electrocardiogram	540 (51.9)	157 (39.9)	383 (59.3)	<0.001
Arterial blood gas	48 (4.6)	17 (4.3)	31 (4.8)	0.725
Venous blood gas	98 (9.4)	41 (10.4)	57 (8.8)	0.261
pH	7.3 (7.3, 7.4)	7.4 (7.3, 7.4)	7.3 (7.3, 7.4)	
PacO <sub>2</sub>	46 (40, 52)	45 (41, 52)	47 (39, 52)	
Pao <sub>2</sub>	45.4 (28.2, 61.7)	44 (28.5, 60.4)	47.2 (27, 62.5)	
Hco <sub>3</sub>	25.7 (22.3, 28.0)	25.2 (22.3, 27.0)	25.9 (22.5, 28.0)	
Electrolytes	851 (81.9)	288 (73.3)	563 (87.1)	<0.001
Sodium, mmol/L	138 (136, 141)	139 (136, 141)	138 (135, 141)	
Potassium, mmol/L	4.1 (3.7, 4.6)	4 (3.7, 4.4)	4.2 (3.8, 4.6)	
Chloride, mmol/L	103 (100, 106)	103 (100, 105)	103 (99, 106)	
Bicarbonate, mmol/L	26 (23, 28)	26 (24, 27)	26 (23, 28)	
Urea, mmol/L	7.6 (5.2, 12.5)	6.7 (4.7, 10.7)	8.4 (5.7, 13.3)	
Creatinine, mmol/L	97 (72, 141)	89 (69, 137)	100 (73, 146)	
Creatinine clearance, mL/min	60 (45, 73)	60 (49, 88)	60 (44, 71)	
Complete blood count	846 (81.4)	286 (72.9)	560 (86.8)	<0.001
Urinalysis	355 (34.2)	99 (25.2)	256 (39.6)	<0.001
Brain natriuretic peptide, pg/mL	2 (0.2)	0 (0)	2 (0.3)	
Troponin	341 (32.8)	90 (22.9)	251 (38.8)	<0.001
Glycated hemoglobin	78 (7.7)	22 (5.6)	56 (8.7)	0.069
Computed tomography	164 (15.8)	47 (11.9)	117 (18.1)	0.008
Most common location, head	151	43	108	
Ultrasonography	22 (2.1)	6 (1.5)	16 (2.5)	0.302
Most common, abdomen	9	3	6	
Cultures of body fluids	189 (18.2)	46 (11.7)	143 (22.1)	<0.001
Most common, urine	128	25	103	
Consultations	339 (32.6)	81 (20.6)	258 (39.9)	<0.001
General medicine	208	42	166	
Endocrinology	35	11	24	
Nephrology	18	5	13	
Neurology	12	5	7	
Other services	114	30	84	

DM, diabetes mellitus.

Values are n (%) or median (interquartile range).

demonstrated variability in presentations, treatment and outcomes across sites and between the different types of diabetes. Average CTAS scores of 1 or 2 and EMS transfers suggest severe presentation by these patients. The results indicate that hypoglycemic episodes with type 2 diabetes outnumbered those with type 1 diabetes 2:1 and that distinct differences existed between the 2 groups, despite the known difficulty in defining the populations. Patients with type 2 diabetes received more investigations and required more interventions while in the ED and more frequently required admission to the hospital. Those findings could be related to more advanced age, comorbid conditions (potential confounders) or more prolonged hypoglycemia related to insulin secretagogues. Our results suggest that diagnostic and treatment approaches differed for both groups, possibly contributing to the impressive use of resources, costs and number of bed-days associated with episodes of hypoglycemia in patients with type 2 diabetes.

Surprisingly, many aspects of presentation and treatment for hypoglycemia in diabetes were similar across types. Sex distribution, linkage with primary care providers, the severity of presentation, mode of arrival, initial vital signs, documentation and recording of blood glucose results and reasons for presentation were comparable between groups, as were treatments, which commonly involved intravenous glucose administration, both in the EMS setting and in the ED; and it was rare for either group to require airway intervention, such as noninvasive ventilation or intubation. Administration of glucagon by EMS could have explained its low use in the ED.

Differences in disposition for patients with type 1 diabetes and type 2 diabetes presenting to the ED with hypoglycemia existed. Patients with type 1 diabetes were more frequently discharged than patients with type 2 diabetes. The majority of subjects with either type of diabetes who were admitted to medical wards and were served by generalist physicians, such as general internal medicine, family medicine and hospitalists, and the injuries associated with the hypoglycemia episode and the primary and secondary diagnoses were also similar between the 2 groups. Finally, the overlap among the list of causes attributed to the hypoglycemia between the 2 groups suggests that focussing on interventions at discharge may be effective in reducing future events.

Previous research in this field is limited; moreover, it is relatively poor quality, old or conducted only in the United States. There has been 1 Canadian study of hypoglycemia presentations to EDs published in the medical literature (7). In that single-centre study, charts of 137 patients presenting to Kingston hospital EDs between January 1, 1995, and March 31, 1997, were reviewed. Most were persons with type 1 diabetes (although that was unclear), and the focus was on tight vs. other types of insulin control. That study, while interesting, does not have direct relevance to the current national picture in which type 2 diabetes cases predominate.

There are also several US studies, including a multicentred chart review (8). In that study, the researchers completed a 1-year chart review on consecutive hypoglycemia cases identified using ICD-9-CM codes. Overall, 636 charts were reviewed of patients with possible hypoglycemia from 3 centres within 1 city, of which

**Table 5**  
Outcomes of 1025 patients with severe hypoglycemia presenting to 10 Canadian emergency departments

Factor	All patients (n=1039)	Type 1 DM (n=393)	Type 2 DM (n=646)	p value
Disposition				
Left against medical advice	31 (2.9)	15 (3.8)	16 (2.5)	0.218
Discharged	764 (73.5)	338 (86.0)	426 (65.9)	<0.001
ED LOS, discharged patients, hours	4.8 (3.1, 8.0)	4.4 (2.8, 6.9)	5.1 (3.5, 8.9)	<0.001
Admitted	241 (23.2)	39 (9.9)	202 (31.3)	<0.001
ED LOS, admitted patients, hours	16.0 (9.2, 22.5)	15.3 (8.7, 29.8)	16.3 (9.4, 25.9)	0.830
Deceased	2 (0.2)	0 (0)	2 (0.3)	
Transferred	1 (0.1)	1 (0.2)	0 (0)	
If admitted, location				
Medical ward	230 (95.4)	39 (100)	191 (94.5)	
Surgical ward	4 (1.7)	0 (0)	4 (1.9)	
Intensive care unit	7 (2.9)	0 (0)	7 (3.5)	
If admitted, admitting service				
General medicine	162 (67.2)	25 (64.1)	137 (67.8)	
Family medicine	19 (7.9)	2 (5.1)	17 (8.4)	
General surgery	1 (0.4)	0 (0)	1 (0.5)	
Pediatrics	0 (0)	0 (0)	0 (0)	
Endocrinology	0 (0)	0 (0)	0 (0)	
Other	59 (24.5)	12 (30.8)	47 (23.3)	
Likely precipitant				
Missed meal/poor nutrition	458 (44.1)	148 (37.6)	310 (47.9)	
Nausea/vomiting/diarrhea illness	130 (12.5)	41 (10.4)	89 (13.8)	
Increased activity	55 (5.3)	28 (7.1)	27 (4.2)	
Error, insulin/OAG agent dose	186 (17.9)	64 (18.9)	122 (18.9)	
Alcohol intake	57 (5.5)	33 (8.4)	24 (3.7)	
Illicit drug use	8 (0.8)	5 (1.3)	3 (0.5)	
Other	435 (41.9)	162 (41.2)	273 (42.3)	
ED diagnosis of hypoglycemia				
Primary ED diagnosis	931 (89.6)	367 (93.4)	564 (87.3)	0.002
Secondary ED diagnosis	74 (7.1)	20 (5.1)	54 (8.4)	0.047
Discharge instructions given	577 (55.5)	250 (63.6)	327 (50.6)	<0.001
Medication changes	269	100	169	
Dietary advice	176	70	106	
Action plan discussed	288	125	163	
Referral to endocrinologist	73	39	34	
Referral to general internist	16	5	11	
Referral for diabetes education	50	25	25	
Referral to primary care physician	279	94	185	
Referral to other services	99	45	54	

DM, diabetes mellitus; ED, emergency department; LOS, length of stay; OAG, oral antidiabetic. Values are n (%) or median (interquartile range).

436 hypoglycemia cases (64%) were confirmed. The main limitation of that study is generalizability; although 3 centres were used, they only represent 1 city. In another study looking at hospitalizations in older adults, Budnitz et al (10) analyzed data of 5077 cases taken from the adverse event data from the National Electronic Injury Surveillance System—Cooperative Adverse Drug Event Surveillance project (2007 through 2009) that indicated hypoglycemia was the second most common cause of emergency hospitalizations for adverse drug events among older Americans. The investigators concluded that hospitalizations could be reduced with improved drug management.

Future studies of hypoglycemia in diabetes will need to include a number of large-volume EDs with a focus on educational activities concerning the treatment of extreme glucose levels that target generalists (e.g. emergency physicians, family physicians, hospitalists or general internal medicine specialists).

#### Study limitations

This study has several limitations that require discussion. First, there are inherent limitations to medical record reviews (11). For example, missing data (<10% of the study sample), poor documentation and variability in clinical care limit the validity of these results; however, we employed valid methods to reduce these biases (e.g. we considered multiple sources of ED information, EMS notes, triage notes, nursing notes, emergency physician notes and consults, in an effort to minimize the effect of poor documentation). In

addition, during the training sessions aspects related to site particularities (e.g. variations among ED chart recording) were addressed.

Second, the use of medical research and teaching centres will not allow the study results to be extrapolated to community centres. The pool of available EDs to conduct research in Canada is not large, and this requirement excluded nonteaching sites. The participating sites are the leading ED research sites in Canada affiliated with a Canadian network of ED researchers, and likely represent the best-case scenario for the estimation of variability.

Third, each site presented unique requests for this national study. The Research Ethics Board for 1 site required that the age be 18 years or older, as 17 year olds were considered to be pediatric and would require a separate ethics application. The protocol for this site was amended to reflect the requirements of the board.

Fourth, original medical charts were the primary sources used at all sites. However, coding issues arose across all sites, suggesting appropriate medical charts may have been missed. Moreover, to avoid overrepresentation of demographic data by certain patients, only the most recent visit was included. In addition, it is known that these cases do not represent all hypoglycemic episodes for which care was accessed. For example, hypoglycemia cases may be attended by EMS, but not transported owing to improvement. Moreover, resolution may occur before contacting EMS, and cases may present after the fact to other locations, such as a family physicians office, ambulatory clinic or even an ED. Once again, these cases likely represent the most severe cases of persistent hypoglycemia.

Fifth, we recognize there is no widely accepted, universal or perfect method to differentiate between type 1 diabetes and type 2 diabetes. We used an accepted approach from the literature, engaged endocrinology consultants as collaborators and relied heavily on diagnosis of the physicians treating the patient in the ED. Despite any misclassification that may have occurred, the groups were defined a priori and demonstrated clear clinical differentiation.

Finally, these results are not population based, none of the EDs represents all of the cases in a confined area. Once again, this level of detail would not be possible on a population-based level; however, the diagnosis of hypoglycemia is often erroneous and administrative data analysis could provide misleading results.

#### Study strengths

This study has used accepted high-quality survey and chart review methods (11), examined academic EDs with trained research staff and employed a standard, sensible data collection form. The large number of patients enrolled and the cross-province nature of the sites make for a more generalizable sample of cases with severe hypoglycemia.

#### Conclusion

This study demonstrated heavy resource use, practice variation and differences in outcome across Canadian EDs in the management of hypoglycemia in patients with type 1 diabetes and 2 diabetes. Type 2 diabetes patients were older, reported more comorbid diseases and received different medications. Similarities in presentation between the 2 groups of patients with diabetes may provide a rationale for standardized approaches for prehospital care providers (e.g. EMS) and ED personnel that could serve to standardize and improve the accuracy and effectiveness of care delivery. Type 2 diabetes patients received more investigations and required more consultations and admissions. The existence of practice variation within and among EDs and their EMS providers suggests standardization of care could be accomplished through the use of clinical practice guidelines.

Finally, even when discharged, this study concurs with previous US-based ED research that suggests discharge planning could be improved and standardized (8). Despite its low frequency of presentation, the high costs associated with hypoglycemia (investigations, prolonged length of stay and frequent need for admission) also highlight the importance of appropriate education of both healthcare professionals and patients with diabetes on ways of minimizing the risk of hypoglycemia. Finally, EDs should place greater emphasis on the development of hypoglycemia management protocols or algorithms to address this problem.

#### Acknowledgements

Data from this study were presented at the Canadian Association of Emergency Physicians (CAEP) Annual Scientific Meeting, St. John's, Newfoundland, Canada; June 4–8, 2011. The authors thank Ms. Nahal Nasser and Mr. Ilias Iliopoulos (Merck Canada) for their support during this project, and Ms. Lisa Ludwig, MBA (Merck Canada) for her initial efforts to link the CAEP Research Consortium with Merck Canada. The authors thank the site data coordinators (in alphabetical order): Ms. Antoinette Colacone (Montreal Jewish General Hospital, Montreal, PQ); Ms. Cathy Clement (Ottawa Hospital Research Institute, Ottawa, ON); Ms. Corinne DeMone (Queen Elizabeth II Health Sciences Centre, Halifax, NS); Ms. Deborah Emerton (Queen's University, Kingston, ON); Dr. Iraj Poureslami (St. Paul's Hospital, Vancouver, BC); Ms. Renee Vilneff (University of Calgary, Calgary, AB), and Ms. Shelley McLeod (University of

Western Ontario, London, ON). The authors also thank Ms. Lindsay Lovstrom and Ms. Stephanie Couperthwaite for data entry, Mrs. Janelle Ostby for secretarial support and Ms. Vera Klein (Executive Director, Canadian Association of Emergency Physicians) for assistance with study administration.

#### Author Disclosures

The development of this study was made possible through the support of Merck Frosst Canada Ltd, who had no input in the manuscript or choice of journal. None of the emergency medicine authors are paid consultants of the sponsor or of CAEP. Dr. Rowe is supported by the Canadian Institutes of Health Research (CIHR) as a Tier I Canada Research Chair in Evidence-based Emergency Medicine through the Government of Canada (Ottawa, ON). Ms. Singh was supported by the Office of Research, Faculty of Medicine and Dentistry, at the University of Alberta. Dr. Villa-Roel is supported by CIHR in partnership with the Knowledge Translation Branch. Dr. Lang's research is supported by Alberta Health Services. Dr. Stiell is a Distinguished Professor and University Health Research Chair of the University of Ottawa. At the time of the study, Drs. Rowe and Sivilotti were paid senior associate editors for CAEP's scientific journal, *Canadian Journal of Emergency Medicine*. Dr. Rowe has received research funding from GSK and Merck, provided Continuing Medical Education (CME) on behalf of AstraZeneca and GSK, and served on an advisory board for Novartis. Dr. Lawrence Leiter has received research funding from, has provided CME on behalf of, or has acted as a consultant to AstraZeneca, BMS, BI, Eli Lilly, Merck, Novartis, Novo Nordisk, Sanofi and Servier. Dr. Vincent Woo has participated in boards, lectures and clinical trials for all of the following: Merck, Novo Nordisk, Lilly/Boehringer Ingelheim, AstraZeneca, BMS, Sanofi and Novartis. Dr. Yale has received payments for lectures and advisory boards from Sanofi, Merck, GSK, Eli Lilly, Bayer, Pfizer, Novo Nordisk, Innovia, Lifescan, Roche, Novartis, BMS, AstraZeneca, Abbott and Medtronic, and research grants from Sanofi, Pfizer, Novo Nordisk, Merck, BMS and Novartis. Dr. I. Hramiak receives research funding from AstraZeneca/Bristol Myers Squibb, Eli Lilly, Hoffmann-La Roche, GlaxoSmithKline, Janssen Ortho, Merck, Novo Nordisk, Pfizer and Sanofi-Aventis.

#### Author Contributions

The data collection, entry, analyses, interpretation and opinions were under the direct control of the study principal investigator (Dr. Rowe), his staff and CAEP Research Consortium collaborators. This study is based on data provided by medical record review from each site. The interpretations, conclusions and opinions expressed herein are those of the researchers and do not necessarily represent the views of the institutions, CAEP or the sponsor. The opinions expressed in this publication are those of the authors and do not necessarily reflect the opinions of Merck Canada Inc. or CAEP.

#### References

- Hepburn DA. Symptoms of hypoglycaemia. In: Frier BM, Fisher BM, eds. *Hypoglycaemia and diabetes: London: Clinical and physiological aspects*. 1993. p. 93–103.
- Cryer PE, Axelrod L, Grossman AB, et al. Evaluation and management of adult hypoglycemic disorders: An Endocrine Society clinical practice guideline. *J Clin Endocrinol Metab* 2009;94:709–28.
- Tanenberg RJ, Newton CA, Drake AJ. Confirmation of hypoglycemia in the "dead-in-bed" syndrome, as captured by a retrospective continuous glucose monitoring system. *Endocr Pract* 2010;16:244–8.
- Lipska KJ, Kosiborod M. Hypoglycemia and adverse outcomes: Marker or mediator? *Rev Cardiovasc Med* 2012;12:132–5.
- Leese GP, Wang J, Broomhall J, et al. Frequency of severe hypoglycemia requiring emergency treatment in type 1 and type 2 diabetes: A population-based study of health service resource use. *Diabetes Care* 2003; 26:1176–80.

6. Meinel N, of the Diabetic Hypoglycemia Editorial Team. Diabetes treatment review. The economic and patient-centered burden of diabetic hypoglycemia. *Diabetic Hypoglycemia* 2011;4:12–4.
7. Stather DR, Houlden RL. Demographics of patients with diabetes mellitus requiring emergency services for severe hypoglycemia in a Canadian community. *Can J Diabetes Care* 2012;22:22–7.
8. Ginde AA, Pallin DJ, Camargo CA. Hospitalization and discharge education of emergency department patients with hypoglycemia. *Diabetes Educ* 2008;34: 683–91.
9. Canadian Diabetes Association Clinical Practice Guidelines Expert Committee. Canadian Diabetes Association 2008 clinical practice guidelines for the prevention and management of diabetes in Canada. *Can J Diabetes* 2008; 32(Suppl):1–201.
10. Budnitz DS, Lovegrove MC, Shehab N, Richards CL. Emergency hospitalizations for adverse drug events in older Americans. *N Engl J Med* 2011;365: 2002–12.
11. Worster A, Haines T. Advanced statistics: Understanding medical record review (MRR) studies. *Acad Emerg Med* 2004;11:187–92.