Estimating State-Level Health Burden of Diabetes: Diabetes-Attributable Fractions for Diabetes Complications

Olga A. Khavjou, MA,[1] Sharon H. Saydah, PhD,[2] Ping Zhang, PhD,[2] Diana C. Poehler, BS,[1]
Simon J. Neuwahl, MSPH,[1] Alyssa R. Leib, BA,[1] Thomas J. Hoerger, PhD,[1] Jing Wang, MPH[2]

Introduction: Limited information is available on the health burden of diabetes at the state level. This study estimated state-specific attributable fractions and the number of cases attributable to diabetes for diabetes-related complications.

Methods: For each state, diabetes-attributable fractions for nine diabetes complications were estimated: three self-reported complications from the 2013 Behavioral Risk Factor Surveillance System, hospitalizations with three complications from 2011 to 2014 State Inpatient Databases, and three complications from 2013 Medicare data. Attributable fractions were calculated using RR and diabetes prevalence and the total number of cases using attributable fractions and total number of complications. Adjusted RR of each complication for people with and without diabetes by age and sex was estimated using a generalized linear model. Analyses were conducted in 2015−2016.

Results: Median state-level diabetes-attributable fractions for self-reported complications were 0.14 (range, 0.10−0.19) for mobility limitations; 0.13 (range, 0.04−0.21) for limitations in instrumental activities of daily living; and 0.12 (range, 0.06−0.20) for severe visual impairment or blindness. Median state-level diabetes-attributable fractions for diabetes-associated hospitalizations were 0.19 (range, 0.08−0.24) for congestive heart failure; 0.08 (range, 0.02−0.16) for myocardial infarction; and 0.62 (range, 0.46−0.73) for lower extremity amputations. Median state-level diabetes-attributable fractions for complications among Medicare beneficiaries were 0.17 (range, 0.14−0.23) for coronary heart disease; 0.28 (range, 0.24−0.33) for chronic kidney disease; and 0.22 (range, 0.08−0.32) for peripheral vascular disease.

Conclusions: Diabetes carries a significant health burden, and results vary across states. Efforts to prevent or delay diabetes or to improve diabetes management could reduce the health burden because of diabetes.
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INTRODUCTION

Diabetes is a costly condition that is associated with disabling or life-threatening complications. Its prevalence has increased rapidly in the past decades, with nearly 29 million Americans living with diabetes.[1] The number of people with diabetes is projected to continue to increase.[2] The disease imposes a large and growing health and economic burden on the healthcare system and society.

Limited information is available on health burden of diabetes at the state level. Yet, such information is needed to assist states and other stakeholders in public health prevention and planning efforts to support individuals with diabetes. To address this need, the Centers for Disease Control and Prevention (CDC) developed an

online toolkit, the Diabetes State Burden Toolkit, available on the CDC website (https://nccd.cdc.gov/Toolkit/DiabetesBurden). The toolkit provides a fast, convenient, and reliable way to generate state-level estimates of the health and economic burden of diabetes. This paper reports the estimated health burden of diabetes, specifically, rates of nine complications attributable to diabetes in each state and describes the methods and data used to derive these estimates.

METHODS

Study Sample

Nine diabetes-related complications from three data sources were assessed: (1) three self-reported complications from the Behavioral Risk Factor Surveillance System (BRFSS)[3]; (2) hospitalizations with three complications from the Healthcare Cost and Utilization Project State Inpatient Databases (SIDs)[4]; and (3) three complications from Medicare data. Analyses were conducted in 2015−2016. The RTI IRB approved the study.

Measures

The 2013 BRFSS was used to estimate prevalence of self-reported diabetes among adults aged ≥18 years, and three diabetes-related complications: severe vision impairment (SVI) or blindness; mobility limitations; and limitations in instrumental activities of daily living (IADLs). BRFSS is a state-based, cross-sectional telephone interview survey conducted by CDC and state health departments annually.[3] The survey represents the civilian non-institutionalized adult population in each state and the District of Columbia (DC) and collects state-level prevalence data regarding risk behaviors and preventive health practices. Diabetes status was defined using the question: *Has a doctor, nurse, or other health professional ever told you that you have diabetes?* BRFSS survey questions used to define the three complications are reported in Appendix Table 1 (available online). Survey weights were applied when analyzing the BRFSS data.

The SIDs were used to estimate diabetes-attributable hospitalizations with congestive heart failure (CHF); myocardial infarction (MI); and lower extremity amputations (LEAs) among adults aged ≥18 years. SIDs capture hospital inpatient stays in the state and contain clinical and resource use information included in a typical discharge abstract.[5] The analysis used publicly available SIDs for 28 states; estimates for 18 other states and DC were obtained from the Agency for Healthcare Research and Quality's Healthcare Cost and Utilization Project through active intramural collaboration. Data were not available for three states (Alabama, Delaware, and Idaho) and were outdated for one state (New Hampshire); these four states were excluded from the analysis. The most recently available years of the SIDs varied across the states; one most recent year of data for each state (between 2011 and 2014) available at the time of analysis was used. Individuals with diabetes were identified based on diagnosis code of any order. CHF and MI were defined using a first-order diagnosis code; LEAs were defined using any order procedure code. Codes from ICD-9-CM used to identify diabetes and complications are listed in Appendix Table 1 (available online).

Medicare claims data from 2013 were used to assess the prevalence of coronary heart disease (CHD); chronic kidney disease (CKD); and peripheral vascular disease (PVD) among adults aged ≥65 years. Data from the 2013 Centers for Medicare & Medicaid Services' Master Beneficiary Summary File were merged with the Chronic Conditions Warehouse (CCW); the Other Chronic or Potentially Disabling Conditions; and the Cost and Utilization segments.[6] The analysis sample was restricted to beneficiaries with full fee-for-service (FFS) coverage during a 2-year reference period. Predefined CCW indicators were used to identify adults with diabetes, CHD, CKD, and PVD.[7]

Prevalence of diabetes was calculated as the proportion of individuals who responded *yes* to the self-reported diabetes BRFSS question. Women who reported having diabetes only during pregnancy were considered to not have diabetes.

Statistical Analysis

For each diabetes complication, an attributable fraction (AF) approach was used to estimate the number of cases that were attributable to diabetes. In the epidemiologic literature, AFs are used to estimate the proportion of disease risk in a population that can be attributed to a risk factor.[8,9] Because the prevalence of these conditions increases with age, the AFs were estimated separately by age group. The formula for calculating the diabetes AF for complication j is shown in Equation 1[9]:

$$AF_j = pd_j \left[\frac{RR_j - 1}{RR_j} \right] \tag{1}$$

where pd_j is the adjusted prevalence of diabetes in the subsample with the complication j, and RR_j is the adjusted RR of complication j in the diabetes subsample relative to the non-diabetes sample.

The age strata for which AFs were estimated, and whether stratified by sex, varied based on the data set. For BRFSS complications, mobility limitations and IADLs were stratified by three age groups (18−64, 65−74, and ≥75 years) and SVI or blindness by two age groups (18−65 and ≥65 years). Complications from SIDs were analyzed by sex and four age groups (18−44, 45−64, 65−74, and ≥75 years). Medicare data were analyzed by sex and two age groups (65−74 and ≥75 years).

For each age or age/sex stratum, probability of having diabetes among individuals with the complication was predicted using a logistic regression and controlling for age, sex, and race/ethnicity. This estimate was used as pd_j in Equation 1 above.

For each stratum, the RR of each complication was estimated as the ratio of the complication's prevalence among people with diabetes to the complication's prevalence among people without diabetes. The RRs were first attempted to be estimated using a log-link binary model but it failed to converge in many age/sex/state strata due to sparseness of data; thus, a generalized linear model with a Poisson family and a log link and controlling for age, sex, and race/ethnicity was used. The number of cases of each complication attributable to diabetes was estimated by multiplying the number of cases of each complication by the diabetes AF. The manuscript reports diabetes-attributable complications as a rate per 10,000 population ages ≥18 years for complications from BRFSS and SID and as a rate per 10,000 population ages ≥65 years for complications from Medicare. Absolute numbers of diabetes-attributable complications in each state and by age and sex are reported in the Diabetes State Burden Toolkit (https://nccd.cdc.gov/Toolkit/DiabetesBurden).

In Medicare data, CCW indicators were not available for beneficiaries enrolled in managed care; thus, the AF estimates were based on a sample restricted to the fully covered FFS beneficiaries.[10] The number of cases with CHD, CKD, and PVD and diabetes and the number of diabetes-attributable cases were extrapolated to the entire Medicare population in the state using a multiplier specific to each state/age/sex group. These multipliers were calculated as the number of total Medicare beneficiaries divided by the number of fully covered FFS beneficiaries.

RESULTS

Table 1 reports state-level crude and age-adjusted prevalence of self-reported diabetes and the rate of diabetes-attributable cases per 10,000 population ages ≥18 years of self-reported complications from BRFSS. The crude prevalence of diabetes ranged from 6.5% in Colorado to 13.8% in Alabama, with a median of 9.6% in Maine. The age-adjusted prevalence of diabetes ranged from 6.3% in Colorado to 12.7% in Alabama, with a median of 8.8% in Kansas.

The rate of diabetes-attributable mobility limitations per 10,000 population ranged from 105 in Utah to 312 in West Virginia, with a median of 188 in Washington. The rate of diabetes-attributable limitations in IADLs per 10,000 population ranged from 25 in Wisconsin to 169 in West Virginia, with a median of 80 in Wyoming and Kansas. The rate of diabetes-attributable cases of SVI or blindness per 10,000 population ranged from 19 in Wisconsin to 116 in West Virginia, with a median of 52 in Michigan.

Table 2 reports state-level rates of diabetes-attributable hospitalizations among adults and cases among Medicare beneficiaries. The rate of diabetes-attributable hospitalizations per 10,000 population with CHF ranged from 1.0 in Utah to 12.2 in West Virginia, with a median of 7.0 in Massachusetts. The rate of diabetes-attributable hospitalizations with MI per 10,000 population ranged from 0.2 in Alabama to 5.6 in DC, with a median of 2.0 in California. The rate of diabetes-attributable hospitalizations with LEAs per 10,000 population ranged from 1.0 in Utah to 7.5 in DC, with a median of 3.4 in New York.

The rate of diabetes-attributable CHD cases per 10,000 population among Medicare beneficiaries ranged from 324 in Colorado to 824 in New York, with a median of 522 in Hawaii. The rate of diabetes-attributable CKD cases per 10,000 population among Medicare beneficiaries ranged from 303 in Wyoming to 631 in Hawaii, with a median of 499 in Wisconsin. The rate of diabetes-attributable PVD cases per 10,000 population among Medicare beneficiaries ranged from 126 in Idaho to 485 in New York, with a median of 236 in Wisconsin.

Figure 1 presents box plots of diabetes AFs for each complication, showing the median, second quartile, third quartile, minimum, and maximum values. Figure 1 demonstrates the proportion of each complication that is estimated to be attributable to diabetes and how these estimates vary across states and complications. The AFs for each complication in each state are reported in Appendix Table 2 (available online). Diabetes AFs were similar across self-reported mobility limitations, limitations in IADLs, and SVI or blindness (median, 0.12−0.14). Limitations in IADLs had the widest range, with a minimum of 0.04 and a maximum of 0.21. Among hospitalizations, the diabetes AF was lowest for MI (median=0.08), followed by CHF (median=0.19), and the diabetes AF is highest for LEAs (median=0.62). LEAs also had the widest range, with a minimum of 0.46 and the maximum of 0.73. For complications among Medicare beneficiaries, the median AF values were 0.17 for CHD, 0.28 for CKD, and 0.22 for PVD. PVD had the widest range of diabetes AFs, with a minimum of 0.08 and a maximum of 0.32.

DISCUSSION

This study provides estimates of diabetes AFs and the number of cases for nine diabetes complications. To the authors' knowledge, this is the first study to comprehensively assess diabetes AFs at the state level. These findings indicate that diabetes carries a significant health burden in each state, although the estimates varied across states. As demonstrated in the efforts from the Diabetes Prevention Program trial, diabetes can be prevented or delayed through lifestyle modifications, such as eating a healthy diet and exercising.[11] Population-based approaches are also important in reducing and preventing diabetes prevalence, mainly through preventing obesity, as they are complementary to clinical preventive strategies and treatment programs.[12] Among adults with diabetes, diabetes self-management education has been shown to improve glucose control, which may prevent or reduce complications.[13] Access to and quality of health care are also critical to the control of risk factors among adults with diabetes, many of whom face significant challenges in access to care, resulting in suboptimal care and increased rates of complications.[14,15]

These findings may be used to assist state-based public health professionals and diabetes advocates to demonstrate the burden of diabetes in their state. Furthermore, the estimated burden of diabetes can be informative to assist states in public health policies and resource planning to implement diabetes prevention strategies. Efforts to prevent, delay, or manage diabetes could significantly reduce health burden of diabetes. For example, across

Table 1. Prevalence of Diabetes and the Rate of Diabetes-Attributable Cases per 10,000 Population of Self-Reported Complications, by State

Statistic	Prevalence of diabetes from BRFSS		Rate of diabetes-attributable cases from BRFSS per 10,000 population ages >18 years		
	Crude, %	Age-adjusted, %	Mobility limitations, *n*	Limitations in instrumental activities of daily living, *n*	Severe visual impairment of blindness, *n*
Median	9.6 (ME)	8.8% (KS)	188 (WA)	80 (WY, KS)	52 (MI)
Minimum	6.5 (CO)	6.3% (CO)	105 (UT)	25 (WI)	19 (WI)
Maximum	13.8 (AL)	12.7% (AL)	312 (WV)	169 (WV)	116 (WV)
State					
Alabama	13.8	12.7	252	167	103
Alaska	7.1	7.3	182	67	n/r[a]
Arizona	10.7	9.8	147	46	n/r
Arkansas	11.5	10.5	208	145	47
California	10.2	9.9	180	88	63
Colorado	6.5	6.3	125	47	38
Connecticut	8.3	7.4	134	83	38
Delaware	11.1	9.9	258	104	80
District of Columbia	7.8	8.4	128	64	51
Florida	11.2	9.4	255	110	75
Georgia	10.8	10.4	201	64	75
Hawaii	8.4	7.5	110	38	36
Idaho	8.4	7.8	167	77	41
Illinois	9.9	9.2	204	78	n/r
Indiana	11.0	10.0	216	79	30
Iowa	9.3	8.3	203	83	43
Kansas	9.6	8.8	202	80	50
Kentucky	10.6	9.7	254	135	57
Louisiana	11.6	10.8	213	136	66
Maine	9.6	8.1	196	81	39
Maryland	9.8	9.2	190	77	62
Massachusetts	8.5	7.7	153	83	67
Michigan	10.4	9.3	190	83	52
Minnesota	7.4	6.8	152	48	32
Mississippi	12.9	12.0	282	156	74
Missouri	9.6	8.7	195	73	49
Montana	7.7	6.7	153	74	69
Nebraska	9.2	8.4	171	68	43
Nevada	9.6	9.0	134	65	60
New Hampshire	9.2	8.1	147	49	24
New Jersey	9.2	8.2	159	52	40
New Mexico	10.7	9.8	240	138	62
New York	10.6	9.7	174	109	86
North Carolina	11.4	10.5	237	112	46
North Dakota	8.9	8.1	129	56	46
Ohio	10.4	9.2	224	96	64
Oklahoma	11.0	10.2	272	91	86
Oregon	9.2	8.3	174	94	42
Pennsylvania	10.1	8.7	219	95	35
Rhode Island	9.3	8.3	183	68	45
South Carolina	12.5	11.3	262	100	53
South Dakota	9.1	8.2	154	85	40

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Table 1. Prevalence of Diabetes and the Rate of Diabetes-Attributable Cases per 10,000 Population of Self-Reported Complications, by State (*continued*)

Statistic	Prevalence of diabetes from BRFSS		Rate of diabetes-attributable cases from BRFSS per 10,000 population ages >18 years		
	Crude, %	Age-adjusted, %	Mobility limitations, *n*	Limitations in instrumental activities of daily living, *n*	Severe visual impairment of blindness, *n*
Tennessee	12.2	11.1	272	113	91
Texas	10.9	10.9	209	132	100
Utah	7.1	7.7	105	42	26
Vermont	7.8	6.7	178	62	28
Virginia	9.8	9.2	182	74	75
Washington	8.6	8.0	188	76	73
West Virginia	13.0	11.2	312	169	116
Wisconsin	8.2	7.3	154	25	19
Wyoming	8.6	8.0	138	80	66

[a]No reliable estimates could be produced.
AL, Alabama; BRFSS, Behavioral Risk Factor Surveillance System; CA, California; CO, Colorado; KS, Kansas; MD, Maryland; ME, Maine; MI, Michigan; UT, Utah; WA, Washington; WI, Wisconsin; WV, West Virginia; WY, Wyoming.

the states more than half of LEAs would be prevented if diabetes were eliminated.

The results on the diabetes-attributable cases of complications varied across the states. Because the estimates are presented as rates, the population size of each state does not contribute to this variation. However, differences in sociodemographic composition of the states likely explain some of this variation.[16] Although the diabetes AFs presented in Figure 1 were aggregated to the state level, the diabetes AFs were estimated separately by age group for complications from BRFSS and by age group and sex for complications from SIDs and Medicare. The demographic composition of a state affects the total number of diabetes-related complications in two ways. First, AFs are generally higher for younger adults than for older adults. For example, in California the diabetes AF for LEA was 0.76 among females aged 18−44 years and 0.41 among females aged 75 years or older (results not reported here). On the other hand, the total number of complications generally increased with age, so that the number of diabetes-attributable cases was usually still higher in the older population, even though the AFs were higher in the younger population.

Even within the same age group, the AFs across the states varied widely. For example, the diabetes AF for LEA among females aged 75 years and older ranged from 0.18 in West Virginia to 0.59 in Maine (results not reported here). For a given age group, the diabetes AF was affected by two factors: prevalence of diabetes among people with the complication and the RR of the complication among people with diabetes relative to people without diabetes (Equation 1). Beyond sociodemographic composition of the state, factors such as

general health, chronic prevention efforts, access to health care, and quality of care are likely contributors to the variation in diabetes prevalence and RRs across states.[17] Previous studies reported that regional variation in care is associated with supply of healthcare resources, likely leading to variation in state-level prevalence of diabetes and its complications.[18,19] In the present study, prevalence of diabetes among people with the complication within an age group was likely driven by diabetes risk factors, such as prevalence of overweight and obesity, and differences in the existing state-specific diabetes prevention, treatment, and care programs.[20,21] The RR was likely a function of both the biological nature of the complication and access to and quality of diabetes care.[14,15,18,19] These findings on the varying diabetes burden across states can be used to help policy and decision makers identify areas with the highest needs when allocating health care resources.

To the authors' knowledge, there are no previously published state-level estimates of diabetes AFs or numbers of diabetes-attributable cases of diabetes complications. However, comparison of national estimates from this analysis with previously published literature revealed that results presented here were consistent with results of other similar analyses. For example, national estimates of RRs of mobility limitations and limitations in IADLs among people with and without diabetes from this analysis were comparable with previously published literature.[22−25] Similarly, the estimated prevalences of CHF, MI, and LEA were similar to results from the Health Indicators Warehouse 2013.[26] A recently published report of cardiovascular events among patients with type 2 diabetes from commercial and Medicare

Table 2. Rate of Diabetes-Attributable Hospitalizations and Events per 10,000 Population, by State

Statistic	Rate of diabetes-attributable hospitalizations from SIDs per 10,000 population ages ≥18 years			Rate of diabetes-attributable events from Medicare per 10,000 population ages ≥65 years		
	Congestive heart failure	Myocardial infarction	Lower extremity amputations	Coronary heart disease	Chronic kidney disease	Peripheral vascular disease
Median	7.0 (MA)	2.0 (CA)	3.4 (NY)	522 (HI)	499 (WI)	236 (WI)
Minimum	1.0 (UT)	0.2 (AL)	1.0 (UT)	324 (CO)	303 (WY)	126 (ID)
Maximum	12.2 (WV)	5.6 (DC)	7.5 (DC)	824 (NY)	631(HI)	485 (NY)
State						
Alabama	n/a[a]	n/a	n/a	581	516	258
Alaska	2.7	0.2	1.4	406	403	149
Arizona	4.6	1.4	3.4	447	481	214
Arkansas	8.9	1.8	3.5	506	392	227
California	5.7	2.0	2.8	603	607	329
Colorado	3.0	1.0	2.2	324	374	143
Connecticut	6.8	1.8	3.6	509	459	206
Delaware	n/a	n/a	n/a	601	506	353
District of Columbia	11.2	5.6	7.5	588	597	371
Florida	7.8	2.7	3.6	645	561	355
Georgia	7.7	1.9	3.8	549	546	275
Hawaii	4.5	3.6	3.6	522	631	201
Idaho	n/a	n/a	n/a	390	422	126
Illinois	7.5	2.1	3.2	583	514	326
Indiana	9.6	2.4	4.2	568	531	279
Iowa	5.9	1.7	2.5	437	415	197
Kansas	7.3	1.4	3.2	474	420	208
Kentucky	10.9	2.7	4.4	660	577	299
Louisiana	5.4	1.1	3.4	644	608	349
Maine	2.8	1.9	2.8	516	464	209
Maryland	7.2	2.4	3.3	604	518	320
Massachusetts	7.0	2.3	2.8	500	539	206
Michigan	8.0	2.4	3.1	722	577	398
Minnesota	6.0	1.9	2.9	370	417	177
Mississippi	7.6	1.3	4.0	549	490	253
Missouri	9.5	2.6	3.7	541	505	273
Montana	5.1	0.6	2.5	369	358	134
Nebraska	2.8	1.0	2.1	415	376	189
Nevada	4.7	1.9	2.3	544	546	290
New Hampshire	n/a	n/a	n/a	462	430	206
New Jersey	7.0	2.8	3.6	737	526	398
New Mexico	4.4	1.9	3.2	477	445	223
New York	6.9	2.3	3.4	824	531	485
North Carolina	7.4	2.1	3.6	536	525	242
North Dakota	7.2	2.7	5.4	429	437	166
Ohio	11.1	2.5	4.3	626	591	320
Oklahoma	7.6	2.4	3.8	565	513	277
Oregon	5.2	1.3	2.9	391	432	166
Pennsylvania	9.6	3.3	5.0	592	520	338
Rhode Island	7.2	2.3	2.4	554	446	185
South Carolina	7.9	1.9	4.3	516	480	245
South Dakota	6.3	0.9	3.0	417	404	186

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Table 2. Rate of Diabetes-Attributable Hospitalizations and Events per 10,000 Population, by State (*continued*)

Statistic	Rate of diabetes-attributable hospitalizations from SIDs per 10,000 population ages ≥18 years			Rate of diabetes-attributable events from Medicare per 10,000 population ages ≥65 years		
	Congestive heart failure	Myocardial infarction	Lower extremity amputations	Coronary heart disease	Chronic kidney disease	Peripheral vascular disease
Tennessee	8.7	2.8	4.4	577	555	270
Texas	7.7	2.7	5.1	667	629	416
Utah	1.0	0.5	1.0	387	418	204
Vermont	4.0	2.8	2.0	414	367	155
Virginia	7.6	2.5	3.9	512	486	202
Washington	5.0	1.5	2.6	393	463	208
West Virginia	12.2	2.0	4.1	701	596	295
Wisconsin	5.9	1.1	2.9	448	499	236
Wyoming	3.6	0.7	1.6	335	303	130

[a]Data for the state were not available.

AL, Alabama; CA, California; CO, Colorado; DC, District of Columbia; HI, Hawaii; ID, Idaho; MA, Massachusetts; NY, New York; SID, State Inpatient Database; UT, Utah; WV, West Virginia; WI, Wisconsin.

claims showed that 53% of Medicare FFS beneficiaries with a heart failure admission have type 2 diabetes, compared with the estimate from this analysis of 47% prevalence of diabetes among Medicare FFS beneficiaries with heart failure.[27] Differences in definitions of diabetes and heart failure can potentially explain the differences between the estimates.

Limitations

This analysis is subject to several limitations. Because of differences in definitions of complications from different data sources, estimates across the data sources are not comparable. BRFSS estimates represent self-reported disease prevalence. Common criticisms of BRFSS are exclusion of individuals without access to phones and
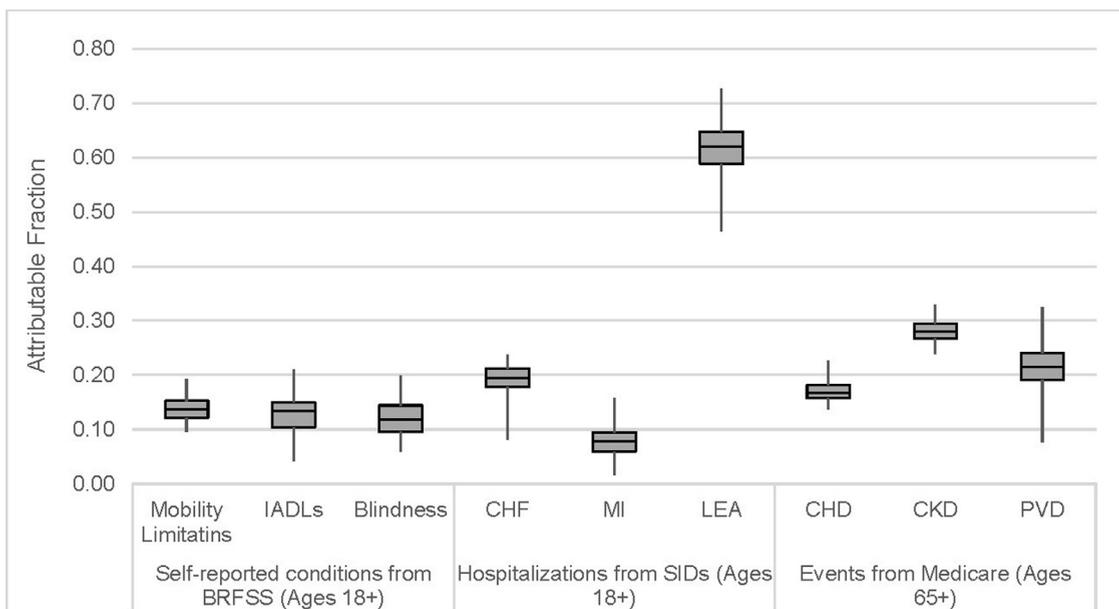
Figure 1. Box plot with attributable fractions for diabetes complications.

BRFSS, Behavioral Risk Factor Surveillance System; CHD, coronary heart disease; CHF, congestive heart failure; CKD, chronic kidney disease; IADLs, limitations in instrumental activities of daily living; blindness, severe visual impairment or blindness; LEA, lower extremity amputation; MI, myocardial infarction; PVD, peripheral vascular disease; SID, State Inpatient Database.

potential recall bias due to self-reported data. However, BRFSS estimates have been found to be reliable and have high level of validity when compared with data from other surveys.[28,29] As a result, BRFSS data are commonly used for state-level surveillance of chronic conditions, including diabetes.[17,30]

SID and Medicare are administrative data sets with SIDs representing events for which individuals were hospitalized within a given year and Medicare estimates representing treated conditions among Medicare beneficiaries. Administrative data provide a good source of real-world healthcare data for reliably reported data; however, because they are primarily collected for billing rather than research purposes, their limitations, such as potential accuracy and bias, should be acknowledged.[31,32] For example, an analysis from Scotland revealed underreporting of diabetes in hospital admission data.[33] By contrast, diabetes prevalence from Medicare CCW data was reported to be higher than prevalence based on self-reports or HbA1c measurements, although the bias was identified to be minimal.[34]

Another limitation is that because CCW indicators were not available for managed care beneficiaries, the sample used to estimate disease prevalence among the Medicare population was restricted to the fully covered FFS beneficiaries, which represent approximately 70% of the Medicare population.[35] The number of diabetes-attributable complications was extrapolated to the entire Medicare population in the state using a multiplier; however, some bias may result. For example, previous studies reported that managed care enrollees have slightly better health outcomes and, specifically, lower prevalence of diabetes than FFS enrollees,[36,37] which could lead to an overestimation of the diabetes burden among Medicare beneficiaries. However, because of the lack of available data for managed care enrollees, researchers commonly assume similar health outcome and cost patterns in the two populations.[38]

SE or CIs were not generated for this analysis. The AF approaches assume that diabetes caused these complications; however, because the data do not allow for a chronological analysis of the outcomes, it cannot be determined whether diabetes was present before the complication and thus led to it. Finally, comorbidities may impact the AF for diabetes complications. Because the analysis did not control for other conditions, the results may be biased.

CONCLUSIONS

A major strength of this study is that it reported state-level estimates of nine complications attributable to diabetes. Other strengths include large sample sizes and completeness of the data sources. The results presented here indicate that diabetes carries a significant health burden, with substantial variability across states. Efforts to prevent, delay, or manage diabetes can lead to significant improvements in the health of the population. Understanding this health burden at the state level can assist in prevention and diabetes care efforts to reduce the burden of diabetes in the population.

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SUPPLEMENTAL MATERIAL

Supplemental materials associated with this article can be found in the online version at https://doi.org/10.1016/j.amepre.2018.09.023.

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