

Hypoglycemia Upon Hospital Admission From Long-term Care: Health Care Resource Use

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The prevalence of diabetes, diagnosed and undiagnosed, among individuals 65 years and older in the United States was an estimated 27% in 2018.¹ In the long-term care (LTC) setting, between 25% and 34% of residents have diabetes, most commonly type 2 diabetes (T2D).^{2,3} The challenges of diabetes management in the LTC setting are numerous.^{3,4} Many LTC residents have difficulty with diabetes self-management because of cognitive and/or physical dysfunction, comorbidities, polypharmacy, and irregular meal intake.^{3,4} Residents may also be dependent for their treatment on caregivers and staff who, because of staffing challenges or other reasons, may not have sufficient resources or diabetes education to adequately monitor and report changes in clinical condition.³ Moreover, lifestyle modifications used in managing diabetes, such as regular physical activity and consistent and predictable meal intake, may be challenging to institute for some LTC residents.³

The American Diabetes Association recommends less stringent glycemic goals for older adults with multiple coexisting chronic illnesses, cognitive impairment, or functional dependence.^{4,5} Nonetheless, tight glycemic control is often reported among older adults with diabetes,⁶⁻⁸ and thus the potential for hypoglycemia in LTC settings is a concern, particularly as recognized risk factors for developing hypoglycemia, such as advanced age, polypharmacy, compromised renal function, and recent hospitalization, are observed in LTC residents.^{3,5,9,10} Moreover, prior studies found that the majority of LTC residents with diabetes were using insulin or an insulin-containing regimen,^{2,11} therapy that has been associated with an increased risk of hypoglycemia.^{2,3}

Cognitive impairment is also associated with increased risk of hypoglycemia^{5,12}; conversely, hypoglycemia is associated with worsening cognition, in addition to other adverse events, such as falls and increased cardiovascular events and mortality.^{3,13} Furthermore, the varied clinical presentations of hypoglycemia, described in detail elsewhere,^{14,15} may be difficult for LTC staff to recognize.

Hypoglycemia can lead to hospitalizations, and, in the general US older population (≥ 65 years), the rates of hospitalizations for hypoglycemia are highest among those 75 years and older,¹⁶ whereas rates of emergency department (ED) visits and hospitalizations for

ABSTRACT

OBJECTIVES: Residents with diabetes in long-term care (LTC) settings often have recognized risk factors for developing hypoglycemia, including advanced age, dementia, and polypharmacy; however, data regarding hypoglycemia in LTC and associated hospitalizations are lacking. Our aim was to describe health care resource use and costs for patients with diabetes and hypoglycemia upon hospital admission.

STUDY DESIGN: Retrospective, descriptive study using a US hospital billing database, October 2015 through September 2019.

METHODS: Eligible patients were those 18 years and older with type 1 or 2 diabetes who (1) were hospitalized with hypoglycemia upon admission from LTC or from home and (2) received insulin during hospitalization. We described the percentages of patients admitted from LTC or from home with hypoglycemia and their characteristics, length of hospitalization, and hospital costs (2019 US\$).

RESULTS: Of 106,602 patients with diabetes admitted from LTC and 4,315,571 from home, 6609 (6%) and 182,756 (4%), respectively, presented with hypoglycemia on hospital admission. Mean ages of patients admitted with hypoglycemia from LTC and home were 73 and 66 years, respectively. The percentages of patients in LTC and home cohorts with dementia were 34% and 12%, respectively; with renal disease, 60% and 52%; and with type 2 diabetes, 95% and 89%. Mean hospital stays were 8.0 days for patients admitted from LTC and 6.7 days for those admitted from home; mean total hospital costs were \$19,800 and \$16,800, respectively.

CONCLUSIONS: These findings highlight the importance of providing optimal diabetes management for patients in LTC settings to prevent hypoglycemia and potential hospitalizations and costs.

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TAKEAWAY POINTS

Treatment of older adults with diabetes in long-term care (LTC) settings is often complex, and there is potential for hospitalization with hypoglycemia.

- ▶ Of patients with diabetes who were admitted from LTC and from home, 6% and 4%, respectively, presented with hypoglycemia on hospital admission.
- ▶ Patients admitted from LTC were older and more likely to have dementia and other comorbidities.
- ▶ Mean hospital stay lengths for those admitted from LTC and home were 8.0 days and 6.7 days, respectively, and mean total costs of hospitalization were high in both cohorts (\$19,800 and \$16,800, respectively).
- ▶ An unmet need exists to highlight diabetes management in LTC given high comorbidity burdens, long hospital stays, and high costs.

insulin-related hypoglycemia and errors in insulin use are highest among those 80 years and older.¹⁷ In a 2007-2009 study, antidiabetic drugs were reported to be one of the most common categories associated with adverse drug events leading to emergency hospitalizations of adults 65 years and older.¹⁸ The authors noted that nearly all the hospitalizations involving insulins and oral hypoglycemic agents resulted from unintentional overdoses of these necessary medications. However, recent US data on the occurrence of hypoglycemia-related hospital admissions of LTC residents are lacking.²

Approximately 25% to 30% of LTC residents experienced at least 1 hospitalization in the United States in 2014, and roughly 10% to 15% experienced at least 1 potentially avoidable hospitalization.¹⁹ The aim of this retrospective, descriptive study was to describe the frequency of hypoglycemia upon hospital admission of patients with diabetes and to evaluate patient characteristics and mean and median length of stay and costs of hospitalizations for patients admitted from LTC settings or from home.

METHODS

Data Source

This study used data from October 2015 through September 2019 drawn from the Premier Healthcare Database, originating from more than 850 participating US hospitals and health care systems in geographically diverse areas, both rural and urban.^{20,21} The database contains administrative, health care, and financial information for approximately one-fourth of annual inpatient admissions in the United States. The data include information on demographics, admission and discharge diagnoses, health care payers, and billed services for determining costs associated with hospitalizations.²¹ The collection, maintenance, and use of the deidentified patient information by Premier Healthcare Database are compliant with standards of the Health Insurance Portability and Accountability Act of 1996.²²

Study Population

We included patients 18 years and older with type 1 diabetes (T1D) or T2D who were hospitalized with hypoglycemia upon admission from LTC, including skilled nursing and intermediate care

facilities, or upon admission from home, and who received intravenous or subcutaneous insulin at any time during the hospital stay. We queried the database for diagnoses of T1D and T2D, identified using *International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM)* diagnosis codes E10.XX and E11.XX, respectively. Hypoglycemia was defined by the presence of at least 1 of the following *ICD-10-CM* diagnosis codes on admission: EXX.641, EXX.649, E15, E16.0, E16.1, E16.2, T38.3X1X, T38.3X4X, or T38.3X5X. The hypoglycemia diagnosis could be primary or secondary on the list of discharge diagnoses, but the coding for “present on admission” was required for study eligibility.²³

Patients admitted from other settings, such as different hospitals or health care facilities, ambulatory surgery centers, or court or law enforcement, were excluded from the study, as were those for whom such information was not available. We also excluded patients with hypoglycemia treated in the ED but not admitted to the hospital and those who used an insulin pump during hospitalization, because insulin pump use is uncommon in the LTC setting.

Study Variables and Outcomes

We collected basic demographic data (age, sex, race, US region, payer type), together with clinical characteristics, including diabetes type (T1D or T2D) and common comorbidities (renal disease, congestive heart failure, dementia, and hepatic disease). The Charlson Comorbidity Index (CCI) score was determined as described by Quan et al²⁴ using *ICD-10-CM* diagnosis codes recorded for each patient encounter.

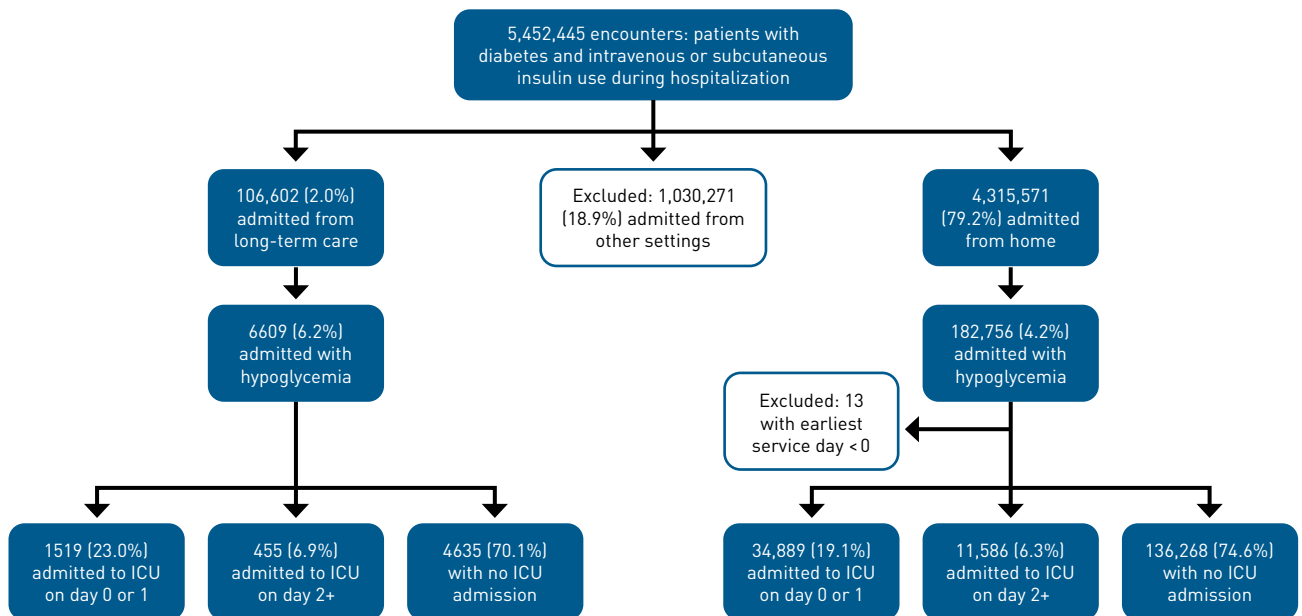
Two encounter-level patient cohorts were identified: (1) patients admitted from LTC and (2) patients admitted from home. In addition, we identified eligible patients who were admitted directly to an intensive care unit (ICU), general or specialized, from the ED (defined as day 0) or on the first day of hospitalization (defined as day 1).

The total length of hospital stay for each patient was available from the database and is detailed later. We also derived length of ICU stay, using ICU room and board charge descriptions, for those patients admitted to the ICU.

The costs related to hospitalization were determined both for all patients and separately for those admitted to the ICU as summed fixed and variable costs. As provided in the Premier database, variable costs included items billable to patients or health insurance providers related to supplies and patient care, including hospital services, medical procedures, equipment, supplies, drugs, and diagnostic evaluations such as imaging and laboratory tests.²¹ Fixed costs included those related to depreciation of equipment, management, maintenance/repair, and overhead.

Statistical Analyses

Descriptive analyses were used to define patient demographic and clinical characteristics, as well as length of hospital and ICU stays

FIGURE. Flowchart Detailing Selection of Eligible Patients With Diabetes From the Premier Healthcare Claims Database, October 2015 Through September 2019*

ICU, intensive care unit.

*The ICU could be of any type, including cardiovascular [open heart] unit, coronary care unit, or general ICU. Examples of excluded admissions from "other settings" were those from different hospitals or health care facilities, through court or law enforcement, and from settings for which information was not available.

and costs. Costs were adjusted to 2019 US\$ using the medical care component of the Consumer Price Index.²⁵ Data analyses were conducted using the SAS software package version 9.4 (SAS Institute).

RESULTS

Patients

We identified 5,452,445 encounters of patients with diabetes who received intravenous or subcutaneous insulin during a hospital stay, including 106,602 admitted from LTC and 4,315,571 from home (Figure). In total, 6,609 of 106,602 encounters (6%) were for patients who presented with a hypoglycemia diagnosis on admission from LTC, whereas 182,756 of 4,315,571 (4%) presented with a hypoglycemia diagnosis on admission from home. Of these patient encounters, 1,519 of 6,609 from LTC (23%) and 34,889 of 182,756 from home (19%) were admitted to an ICU on day 0 or day 1 of hospitalization (Figure).

The mean ages of patients with diabetes who were admitted with hypoglycemia were 73 years from LTC and 66 years from home; the percentages of women were 55% and 51% in the LTC and home cohorts, respectively (Table 1). The distributions of race, US region, and payer are described in Table 1.

The majority of patients in both cohorts had T2D, including 95% of those admitted from LTC and 89% of those admitted from home (Table 1). The percentages of patients admitted from LTC with renal

disease, congestive heart failure, and dementia were 60%, 49%, and 34%, respectively, whereas the corresponding percentages among those admitted from home were 52%, 40%, and 12%, respectively. The percentages of patients with a CCI score of 5 or greater were 66% and 58% among those admitted from LTC and from home, respectively (Table 1).

Length and Cost of Stays in Hospital and ICU

The mean hospital stays were 8.0 days for patients admitted from LTC and 6.7 days for patients admitted from home, and the median hospital stays were 6 days and 5 days, respectively. For patients admitted to the ICU on day 0 or 1, the mean ICU stays were 4.6 and 4.1 days and median ICU stays were 3 and 2 days, respectively (Table 2).

Mean total costs of hospitalization for patients admitted from LTC were \$19,800 and \$16,800 for those admitted from home. For patients admitted to the ICU on day 0 or 1 from LTC, mean total costs were \$28,100, whereas those admitted from home had mean total costs of \$26,300.

DISCUSSION

The results of this retrospective study describe the characteristics of patients with diabetes who had a hypoglycemia diagnosis upon hospital admission from LTC or from home, together with length of hospitalizations and associated costs. We observed that the

TABLE 1. Baseline Characteristics of Patients With Diabetes and Hypoglycemia Upon Hospital Admission

| | Admitted from LTC (n = 6609) | Admitted from home (n = 182,743) |
|--|------------------------------|----------------------------------|
| Female sex, n (%) | 3599 (54.5) | 93,613 (51.2) |
| Age in years | | |
| Mean (SD) | 73.3 (11.9) | 66.0 (14.9) |
| Range | 20-89 | 18-89 |
| Race, available data, n (%) ^a | | |
| White | 4556 (70.0) | 119,827 (66.7) |
| Black | 1417 (21.8) | 40,600 (22.6) |
| Other | 536 (8.2) | 19,345 (10.8) |
| US Census Bureau region, n (%) | | |
| Midwest | 1920 (29.1) | 35,708 (19.5) |
| Northeast | 1692 (25.6) | 30,070 (16.5) |
| South | 2378 (36.0) | 89,365 (48.9) |
| West | 619 (9.4) | 27,600 (15.1) |
| Payer, n (%) | | |
| Medicare | 5808 (87.9) | 129,205 (70.7) |
| Medicaid | 471 (7.1) | 22,474 (12.3) |
| Managed care | 181 (2.7) | 16,558 (9.1) |
| Self-pay, other | 149 (2.3) | 14,506 (7.9) |
| Diabetes type ^b | | |
| Type 1 diabetes | 338 (5.1) | 19,812 (10.8) |
| Type 2 diabetes | 6255 (94.6) | 162,106 (88.7) |
| CCI score | | |
| Mean (SD) | 5.5 (2.5) | 5.0 (2.6) |
| Median (range) | 6 (1-20) | 5 (1-20) |
| CCI score categorized, n (%) | | |
| 1-4 | 2254 (34.1) | 76,820 (42.0) |
| 5-8 | 3735 (56.5) | 91,713 (50.2) |
| 9-20 | 620 (9.4) | 14,210 (7.8) |
| Comorbidity, n (%) | | |
| Renal disease | 3937 (59.6) | 95,657 (52.4) |
| Congestive heart failure | 3267 (49.4) | 72,556 (39.7) |
| Dementia | 2212 (33.5) | 21,705 (11.9) |
| Moderate/severe hepatic disease | 167 (2.5) | 5090 (2.8) |

CCI, Charlson Comorbidity Index; LTC, long-term care.

^aPercentages for each race represent percentages of available race data.

^bBoth type 1 and type 2 diabetes were recorded for 16 (0.2%) and 825 (0.5%) patients in the LTC and home cohorts, respectively.

patients admitted from LTC tended to be older on average than those admitted from home. The comorbidity burdens among those admitted from LTC and home included dementia (34% and 12%, respectively), renal disease (60% and 52%), and congestive heart failure (49% and 40%). Mean hospital stays were 8.0 days for patients admitted from LTC and 6.7 days for those admitted from home, and mean total costs of hospitalization were high in both cohorts (\$19,800 and \$16,800, respectively).

Our findings highlight the burden of hospitalizations among patients with diabetes admitted with hypoglycemia from LTC settings. These findings are in line with those of other studies, although none of these earlier studies are directly comparable and few are focused on LTC. In one UK study, admissions for hypoglycemia resulted in longer hospital stays and greater costs than admissions for other causes among patients with diabetes using insulin.²⁶ In a retrospective Israeli study of patients with diabetes, episodes of severe hypoglycemia were associated with increased health care resource use and more frequent and longer hospital stays relative to the time preceding the episodes.²⁷ In Italian nursing homes, a higher prevalence of dementia and comorbidities has been recorded among residents with hypoglycemia.^{12,28} We also found that one-third of patients with hypoglycemia from LTC had dementia, whereas only 12% of those admitted from home had dementia.

Summed together, these study results point to the importance of optimizing diabetes management in LTC settings. Less stringent glycemic goals are recommended for older adults in LTC—namely, maintaining a glycated hemoglobin A_{1c} (HbA_{1c}) threshold of less than 8.5% (69 mmol/mol), when feasible, rather than the generally recommended target of HbA_{1c} less than 7% (53 mmol/mol) for younger, healthy adults.³ Practitioners should also be aware of clinical factors that can lower or raise HbA_{1c} levels. Moreover, staff and practitioner education is important.^{4,11,29} For residents requiring insulin, education should incorporate principles of good insulin injection technique, including injection site rotation, not reusing the same needle, and selection of optimal needle length, to promote consistent subcutaneous delivery and minimize risk of intramuscular injection and potential hypoglycemia.^{4,30}

The findings of this study add to the limited data regarding LTC residents with diabetes who present with hypoglycemia upon hospital admission. We included large patient cohorts from a well-maintained database that is nationally representative of the US population and includes the costs associated with hospitalization. We used diagnosis codes for diabetes to identify eligible patients and reduce the chance of including patients with other causes of hypoglycemia, such as liver failure or untreated hypothyroidism.

Limitations

We acknowledge several limitations of this study, including lack of access to prior (prehospitalization) lists of medications and clinical characteristics, including prehospitalization HbA_{1c} values. We captured insulin therapy during the hospital stay but could not confirm whether patients were receiving insulin beforehand. The reasons for ICU admissions were not available. In addition, because the database is limited to encounter data for billing during hospitalization, we do not have information about the cause of hypoglycemia and the clinical course. Hence we recognize that hypoglycemia could have been associated with a comorbidity or acute condition, such as renal or hepatic failure, that resulted in the hospital stay and associated costs. We report direct costs associated with hospitalization; other direct medical costs and any indirect costs, such as lost wages of

TABLE 2. Length and Cost of Hospital and ICU Stays for Patients With Diabetes Admitted With Hypoglycemia

| | All patients | | Patients admitted to ICU on day 0-1 | |
|---|-------------------------------|----------------------------|-------------------------------------|-------------------------------|
| | From LTC (n = 6609) | From home (n = 182,743) | From LTC (n = 1519) | From home (n = 34,889) |
| Inpatient length of stay in days | | | | |
| Mean (SD) | 8.0 (9.6) | 6.7 (8.2) | 9.3 (9.8) | 8.7 (10.2) |
| Median (IQR) | 6 (3-9) | 5 (3-8) | 7 (4-11) | 6 (3-10) |
| Range | 1-257 | 1-470 | 1-161 | 1-431 |
| ICU length of stay in days | | | | |
| Mean (SD) | - | - | 4.6 (5.2) | 4.1 (5.4) |
| Median (IQR) | - | - | 3 (2-6) | 2 (1-5) |
| Range | - | - | 1-63 | 1-163 |
| Cost of inpatient stay in 2019 US\$, mean (SD) ^a | | | | |
| Mean (SD) | \$19,830 (\$28,610) | \$16,800 (\$25,462) | \$28,129 (\$36,817) | \$26,263 (\$35,079) |
| Median (IQR) | \$12,190 (\$7014-\$22,320) | \$9858 (\$5692-\$18,623) | \$18,546 (\$10,791-\$32,776) | \$16,060 (\$8969-\$30,447) |
| Range | \$14-\$810,808 | \$29-\$2,108,354 | \$1668-\$810,808 | \$165-\$1,539,060 |

ICU, intensive care unit; IQR, interquartile range; LTC, long-term care.

^aWe excluded 246 encounters (12 from LTC [0.2%] and 234 [0.1%] from home) from cost analyses because hospital costs were recorded as \$0. Of these encounters, 5 admissions from LTC (0.3%) and 50 admissions from home (0.1%) were excluded from cost analyses for the ICU subcohorts.

family members, were not available in the database. Because the Premier data are at the encounter level rather than the patient level, a patient could be traced within the same hospital, but we had no way of determining whether patients were admitted multiple times but at different hospitals. Moreover, one patient could have multiple encounters, and this study assumes each admission is independent. Finally, the possibility of coding discrepancies is a general limitation of administrative database studies.

CONCLUSIONS

Our findings suggest that there is an unmet need to highlight awareness of risk factors for hypoglycemia, such as advanced age, comorbidities, and polypharmacy, in managing diabetes for LTC residents to prevent the occurrence of hypoglycemia and potential hospitalizations and costs. These findings further support the importance of optimizing diabetes management in the LTC setting. ■

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