Journal of Diabetes and Its Complications xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Journal of Diabetes and Its Complications

journal homepage: www.jdcjournal.com

An expanded prevention quality diabetes composite: Quantifying the burden of preventable hospitalizations for older adults with diabetes

Chin-Lin Tseng *, Orysya Soroka, Leonard M. Pogach

Department of Veterans Affairs-New Jersey Healthcare System, 385 Tremont Avenue, East Orange, NJ, United States

ARTICLE INFO

Article history:
Received 17 August 2017
Received in revised form 25 January 2018
Accepted 28 January 2018
Available online xxxx

Keywords:
Diabetes mellitus
Preventable hospitalization
Quality measurement
Surveillance
Health services research

ABSTRACT

Aim: To expand the existing United States Agency for Health Research and Quality (AHRQ) Diabetes composite (AHRQ-DC) to include additional preventable hospitalizations specific or relevant to diabetes.
Methods: A cross-sectional analysis of 834,696 veteran patients with diabetes aged ≥65 years in 2012. An Expanded Diabetes Composite (Expanded-DC) was developed utilizing: (1) the diabetes-specific category: the AHRQ-DC (short-term and long-term complications, uncontrolled diabetes, lower extremity amputations) and two proposed conditions: hypoglycemia and lower extremity ulcers/inflammation/infections (LEU) and (2) the diabetes-relevant category: the AHRQ-Acute Composite (dehydration, pneumonia, urinary tract infections) and one proposed condition, acute kidney injury (AKI).
Results: The study population was 98% male, 80% White, 10% Black, and 5% Hispanic; 71% had complex comorbidities. There were 64,243 (77.0 admissions/1000 patients) hospitalizations in the Expanded-DC, compared to 13,523 (16.2) in the AHRQ-DC, a 4.7 fold increase. Hospitalizations from AHRQ-Acute Composite and the three proposed conditions added 79% to the Expanded-DC. LEU and hypoglycemia added 39% to the diabetes-specific category. AKI added 18% to the diabetes-relevant category. Blacks incurred more preventable hospitalizations (85.9) than Whites (74.7); as did patients with complex comorbidities (93.6) versus those without (34.6).
Conclusion: The AHRQ-DC substantially underestimates rates of clinically important preventable hospitalizations in older diabetes patients.

Published by Elsevier Inc.

1. Introduction

According to the most recent National Diabetes Statistic Report, 25.2% of the United States (US) population over 65 years of age, or 12.0 million persons, have diabetes in 2015.[1] In 2012, the major cost component of diabetes care was inpatient care (43% of the total medical cost); and 64% of in-patient hospital days related to diabetes complications or general medical conditions with excess prevalence were incurred by adults 65 and older.[2] Identification of rates for preventable hospitalizations that are specific for diabetes or have excessive prevalence in patients with diabetes is therefore important for population health surveillance to assess and improve public health strategies to decrease diabetes related morbidity. Preventable hospitalizations are defined as hospital admissions for acute or worsening chronic conditions that might not have required hospitalization if they had been managed successfully in ambulatory care settings.[3]

The US Agency for Health Research and Quality (AHRQ) preventive quality indicators (PQIs) are a set of surveillance measures to identify and quantify the prevalence of preventable hospitalizations.[4] They are intended to be used as inexpensive and accessible public health screening tools to evaluate the annual prevalence as well as multi-year trends of specific preventable hospitalizations. This information can be used at local, regional, and national levels to identify opportunities to improve care and address potential disparities in care both in communities and in healthcare systems.

The existing PQIs reported for diabetes include uncontrolled diabetes, diabetes short-term complications, diabetes long-term complications, and lower extremity amputations (LEA). They are currently designated as the AHRQ Prevention Quality Diabetes Composite (AHRQ-DC).[4]

However, diabetes is also associated with, and may have increased prevalence of other common medical conditions that are potentially preventable in older adults. These conditions include dehydration, bacterial pneumonia, and urinary tract infections (UTI). For example, the Centers for Disease Control and Prevention (CDC) estimated that other than age ≥ 65 years, diabetes was the most common indication for

Declaration of Interests: All authors report no conflicts of interest.
Disclaimer: The views expressed in this article are those of the authors and do not necessarily reflect the position or policy of the Department of Veterans Affairs or the United States government.

* Corresponding author at: VA New Jersey Healthcare System, 385 Tremont Avenue, East Orange, NJ, United States.
E-mail address: chin-lin.tseng@va.gov (C.-L. Tseng).

https://doi.org/10.1016/j.jdiacomp.2018.01.013
1056-8727/Published by Elsevier Inc.

receipt of the 23-valent pneumococcal polysaccharide vaccine, with 20% of all cases in 2009 compared to 10% of cases in 1998–1999.[5] UTI in patients with diabetes had 8.2% prevalence in 2009, of whom 10% had UTI related hospitalizations in the same year and 34% had UTI in prior year.[6] These conditions are already included in the AHRQ Prevention Quality Acute Composite;[4] we propose that they should be considered for separate reporting and surveillance for older adults with diabetes.

Additionally, there are other serious yet potentially preventable hospitalizations for clinical conditions that are not designated as AHRQ PQIs; they include acute kidney injury (AKI), hypoglycemia, and lower extremity infections, inflammation, and/or ulcers that did not result in amputations during the hospital stay (LEU). In 2013, the AKI incidence rate in Medicare patients with diabetes and chronic kidney disease (CKD) was 203.1 per 1000 patient years, much higher than those with CKD only (140.3), diabetes only (50.1), and those with neither condition (23.7).[7] The incidence of lower extremity infections among Medicare beneficiaries with diabetes was 6.0% compared to 0.5% for LEA.[8] Hypoglycemia is another short-term complication; hospitalizations for hypoglycemia exceeded those for hyperglycemia in older adults in recent years.[9] The epidemiological data warrant hospitalizations for these conditions to be considered for distinct PQIs.

Therefore, our overarching goal was to develop and evaluate an Expanded Prevention Quality Diabetes Composite (Expanded-DC) that would allow for a more accurate estimate of potentially preventable hospitalizations incurred by older adults with diabetes. Our primary study objectives were to estimate and compare the rates of preventable hospitalizations in the AHRQ-DC and Expanded-DC. Our secondary objectives were to evaluate potential racial-ethnic disparities in estimates of preventable hospitalizations, and to separately assess rates among those with and without coexisting complex comorbid conditions.

2. Subjects

Patient-level electronic medical records were utilized in the study and it was approved by the Institutional Review Board of the New Jersey Health Care System under the USA Department of Veterans Affairs for exemption of informed consent and HIPAA Authorization.

3. Materials and methods

3.1. Study population and data sources

We identified the USA Veterans Health Administration (VHA) Veteran patients with diabetes who were ≥65 years at the beginning of calendar year 2012 as the study population. The data sources were patient-level data from VHA and Medicare files. Diabetes was determined using data from the prior two years based on a previously validated approach.[10] Patients enrolled in Medicare managed plans in years 2011 and 2012 were removed because their medical records from the managed plans were not available.

3.2. Outcome measures

Our conceptual framework (Fig. 1) for an Expanded-DC includes diabetes specific and diabetes relevant categories. Preventable hospitalizations for the diabetes specific category were identified utilizing PQIs from the current AHRQ-DC (PQI #93): short-term diabetes complications (PQI #1), long-term diabetes complications (PQI #3), uncontrolled diabetes (PQI #14), and LEA (PQI #16).[4] Additionally, we proposed to evaluate hospitalizations for hypoglycemia as well as LEU as they were not clearly identified in the AHRQ-DC based on the International Classification of Diseases, 9th revision, clinical modification (ICD-9-CM) codes.

The diabetes relevant category includes dehydration (PQI #10), bacterial pneumonia (PQI #11), and UTI (PQI #12), from the existing AHRQ Prevention Quality Acute Composite (PQI #91) and AKI as a proposed PQI.[4]

AKI was determined using code 584.9, the only code billable to Medicare. Hospitalizations linked to activities of dialysis within prior three months were not considered as AKI.[11] When developing our methodology, we ascertained that the ICD-9-CM codes used to define admissions for hypoglycemia were not consistent with the most current accepted methodology. In the study, we identified hypoglycemia based on previously developed methodology, which has been utilized to evaluate hospitalization for hypoglycemia among Medicare beneficiaries using administrative data.[9,12] The AHRQ category of diabetes long-term

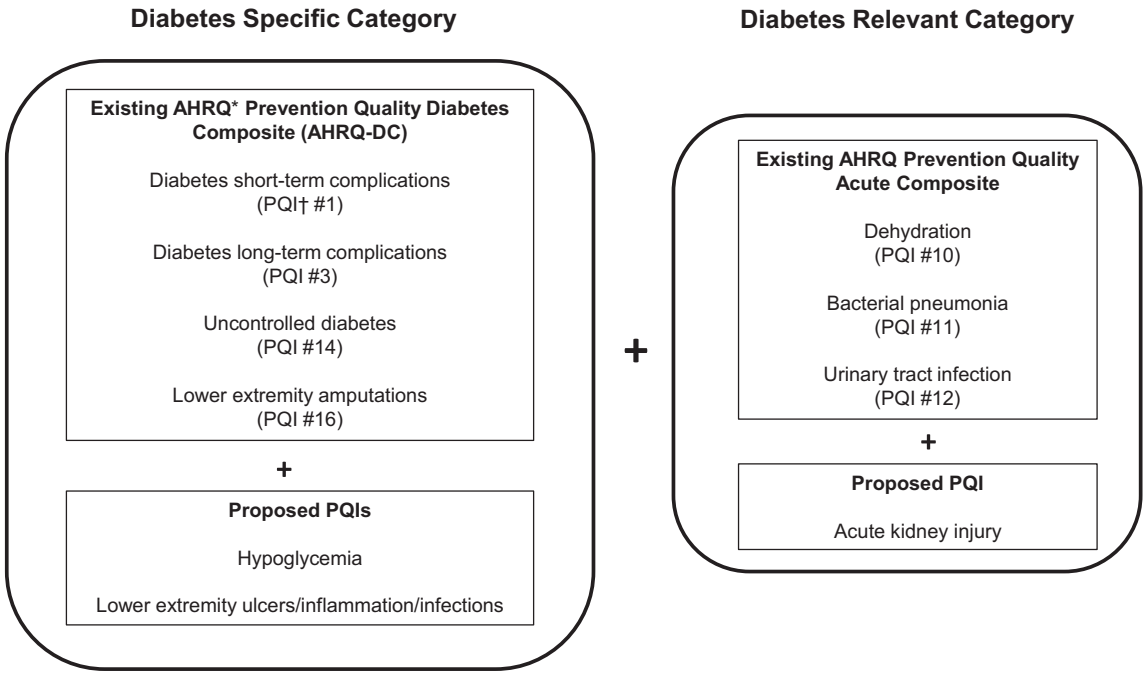

Fig. 1. The conceptual framework of the expanded prevention quality diabetes composite *AHRQ stands for the Agency for Health Research and Quality. †PQI stands for Prevention Quality Indicator (from AHRQ).

Please cite this article as: Tseng C-L, et al. An expanded prevention quality diabetes composite: Quantifying the burden of preventable hospitalizations for older adults with di.... (2017), https://doi.org/10.1016/j.jdiacomp.2018.01.013

complications based on ICD-9-CM codes did not include LEU. We used codes from CDC to define LEU (454, 707.1, 680. 6–680.7, 681.1, 682.6–682.7, 711.05–711.07, 730.05–730.07, 730.15–730.17, 730.25–730.27, 730.35–730.37, 730.85–730.87, 730.95–730.97, 785.4).[13]

AHRQ technical specifications were used to define the existing PQIs with the exception of diabetes long-term complications and dehydration.[4] Specifically, the AHRQ definition for diabetes long-term complications includes ICD-9-CM code 250.8 that is also used in the validated algorithm to define hypoglycemia.[12] The AHRQ definition for dehydration includes hospitalizations with any secondary diagnosis codes for dehydration following a principal diagnosis code for AKI.[4] Therefore, we revised the definition for diabetes long-term complications and dehydration by simply re-classifying hospitalizations qualifying for the definition of hypoglycemia and AKI, respectively.

Following the AHRQ technical specifications, we used ICD-9-CM procedure codes to define LEA and the principal diagnosis code to define all other studied preventable hospitalizations; all hospitalizations were restricted to hospital admissions that were not recorded as transfers from a different hospital, a skilled nursing facility, an intermediate care facility, or another health care facility.[4] We then reported rates for each individual PQI, the AHRQ-DC and the Expanded-DC.

3.3. Other variables

We derived a variable indicating in year 2011 presence/absence of any of the following complex comorbid conditions based on our prior work:[14] advanced diabetes complications (lower extremity amputations, advanced retinopathy, gastroparesis, autonomic neuropathy, and diabetic poly neuropathy), cognitive impairment/dementia, major neurological conditions (Parkinson's disease, hemiplegia/paraplegia/quadriplegia, epilepsy, aphasia, dysphasia, apraxia, multiple sclerosis), limited life expectancy (cancer, end stage hepatic disease, end stage renal disease), cardiovascular conditions (myocardial infarction, chronic heart failure, ischemic vascular disease, transient ischemic attack), major depression, and substance/alcohol abuse (Supplementary Table 1).

Age (65–74, 75–84, and ≥ 85 years old) and sex were used for the purpose of population standardization in comparing rates across racial/ethnic subgroups. We categorized racial/ethnic subgroups into four mutually exclusive groups: non-Hispanic Blacks (Blacks), non-Hispanic Whites (Whites), Hispanics, and others (including Asians, Pacific Islanders, Native Americans, and mixed races).

3.4. Statistical techniques

We calculated the rates for individual and different categories of PQIs as the number of hospitalizations per 1000 persons. We also assessed the marginal impact of including additional preventable hospitalizations; we defined it as the percentage of the number of added hospitalizations among the resulting total based on the Expanded AHRQ-DC (or its subcategories). It was therefore calculated as 100% times the ratio of the number of added hospitalizations to the sum of existing and added hospitalizations. In order to compare rates and the marginal impacts among racial/ethnic groups, we calculated age-and-sex standardized rates for each racial/ethnic group using the overall study population as the standard population. Lastly, we calculated the age-and-sex standardized rates separately for patients with and without complex comorbid conditions.

Statistical analyses were conducted using SAS (version 9.4; SAS institute, Inc., Cary, NC, USA).

4. Results

We identified 1,087,817 patients with diabetes and alive as of the beginning of 2012 who were at least 65 years old. We excluded 253,121 patients enrolled in Medicare managed plans in 2011 and 2012, resulting in 834,696 patients as the final study population. Table 1 shows that there were 49% aged 65–74, 35% aged 75 to 84, and 16% aged 85 or older. Most were men (98%) and White (80%); 10% were Black and 10% were Hispanic and other racial categories. Overall, 594,308 (71%) of the study population had complex medical conditions.

The study population incurred 64,243 studied preventable hospitalizations (rate: 77.0 admissions per 1000 patients; Table 2) in the expanded-DC, out of a total of 417,352 hospitalizations. There were 22,013 (26.4) hospitalizations for the diabetes specific category and 42,245 (50.6) for the diabetes relevant category. Of the 10 studied PQIs, the three PQIs with the highest rates were from the diabetes relevant category: pneumonia (17,557 admissions; rate: 21.0), AKI (11,833; 14.2), and UTI (8940; 10.7). Among the diabetes specific category, the highest three PQIs were LEU (8119; 9.7), diabetes long-term complications (6399, 7.7), and hypoglycemia (3347, 4.0). Overall, the rate for uncontrolled diabetes was the lowest (970, 1.2).

The age-and-sex adjusted rates for the Expanded-DC were 74.7 for Whites, 85.9 for Blacks, and 77.1 for Hispanics. Compared to Whites and Hispanics, Blacks were more likely to incur a preventable hospitalization except for LEU and pneumonia.

Table 3 shows marginal impacts of adding additional PQIs to the estimates for overall and by PQI category. There were 13,523 (16.2) hospitalizations based on the current AHRQ-DC. Additional PQIs from the current AHRQ-Acute Composite and three proposed PQIs added 50,720 (60.8) hospitalizations with a marginal impact of 79% to the number (64,243) and rate (77.0) of Expanded-DC. Of the 64,243 hospitalizations in Expanded-DC, 48,311 (57.9) were from seven existing AHRQ PQIs; the three proposed PQIs added additional 15,932 hospitalizations to the total, with 25% marginal impact.

For diabetes specific category, hypoglycemia and LEU added an additional 8490 hospitalizations (39% marginal impact; the majority (8119) being LEU). Hypoglycemia added 71% hospitalizations to diabetes short-term complications; the revised rate was 5.7 compared to 1.7. LEU added 8119 (76%) hospitalizations to lower extremity complications, with a rate of 12.8. For the diabetes relevant category, AKI added an additional 7446 (18%) hospitalizations.

The marginal impacts of the three proposed PQIs to the Expanded-DC were similar (range: 23%–25%) across races/ethnicity. However, racial/ethnic differences varied among the individual PQIs as well as the two categories. The marginal impact of AKI to the diabetes relevant category was 24% in Blacks compared to 17% in Whites. For the diabetes specific category, hypoglycemia and LEU together contributed additional 23% for Blacks to 42% for Whites. Individually, the marginal impact from adding LEU to lower extremity complications was highest in Whites (79%) and lowest in Blacks (55%), although the marginal

Table 1
Characteristics of the study population.*

	Number (%)
Total	834,696
Age, in years (%)	
65–74	409,784 (49)
75–84	294,394 (35)
≥ 85	130,518 (16)
Sex	
Men	816,569 (98)
Women	18,127 (2)
Race/ethnicity	
Non-Hispanic White	665,183 (80)
Non-Hispanic Black	83,049 (10)
Hispanic	41,651 (5)
Others	44,813 (5)
Complex comorbid conditions	
Presence	594,308 (71)
Absence	240,388 (29)

* We identified Veterans Health Administration veteran patients with diabetes who were ≥65 years at the beginning of 2012 as the study population.

Please cite this article as: Tseng C-L, et al. An expanded prevention quality diabetes composite: Quantifying the burden of preventable hospitalizations for older adults with di.... (2017), https://doi.org/10.1016/j.jdiacomp.2018.01.013

Table 2
Rates of preventable hospitalizations included in the Expanded Diabetes Prevention Quality Composite (Expanded-DC).

	Racial/ethnic groups								Complex comorbidities			
	All		Non-Hispanic White		Non-Hispanic Black		Hispanic		Others		Yes		No	
Number of patients	834,696		665,183		83,049		41,651		44,813		594,308		240,388	
	No.[a]	Rate[b]	No.[a]	Rate[b]	No.[a]	Rate[b]	No.[a]	Rate[b]	No.[a]	Rate[b]	No.[a]	Rate[b]	No.[a]	Rate[b]
Expanded-DC	64,243	*77.0*	50,472	*74.7*	6448	*85.9*	3104	*77.1*	4219	*96.5*	56,987	*93.6*	7256	*34.6*
Diabetes specific category	22,013	*26.4*	16,505	*24.7*	2565	*32.0*	1232	*29.8*	1711	*37.5*	19,345	*32.8*	2668	*11.8*
Existing Agency for Health Research and Quality (AHRQ) Prevention Quality Indicator (PQI)														
Diabetes short-term complications	1403	*1.7*	914	*1.4*	285	*3.3*	88	*2.1*	116	*2.4*	1125	*2.0*	278	*1.1*
Diabetes long-term complications with revision[c]	6399	*7.7*	4805	*7.2*	727	*9.0*	336	*8.0*	531	*11.5*	5766	*9.9*	633	*2.8*
Uncontrolled diabetes	970	*1.2*	644	*1.0*	161	*2.0*	73	*1.8*	92	*2.0*	815	*1.4*	155	*0.7*
Lower extremity amputation (LEA)	2524	*3.0*	1715	*2.6*	447	*5.6*	145	*3.5*	217	*4.8*	2365	*4.1*	159	*0.7*
Proposed PQI														
Hypoglycemia	3347	*4.0*	2369	*3.5*	559	*7.2*	189	*4.6*	230	*5.3*	2908	*4.8*	439	*2.1*
Lower extremity ulcers/inflammation/infections (LEU)	8119	*9.7*	6580	*9.9*	517	*6.7*	434	*10.5*	588	*12.9*	7059	*11.9*	1060	*4.7*
Diabetes relevant category	42,245	*50.6*	33,977	*50.0*	3886	*54.0*	1874	*47.4*	2508	*59.0*	37,657	*60.8*	4588	*22.8*
Existing AHRQ PQI														
Urinary tract infection	8940	*10.7*	6928	*10.1*	949	*13.9*	488	*12.5*	575	*13.8*	8036	*12.8*	904	*4.6*
Bacterial pneumonia	17,557	*21.0*	14,832	*21.8*	1053	*14.5*	702	*17.9*	970	*23.1*	15,665	*25.2*	1892	*9.4*
Dehydration with revision[d]	3915	*4.7*	3106	*4.6*	408	*5.4*	180	*4.5*	221	*5.3*	3456	*5.6*	459	*2.3*
Proposed PQI														
Acute kidney injury	11,833	*14.2*	9111	*13.5*	1476	*20.1*	504	*12.4*	742	*16.9*	10,500	*17.2*	1333	*6.5*

Some hospitalizations with a procedure code for LEA also qualified as another PQI; these hospitalizations were kept in the statistic of individual PQIs but not doubly counted in any composite measure as per AHRQ practice.

[a] "No.": Number of hospitalizations.

[b] Rates were in 1000 patients. Rates for subgroups were standardized to the age and sex distribution of the overall study population.

[c] The AHRQ definition for diabetes long-term complications includes a code 250.8 that is also used in the algorithm to define hypoglycemia (Reference #12). Therefore, we revised the definition for long-term complications by simply re-classifying hospitalizations qualifying for the definition of hypoglycemia.

[d] The AHRQ definition for dehydration includes hospitalizations with any secondary diagnosis codes for dehydration following a principal diagnosis code for acute kidney injury (Reference #3). Therefore, we revised the definition for dehydration by simply re-classifying hospitalizations qualifying for the definition of acute kidney injury.

impacts of adding hypoglycemia to diabetes short-term complications were similar among racial/ethnic groups (range: 69%–72%).

Patients with complex comorbidities had a greater rate (93.6) for the expanded-DC than those without the comorbidities (34.6) (Table 2). The same pattern of comparisons was observed for both the diabetes specific category (32.8 vs. 11.8) and diabetes relevant category (60.8 vs. 22.8). The impacts of adding the three proposed PQIs were comparable in those with (36%) and without (39%) complex conditions (data not shown).

5. Discussion

Diabetes is a common, complex, and costly disease. There has been a marked reduction in the incidence of end-stage complications of diabetes from 1990 to 2010.[15] However, the annual numbers of amputations, cases of end-stage renal disease, and strokes continue to increase because of the large increase in the number of prevalent cases of diabetes.[15] With the baby boomers entering their elderly years, the total burden, or absolute number of cases of complications, will probably continue to increase in the coming decades. In fact, the direct medical costs for chronic complications and excess prevalence of general medical conditions attributed to diabetes have increased markedly, from $91.8 billion in 2002 to $176 billion in 2012 and the proportion of cost incurred by adults 65 and older increased from about 52% to 59% over the same period.[2,16] Since inpatient care is the major cost component of diabetes care and individuals aged 65 accounting for 64% of inpatient stays (diabetes related or general conditions) with excess prevalence,[2] a focus upon preventive hospitalizations is appropriate.

In adding existing PQIs from the AHRQ Acute Composite (pneumonia, UTI, and dehydration) and our proposed PQIs (LEU, AKI, and hypoglycemia) to the AHRQ-DC to form an Expanded-DC, the rate increased from 16.2 per 1000 patients based on the AHRQ-DC to 77.0 per 1000 patients based on the Expanded-DC, about 4.7 fold increase. The marginal impact of the proposed PQIs was 25%, reflecting the importance of evaluating hospitalizations for these medical conditions in older adults.

The rate of diabetes specific preventable hospitalizations in the Expanded-DC was 26.4 admissions per 1000 patients compared to 16.2 admissions per 1000 patients from the AHRQ-DC. Adding LEU and hypoglycemia may provide additional insight for both the public health sector and integrated health care systems regarding opportunities for prevention of these hospitalizations.

Specifically, the rate of hospitalizations for hypoglycemia was 4.0 per 1000 patients, 3.3 fold higher than the 1.2 rate for uncontrolled diabetes. Including hypoglycemia as a short-term complication also has face validity since this complication can occur suddenly in patients with diabetes of any duration, and it aligns with the USA Department of Health and Human Services National Action Plan for Prevention of Adverse Drug Events.[17]

Similarly, our study highlights that the current AHRQ-DC underestimates the total burden of lower extremity complications in older adults with diabetes. We found that the lower extremity complications rate increased by 76%, from 3.0 (for LEA) to 12.8 per 1000 patients, by combining LEU and LEA. The lower extremity complications composite is aligned with an ongoing CDC public service campaign to improve foot care.[18] Indeed, a recent research report recommends greater coordination between primary care and specialists for patients at high risk for lower extremity complications.[19]

The rate of AKI was 14.2 per 1000 patients, second to pneumonia, in the diabetes relevant category. Moreover, we note that hospitalizations for AKI were likely underestimated because of the reliance upon ICD codes, and thus do not incorporate baseline serum creatinine and estimated glomerular filtration rate in the ambulatory care setting.[20] We note that the Food and Drug Administration has issued advisories for Sodium Glucose Transport-2 medications in relation to acute kidney injury,[21] although findings from a recent study did not suggest an increased risk.[22] Nonetheless, diabetes and CKD were found to "influence AKI risk both independently and synergistically" in a Medicare population.[7] Moreover, the National Diabetes Kidney Education Program recommends that clinicians should identify patients with chronic kidney disease, be alert to risk factors for AKI in older adults, including acute

Please cite this article as: Tseng C-L, et al. An expanded prevention quality diabetes composite: Quantifying the burden of preventable hospitalizations for older adults with di.... (2017), https://doi.org/10.1016/j.jdiacomp.2018.01.013

Table 3
The marginal impacts of adding additional prevention quality indicators (PQIs).

	Racial/ethnic groups									
	All		Non-Hispanic White		Non-Hispanic Black		Hispanic		Others	
Number of patients	834,696		665,183		83,049		41,651		44,813	
	*No.	†Rate	*No.	†Rate	*No.	†Rate	*No.	†Rate	*No.	†Rate
Adding Agency for Health Research and Quality (AHRQ) Prevention Quality Acute Composite and three proposed PQIs										
Expanded Diabetes Prevention Quality Diabetes composite (Expanded-DC)	64,243	77.0	50,472	74.7	6448	85.9	3104	77.1	4219	96.5
AHRQ Prevention Quality Diabetes Composite (AHRQ-DC)	13,523	16.2	9656	14.5	1992	24.5	778	18.8	1097	24.0
Added preventable hospitalizations	*50,720*	*60.8*	*40,816*	*60.2*	*4456*	*61.4*	*2326*	*58.3*	*3122*	*72.5*
‡**Marginal Impact**	**79.0%**		**80.6%**		**71.5%**		**75.6%**		**75.1%**	
Adding lower extremity ulcers/inflammation/infections (LEU), hypoglycemia, and acute kidney injury										
Expanded-DC	64,243	77.0	50,472	74.7	6448	85.9	3104	77.1	4219	96.5
Existing PQIs from AHRQ-DC and Acute Composite	48,311	57.9	37,949	56.1	4932	65.8	2316	57.9	3114	72.0
Added preventable hospitalizations	*15,932*	*19.1*	*12,523*	*18.7*	*1516*	*20.1*	*788*	*19.2*	*1105*	*24.5*
†**Marginal Impact**		**24.8%**		**25.0%**		**23.4%**		**24.8%**		**25.4%**
Adding LEU and hypoglycemia										
Diabetes specific category	22,013	26.4	16,505	24.7	2565	32.0	1232	29.8	1711	37.5
AHRQ-DC	13,523	16.2	9656	14.5	1992	24.5	778	18.8	1097	24.0
Added preventable hospitalizations	*8490*	*10.2*	*6849*	*10.3*	*573*	*7.5*	*454*	*11.0*	*614*	*13.5*
‡**Marginal Impact**		**38.6%**		**41.5%**		**23.3%**		**36.9%**		**35.9%**
Adding LEU										
LE complications	10,643	12.75	8295	12.4	964	12.2	579	14.0	805	17.7
Lower extremity amputations	2524	3.02	1715	2.6	447	5.6	145	3.5	217	4.8
Added preventable hospitalizations	*8119*	*9.73*	*6580*	*9.9*	*517*	*6.7*	*434*	*10.5*	*588*	*12.9*
‡**Marginal Impact**		**76.3%**		**79.3%**		**54.6%**		**75.2%**		**72.9%**
Adding hypoglycemia										
Short-term diabetes complications	4750	5.7	3283	4.9	844	10.5	277	6.7	346	7.7
Existing Short-term complications PQI from AHRQ	1403	1.7	914	1.4	285	3.3	88	2.1	116	2.4
Added preventable hospitalizations	*3347*	*4.0*	*2369*	*3.5*	*559*	*7.2*	*189*	*4.6*	*230*	*5.3*
‡**Marginal Impact**		**70.5%**		**71.6%**		**68.5%**		**69.3%**		**68.7%**
Adding acute kidney injury										
Diabetes relevant category	42,245	50.6	33,977	50.0	3886	54.0	1874	47.4	2508	59.0
AHRQ Prevention Quality Acute Composite	34,799	41.7	28,302	41.6	2941	41.3	1539	39.2	2017	48.0
Added preventable hospitalizations	*7446*	*8.9*	*5675*	*8.4*	*945*	*12.7*	*335*	*8.2*	*491*	*11.0*
‡**Marginal Impact**		**17.6%**		**16.8%**		**23.5%**		**17.3%**		**18.7%**

Some rates may not be equal to the sum of multiple rates due to rounding errors.
* 'No.': Number of hospitalizations.
† Rates were in 1000 patients. Rates for subgroups were standardized to the age and sex distribution of the overall study population.
‡ The marginal impact was calculated as 100% times the ratio of added hospitalizations to the sum of existing and added hospitalizations.

illness with anorexia or infection that could result in dehydration, and avoid nephrotoxic medications, including contrast agents.[23]

Although the overall underestimation of preventable hospitalizations was similar among racial/ethnic groups, there were Black-White differences in several preventable hospitalizations. An unexpected finding was that Whites had a lower LEA rate (2.6 vs. 5.6 per 1000 patients) but a higher LEU rate (9.9 vs. 6.7 per 1000 patients) when compared to Blacks. We speculate that this is a result of our decision to maintain peripheral artery disease, which has a higher prevalence among Blacks, in the diabetes long-term complications PQI.[24] Our results showed that the rate for this PQI was greater in Blacks (9.0 per 1000 patients) than Whites (7.2 per 1000 patients). When combining PQIs for LEA and LEU together, we found that the rate of hospitalizations for all lower extremity complications was comparable between Blacks (12.2 per 1000 patients) and Whites (12.4 per 1000 patients). These findings suggest the need to assess both LEA and LEU simultaneously in understanding racial differences in hospitalizations for lower extremity complications.[24]

Additionally, Whites had higher rates of pneumonia (21.8 vs. 14.5 per 1000 patients). Whether this reflects difference in pulmonary comorbid conditions or adherence to receipt of the pneumococcal vaccine cannot be ascertained in this study. However, these findings reinforce the importance of the CDC Pneumococcal Vaccination Public Service Program for persons with diabetes.[25]

As expected, we found that patients with complex medical comorbidities had higher rates of preventable hospitalizations, about 2.7 fold larger than those without such comorbidities. Hence stratifying the population into subgroups of interest may further improve targeted prevention efforts. Furthermore, the consideration of comorbid conditions and medication use can lead to the development of risk adjusted rates that would enable comparisons of diabetes specific complications, such as short-term complications and amputations across geographic regions and large health care systems.[26,27] A recent publication reported that on average, frail elderly persons accounted for the most potentially preventable inpatient spending for nearly all individual ambulatory care sensitive conditions, but it also raised concerns over the limitations of risk adjustment.[28] For targeted efforts in disease management and care coordination, high risk patients may be identified based on linked ambulatory care and hospital records. One such example for diabetes is development of the Diabetes Complications Severity Index which is used to identify patients with diabetes at high risk for all-cause complications or mortality.[29]

At the population level, rates of PQIs should be interpreted as the starting point for a more in-depth investigation. We recommend that AHRQ may proactively create technical reports for both individual and composite PQIs at the national and regional levels.[30] There already are existing national public health programs targeting hypoglycemia,[17] foot conditions,[18] kidney diseases[20] and pneumonia.[25] State Departments of Health and some large health care systems could evaluate the rates of these conditions in their own systems. For actual clinical care, large managed care systems with analytic capabilities could utilize

Please cite this article as: Tseng C-L, et al. An expanded prevention quality diabetes composite: Quantifying the burden of preventable hospitalizations for older adults with di.... (2017), https://doi.org/10.1016/j.jdiacomp.2018.01.013

nurses to identify higher risk patients and provide to them individual self-management education and referral to specialists and care coordination. We note that recently Centers for Medicare and Medicaid introduced payment proposals that would incorporate some acute care PQIs as well as unplanned admissions for diabetes for Accountable Care Organizations.[31] This may increase visibility of PQIs by health care systems.

Our study has significant strengths. The VHA is an integrated national health care system in which veterans receive health care at individual facilities organized into regional networks consisting of multiple facilities with associate outpatient clinics. There is a national system of electronic health records with combined laboratory, pharmacy, and administrative data. The merge of the VHA health care system data with Medicare data enabled us to ascertain the totality and rates of hospital admissions for a denominator of patients with definite diabetes. Therefore, our approach can also be utilized by health care systems with electronic health records to track and target care coordination and prevention efforts to improve quality of diabetes care.

We also acknowledge limitations, most prominently the reliance on administrative data, which can impact the assessment of severity of comorbid conditions. The use of ICD-10-CM taxonomies is expected to permit determination of patients as having Type 1 or Type 2 diabetes and better discrimination of more severe stages of both diabetes specific and relevant comorbid conditions than possible with ICD-9-CM coding, and thus technical specifications to match them to ICD-9-CM codes would need to be developed.[32]

Our findings suggest that an Expanded-DC improves assessment of the burden of preventable hospitalizations in older adults with diabetes. Future challenges in evaluating serious health events incurred by patients with diabetes may include incorporating emergency department visits and risk adjustment for the prevalence and severity of comorbid conditions using administrative, laboratory, and pharmacy data.[29] Finally, while our proposal is focused on national, state and local surveillance efforts in the United States, it can contribute to continuing international research and development efforts as in the Organization for Economic Co-operation and Development to improve the indicators, including the effort to better identify “all risk-outcome relationships for diabetes.”[33]

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jdiacomp.2018.01.013.

Acknowledgements

We also thank Ms. Mazhgan Rowneki for providing assistance in manuscript editing and submission.

Funding

The research was funded by the Department of Veterans Affairs, Veterans Health Administration, Office of Research and Development, Health Services Research and Development [merit review grant number: IIR 11–077]. The funding source played no role in study design, data collection, data analysis and interpretation, writing of the manuscript, and in the decision to submit the article for publication. https://www.hsrd.research.va.gov/for_researchers/pub_notice.cfm.

References

1. The Centers for Disease Control and Prevention (CDC). National Diabetes Statistics Report. https://www.cdc.gov/diabetes/pdfs/data/statistics/national-diabetes-statistics-report.pdf 2017. [Accessed: January 22, 2018].
2. American Diabetes Association. Economic costs of diabetes in the U.S. in 2012. *Diabetes Care.* 2013;36:1033-46.
3. Moy E, Chang E, Barrett M. Centers for Disease Control and Prevention (CDC) potentially preventable hospitalizations - United States, 2001-2009. *MMWR Suppl.* 2013;62:139-43. https://www.cdc.gov/mmwr/preview/mmwrhtml/su6203a23.htm. Accessed January 22, 2018.
4. Agency for Healthcare Research and Quality. Prevention quality indicators technical specifications updates - version 6.0 (ICD09). http://www.qualityindicators.ahrq.gov/Modules/PQI_TechSpec_ICD09_v60.aspx 2016. Accessed January 22, 2018.
5. Muhammad RD, Oza-Frank R, Zell E, et al. Epidemiology of invasive pneumococcal disease among high-risk adults since the introduction of pneumococcal conjugate vaccine for children. *Clin Infect Dis.* 2013 Mar;56:e59-7.
6. Yu S, Fu AZ, Qiu Y, et al. Disease burden of urinary tract infections among type 2 diabetes mellitus patients in the US. *J Diabetes Complications.* 2014;28:621-6.
7. United States Renal Data System. 2015 USRDS annual data report: Epidemiology of kidney disease in the United States. Bethesda, MD: National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases. https://www.usrds.org/2015/download/vol1_05_AKI_15.pdf 2015. Accessed January 22, 2018.
8. Margolis DJ, Malay DS, Hoffstad OJ, et al. *Incidence of Diabetic Foot Ulcer and Lower Extremity Amputation among Medicare Beneficiaries, 2006 to 2008: Data Points #2.Data Points Publication Series [Internet]. Rockville (MD): Agency for Healthcare Research and Quality (US). 2011.*
9. Lipska KJ, Ross JS, Wang Y, et al. National trends in US hospital admissions for hyperglycemia and hypoglycemia among Medicare beneficiaries, 1999 to 2011. *JAMA Intern Med.* 2014;174:1116-24.
10. Miller DR, Safford MM, Pogach LM. Who has diabetes? Best estimates of diabetes prevalence in the veterans health administration based on computerized patient data. *Diabetes Care.* 2004;27:B10-21.
11. Lafrance JP, Miller DR. Defining acute kidney injury in database studies: The effects of varying the baseline kidney function assessment period and considering CKD status. *Am J Kidney Dis.* 2010 Oct;56:651-60.
12. Ginde AA, Blanc PG, Lieberman RM, Camargo Jr CA. Validation of ICD-9-CM coding algorithm for improved identification of hypoglycemia visits. *BMC Endocr Disord.* 2008;8:4, https://doi.org/10.1186/1472-6823-8-4.
13. Centers for Disease Control and Prevention (CDC). Geography: National. Indicators: Lower extremity diseases: Hospitalization for lower extremity conditions (PAD ULCER, and neuropathy) read more. https://gis.cdc.gov/grasp/diabetes/DiabetesAtlas.html#. Accessed January 22, 2018.
14. Pogach LM, Tiwari A, Maney M, et al. Should mitigating comorbidities be considered in assessing healthcare plan performance in achieving optimal glycemic control. *Am J Manag Care.* 2007;13:133-40.
15. Gregg EW, Li Y, Wang J, et al. Changes in diabetes-related complications in the United States, 1990-2010. *N Engl J Med.* 2014;370:1514-23.
16. *Economic costs of diabetes in the U.S. in 2002. American Diabetes Association.Diabetes Care.* 2003;26:917-32.
17. Department of Health and Human Services National Action Plan for ADE prevention-diabetes agents. https://health.gov/hcq/pdfs/ADE-Action-Plan-Diabetes-Agents.pdf. Accessed January 22, 2018.
18. The Centers for Disease Control and Prevention (CDC). Diabetes and your feet. https://www.cdc.gov/features/diabetesfoothealth/. Accessed January 22, 2018.
19. Patient-Centered Outcomes Research Institute. Topic Summary: Reducing Disparities in Lower-Extremity Amputation among Racial/Ethnic Minorities and Low-Income Populations. Washington, DC. Patient-Centered Outcomes Research Institute. [https://www.pcori.org/sites/default/files/PCORI-Clinical-Interventions-To-Reduce-Lower-Extremity-Amputation-Disparities-Workgroup-Topic-Summary-110414.pdf. Accessed: January 22, 2018].
20. Siew ED, Basu RK, Wunsch H, et al. Optimizing administrative datasets to examine acute kidney injury in the era of big data: Workgroup statement from the 15(th) ADQI consensus conference. *Can J Kidney Health Dis.* 2016 Feb 26;3:12.
21. Department of Health and Human Services. FDA drug safety communication: FDA strengthens kidney warnings for diabetes medicines canagliflozin (Invokana, Invokamet) and dapagliflozin (Farxiga, Xigduo XR). https://www.fda.gov/Drugs/DrugSafety/ucm505860.htm. Accessed January 22, 2018.
22. Nadkarni GN, Ferrandino R, Chang A, et al. Acute kidney injury in patients on SGLT2 inhibitors: A propensity-matched analysis. *Diabetes Care.* 2017;21.
23. National Institute of Diabetes and Digestive and Kidney Diseases. National Kidney Disease Education Program. https://www.niddk.nih.gov/health-information/communication-programs/nkdep. Accessed January 22, 2018.
24. Boyko EJ, Monteiro-Soares M, Wheeler SGB, et al. Peripheral Arterial Disease, Foot Ulcers, Lower Extremity Amputations, and Diabetes. Chapter #20 in Diabetes in America. 3rd ed. Bethesda, MD: National Institutes of Health, NIH Pub No. 17–1468; 2017.
25. Centers for Disease Control and Prevention (CDC). Diabetes type 1 and type 2 and adult vaccination. https://www.cdc.gov/vaccines/adults/rec-vac/health-conditions/diabetes.html. Accessed January 22, 2018.
26. Helmer DA, Tseng CL, Brimacombe M, et al. Applying diabetes-related prevention quality indicators to a national cohort of veterans with diabetes. *Diabetes Care.* 2003 Nov;26:3017-23.
27. Tseng CL, Rajan M, Miller DR, et al. Use of administrative data to risk adjust amputation rates in a national cohort of Medicare-enrolled veterans with diabetes. *Med Care.* 2005 Jan;43:88-92.
28. Figueroa JF, Joynt Maddox KE, Beaulieu N, Wild RC, Jha AK. Concentration of potentially preventable spending among high-cost Medicare subpopulations: An observational study. *Ann Intern Med.* 2017(10):706-13.
29. Young BA, Lin E, Von Korff M, et al. Diabetes complications severity index and risk of mortality, hospitalization, and healthcare utilization. *Am J Manag Care.* 2008;14:15-23.
30. Fingar KR, Barrett ML, Elixhauser A, Stocks C, Steiner CA. Trends in potentially preventable inpatient hospital admissions and emergency department visits.

Please cite this article as: Tseng C-L, et al. An expanded prevention quality diabetes composite: Quantifying the burden of preventable hospitalizations for older adults with di.... (2017), https://doi.org/10.1016/j.jdiacomp.2018.01.013

HCUP Statistical Brief #195. Rockville, MD: Agency for Healthcare Research and Quality; 2015. https://www.hcup-us.ahrq.gov/reports/statbriefs/sb195-Potentially-Preventable-Hospitalizations.jsp. Accessed January 22, 2018.
31. Accountable Care Organization. Quality measure narrative specifications. https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/sharedsavingsprogram/Downloads/2017-Reporting-Year-Narrative-Specifications.pdf. Accessed January 22, 2018.
32. Fenton SH, Benigni MS. Projected impact of the ICD-10-CM/PCS conversion on longitudinal data and the joint commission Core measures. *Perspect Health Inf Manag.* 2014.11(1g). eCollection 2014. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4142515/. Accessed January 22, 2018.
33. Brownwood I. HCQI project, OECD. Progress on HCQI research and development work. http://www.oecd.org/els/health-systems/Item-11a-Primary-Care-Ian-Brownwood-OECD%20.pdf. Accessed January 22, 2018.

Please cite this article as: Tseng C-L, et al. An expanded prevention quality diabetes composite: Quantifying the burden of preventable hospitalizations for older adults with di.... (2017), https://doi.org/10.1016/j.jdiacomp.2018.01.013