Published in final edited form as:

Diabetes Care. 2020 October ; 43(10): 2453–2459. doi:10.2337/dc20-0586.

National and State-Level Trends in Nontraumatic Lower-Extremity Amputation Among U.S. Medicare Beneficiaries With Diabetes, 2000–2017

Jessica L. Harding[1], **Linda J. Andes**[2], **Deborah B. Rolka**[2], **Giuseppina Imperatore**[2], **Edward W. Gregg**[3], **Yanfeng Li**[4], **Ann Albright**[2]

[1]Division of Transplantation, Department of Surgery, Emory University School of Medicine, Atlanta, GA

[2]Division of Diabetes Translation, Centers for Disease Control and Prevention, Atlanta, GA

[3]Department of Epidemiology and Biostatistics, School of Public Health, Imperial College, London, U.K.

[4]Division of Heart Disease and Stroke Prevention, Centers for Disease Control and Prevention, Atlanta, GA

Abstract

OBJECTIVE—Diabetes is a leading cause of nontraumatic lower-extremity amputation (NLEA) in the U.S. After a period of decline, some national U.S. data have shown that diabetes-related NLEAs have recently increased, particularly among young and middle-aged adults. However, the trend for older adults is less clear.

RESEARCH DESIGN AND METHODS—To examine NLEA trends among older adults with diabetes (≥67 years), we used 100% Medicare claims for beneficiaries enrolled in Parts A and B, also known as fee for service (FFS). NLEA was defined as the highest-level amputation per patient per calendar year. Annual NLEA rates were estimated from 2000 to 2017 and stratified by age-group, sex, race/ethnicity, NLEA level (toe, foot, below-the-knee amputation [BKA], or above-the-knee amputation [AKA]), and state. All rates were age and sex standardized to the 2000 Medicare population. Trends over time were assessed using Joinpoint regression and annual percent change (APC) reported.

Corresponding author: Jessica L. Harding, jessica.harding@emory.edu.

Author Contributions. J.L.H. conducted the literature search, provided input into the study design, interpreted the results, and wrote the manuscript. L.J.A. performed the statistical analysis and reviewed/edited the manuscript. D.B.R. conceived and designed the study, provided technical support, and reviewed/edited the manuscript. G.I., E.W.G., Y.L., and A.A. revised the manuscript for important intellectual content. E.W.G. conceived and designed the study and reviewed/edited the manuscript. L.J.A. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Duality of Interest. No potential conflicts of interest relevant to this article were reported.

Prior Presentation. Parts of this study were presented at the 80th Scientific Sessions of the American Diabetes Association, 12–16 June 2020.

This article contains supplementary material online at https://doi.org/10.2337/figshare.12624914.

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

RESULTS—NLEA rates (per 1,000 people with diabetes) decreased by half from 8.5 in 2000 to 4.4 in 2009 (APC − 27.9, $P < 0.001$). However, from 2009 onward, NLEA rates increased to 4.8 (APC 1.2, $P < 0.01$). Trends were similar across most age, sex, and race/ethnic groups, but absolute rates were highest in the oldest age-groups, Blacks, and men. By NLEA type, overall increases were driven by increases in rates of toe and foot NLEAs, while BKA and AKA continued to decline. The majority of U.S. states showed recent increases in NLEA, similar to national estimates.

CONCLUSIONS—This study of the U.S. Medicare FFS population shows that recent increases in diabetes-related NLEAs are also occurring in older populations but at a less severe rate than among younger adults (<65 years) in the general population. Preventive foot care has been shown to reduce rates of NLEA among adults with diabetes, and the findings of the study suggest that those with diabetes—across the age spectrum—could benefit from increased attention to this strategy.

Diabetes is a leading cause of nontraumatic lower-extremity amputation (NLEA) (1,2). NLEA rates are influenced by multiple aspects of comprehensive diabetes care, including glycemic management, cardiovascular risk factor management, early detection of diabetes-related complications, and diabetes self-care management (3,4). Therefore, examining NLEA rates in and across populations may indicate the success, or lack thereof, of clinical and public health efforts to prevent diabetes-related complications (3,4).

National U.S. surveillance on the basis of the National Inpatient Sample (NIS), the largest publicly available all-payer inpatient health care database in the U.S., showed that rates of NLEA declined by about half between 1990 and 2010(5), representing a major success in ongoing efforts to prevent complications in people with diabetes. However, more recently, NIS data have revealed a leveling off and, in some cases, an increase in NLEA, with the most concerning increases observed in young and middle-aged adults among whom both minor and major amputations have increased (6). The direction of NLEA in the older NIS population is less clear because among adults aged 65–74 years, only minor amputations increased, while among those age ≥75 years, rates of major amputations have continued to decline (6). We are not aware of other population-based data systems reporting such shifts in the rates of NLEA, raising the question of whether recent findings are specific to the NIS or to younger populations.

In this study, we used Medicare claims data to ascertain trends in NLEA rates between 2000 and 2017 among older U.S. adults with diabetes. Examining trends in NLEA rates across multiple populations and in multiple data sources is imperative to our collective understanding of diabetes care in the U.S. and will help to shape our strategic direction for prevention and treatment in the future.

RESEARCH DESIGN AND METHODS

Study Population

Medicare, a federally funded health insurance program, is available for U.S. adults aged ≥65 years, younger people with disabilities, and people with end-stage renal disease (7). Medicare has two parts: Part A (hospital insurance) and Part B (Medicare insurance). You are eligible for premium-free Part A if you are aged ≥65 years and you or a spouse, parent, or child worked and paid Medicare taxes for at least 10 years (7). Part B is a voluntary program that requires the payment of a monthly premium for all months of coverage. Claims data are available for those who are enrolled in Medicare Part A and Part B, also known as fee for service (FFS). Claims data are available for 100% of all Medicare FFS members. In this study, we used beneficiary enrollment and claims files, including inpatient, skilled nursing facility (SNF), hospital outpatient, and professional services (carrier) data from the Chronic Conditions Data Warehouse of the Centers for Medicare & Medicaid Services. The beneficiary enrollment files contain sociodemographic and monthly enrollment information; claims files include diagnosis and procedure codes, service beginning date, and service ending date. Medicare claims data include inpatient hospital care, hospital outpatient services, emergency department care, SNF care, professional services, and other outpatient care, services, and supplies (8). For each index year (2000–2017), we used a 24-month reference window made up of the index year and the previous year. To be included in the study, beneficiaries had to be enrolled in Medicare Parts A and B for all 24 months of the reference window. Because of the requirement of 24 months of continuous enrollment, only beneficiaries aged ≥67 years at the end of the index year were included. The population with diabetes was defined as having either a single inpatient or an SNF claim or at least two outpatient claims (either hospital outpatient or carrier) that were made at least 1 day apart during the 2-year reference period. ICD-9, Clinical Modification (CM), diagnosis codes 250.x were used from January 1999 through September 2015, and ICD-10-CM diagnosis codes E10–E11 were used from October 2015 onward. Diagnosis codes E10 and E11 were chosen to ensure consistency with diagnosis code 250.x over time.

NLEA Hospitalizations

NLEA cases were identified from inpatient, hospital outpatient, and carrier files using ICD-9-CM procedure codes from January 2000 through September 2015, ICD-10-CM from October 2015 through December 2017, and Current Procedural Terminology codes, excluding diagnosis codes for traumatic amputation (Supplementary Table 1). To prevent overestimation of NLEA rates as a result of planned multistep procedures that may occur across weeks or months, as well as recurrent NLEAs that may simply reflect a failure of healing of the initial NLEA, we included only the highest-level NLEA per patient per calendar year. NLEA levels were categorized as toe, foot, below-the-knee amputation (BKA), or above-the-knee amputation (AKA) (Supplementary Table 1).

Comorbidities

Comorbidities were identified by indicators constructed by the Chronic Conditions Data Warehouse from primary and secondary diagnosis codes in inpatient, hospital outpatient, SNF, home health, and carrier data using coding algorithms (9). Less than 0.02% of data were missing for comorbidities across all years.

Statistical Analysis

Demographic and comorbid conditions among the overall and NLEA diabetic population are reported as proportions. We calculated annual NLEA rates (2000–2017) as the number of Medicare FFS beneficiaries with the highest-level amputation in the index year divided by all Medicare FFS beneficiaries with and without diabetes. Rates were age and sex standardized to the 2000 Medicare population using the direct method and stratified by age-group (67–69, 70–74, 75–79, 80–84, ≥85 years), sex, race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, Asian/Pacific Islander [API], other), NLEA level (toe, foot, BKA, AKA), and state. All rates were estimated using SAS 9.4 statistical software. We used Joinpoint Trend Analysis Software version 4.5.0.1 to analyze trends in annual NLEA rates as well as trends in comorbidities. This software uses permutation tests to identify points where linear trends change significantly in either direction or magnitude and calculates an annual percent change (APC) for each time period identified (10). A maximum of two join points was specified for all analyses. P, < 0.05 was established as statistically significant.

This study includes all U.S. Medicare beneficiaries fully enrolled for a 24-month period, and the margin of error is, <0.02%. For this reason, sample statistics, such as 95%CIs, are not reported for anyanalyses.

RESULTS

The number of Medicare FFS beneficiaries with diabetes increased from 4.63 million to 6.87 million between 2000 and 2017 (Table 1 and Supplementary Table 2). Among this population, the proportion of men and adults aged ≥85 years increased between 2000 and 2017, as did the proportion of people classified with comorbidities of liver disease, peripheral vascular disease, chronic kidney disease, chronic obstructive pulmonary disease, hypertension, cancer, obesity, depression, and hyperlipidemia (Table 1). In contrast, the proportion of Medicare FFS beneficiaries with acute myocardial infarction, stroke, and ischemic heart disease decreased during the same period. Among Medicare beneficiaries with diabetes who also had an NLEA, results were similar to those with diabetes (overall), with some exceptions: The proportion of older adults aged ≥85 years who had both diabetes and an NLEA declined over time, while the proportion among younger age-groups (67–69 and 70–74 years) increased; the proportion with acute myocardial infarction increased; and the proportion of toe and foot NLEAs increased, while BKA and AKA declined (Supplementary Table 3).

NLEA rates (per 1,000 people with diabetes) decreased by half from 8.5 in 2000 to 4.4 in 2009 (APC −7.9, $P < 0.001$). However, from 2009 onward, NLEA rates increased, reaching 4.8 in 2017 (APC 1.2, $P < 0.01$). Trends were generally similar across most sex, age, and race/ethnic groups, with initial declines followed by an increase or stagnation in NLEA rates (Fig. 1A–C and Supplementary Table 4). Rates were consistently higher in the oldest age-groups, Blacks, and men, while the greatest relative increases in APC were observed among the younger age-groups, men, and White or Hispanic adults. By NLEA type, overall increases were driven by increases in rates of toe and foot NLEAs, while rates of BKA and AKA continued to decline over time (Fig. 1D and Supplementary Table 4). As a comparison, trends were similar among Medicare beneficiaries without diabetes, although absolute NLEA rates as well as relative APC increases in later time periods were substantially higher among people with versus without diabetes (Supplementary Table 5) (counts, Supplementary Table 6).

All U.S. states showed significant declines in NLEA rates among Medicare FFS beneficiaries with diabetes between 2000 and ~2009/2010, with some variation in the magnitude of APC decline (Fig. 2). Between ~2009/2010 and 2017, 27 (54%) states had significant increases in NLEA rates, 16 showed nonsignificant increases in NLEA rates (32%), 5 showed a nonsignificant decline in NLEA rates (10%), and 2 (4%) (Alabama and Mississippi) demonstrated significant declines in NLEA rates.

CONCLUSIONS

In this study, we show that among U.S. Medicare FFS beneficiaries with diabetes aged ≥67 years, rates of NLEA increased slightly between 2009 and 2017 after a period of rapid decline. Rates were highest in men, the oldest age-groups, and Blacks, while the greatest relative increases in NLEA rates were seen among men, the younger age-groups, and White or Hispanic adults. Recent increases in NLEA rates are occurring across most U.S. states and appear to be driven by increases in rates of toe and foot NLEAs, while rates of BKA and AKA continue to decline.

These results are largely consistent with other national U.S. data. For example, using data from the NIS and the National Health Interview Survey, Geiss et al. (6) recently reported increases in diabetes-related NLEAs among young and middle-aged adults, driven largely by minor amputations. These increases are of greater magnitude than those reported in the current study. For example, in those aged 18–44 and 45–64 years, the APC in NLEA rates between 2010 and 2015 were 9.0 and 6.1, respectively, compared with 1.2 in this population of Medicare beneficiaries aged ≥67 years. In this same study, Geiss et al. showed no significant increase among older adults, although the magnitude of NLEA rates over time was similar to those reported in this study.

Using data from the U.S. Renal Data System (USRDS), Harding et al. (11) also reported a recent stall in progress of NLEA among a high-risk population of people with both diabetes and end-stage renal disease. Overall, between 2013 and 2015, no change in NLEA rates was observed where declines had previously been noted. Among those aged 65–74 and ≥75 years, relative APC increases of 2.2 and 1.4, respectively, were observed between 2013 and 2015, although these did not reach statistical significance (11). The lack of significance among older adults in both the NIS and the USRDS studies may be attributed to fewer years of follow-up compared with the current study.

Outside of the U.S., only a few studies have reported recent trends in diabetes-related NLEAs. In the U.K., an analysis from Diabetes UK reported a 19.4% increase in diabetes-related NLEAs in England between 2010–2013 and 2014–2017 (12). In Belgium, a nationwide study reported continued declines in both minor and major amputations between 2009 and 2013 (13). Finally, in Germany, continued declines have been observed for both minor and major NLEAs, although this analysis was limited to between 2008 and 2012 (14). None of these studies explored trends in NLEA rates by age-group.

In the current study, there was some variation in diabetes-related NLEA trends by state. Overall, all states reported significant declines in NLEA rates between 2000 and

~2009/2010, ranging from an APC of −2.3 to an APC of −10.6, with APCs typically higher for those states with higher absolute NLEA rates at baseline (year 2000). These declines were likely due to nationwide advances in acute clinical care, improvements in the performance of the health care system as well as improvements in key risk factors, and advances in more intensive medical procedures, such as revascularization and wound treatment (15–18). However, in more recent years, we show that most U.S. states have seen an increase in NLEA rates. The greatest increases were observed in South Dakota, North Dakota, Maine, Oregon, Idaho, Utah, and Oklahoma, while significant declines were noted for Alabama and Mississippi possibly because of their relatively high baseline NLEA rates. Geographical variation with respect to absolute rates of NLEAs per state has been described in previous studies (19). In this study, we aimed to explore geographic variation with respect to trends in NLEA rates. To that end, our findings suggest that increases in NLEA rates are a nationwide phenomenon, although the magnitude of increase varies considerably between states.

Contributing to this variation are important differences in NLEA rates identified among subgroups of the population. For example, NLEA rates were highest in men, the oldest age-groups, and Blacks, while the greatest relative increases in NLEA rates were seen among men, the younger age-groups, and White or Hispanic adults. Higher absolute rates in men (vs. women), older (vs. younger) age-groups, and Blacks (vs. Whites) are well known (20,21), with commonly cited reasons being differences in routine preventive care, medication adherence, and health system and social factors (22,23). However, greater relative increases in younger (vs. older) adults and in Whites (vs. Blacks) is perhaps unexpected. These findings are consistent with data from the NIS and USRDS, although reasons for the disparity remain elusive. One possible explanation for greater NLEA increases in younger adults is poorer risk factors, including those related to obesity, smoking, HbA_{1c}, blood pressure, and lipid level control, that have been observed in more recent years (15,24). Large-scale studies with granular data to tease out key risk factors could help to identify the drivers of NLEA increases and the variation of those increases across the U.S., which could help to inform clinical practices and policy options.

Reasons for the observed increase in diabetes-related NLEA rates among older Medicare beneficiaries in the U.S. are unclear, although several hypotheses exist. First, an increase in hospitalization rates of minor NLEAs may suggest changes in clinical practice that favor earlier minor NLEAs to prevent major NLEAs in the future. This hypothesis is supported in our study by continued declines in BKA and AKA, while rates of toe and foot NLEAs increased. Second, as indicated by our analysis of comorbidities, people with diabetes, generally, present with more comorbidities today compared with previous years, which may lead to an increased risk for complications such as NLEA (25). Third, we speculate that it is possible that stagnating NLEA rates are due to shortcomings in early prevention practices (i.e., physician and patient self-management education, use of appropriate foot wear, identification of high-risk feet [26,27]), leading to an increase in the prevalence of foot problems (ulcers and infection). Fourth, the profile of people with diagnosed diabetes may be changing. For example, decreasing mortality among those with diabetes, combined with decreasing incidence of newly diagnosed diabetes, is increasing the average duration of diabetes in the population, and this shift may be affecting the risk of complications

(28). Changes in diabetes screening and diagnostic criteria throughout the study period may also have contributed to a different pool of people with diagnosed diabetes with different susceptibility to complications (29). Finally, the increasing cost of insulin and other diabetes medications could be causing patients to cut back on treatment to minimize costs (30), thus exposing them to an increased risk for complications such as NLEA (31).

The results of this study have some implications for public health and health care practice. The increasing number of people living with diabetes is likely to also increase the number of people with NLEA, with implications at the individual, health care, and economic level. Improved awareness by health care providers, in particular awareness of early prevention practices such as diabetes self-management education and support, appropriate use of footwear, and identification of high-risk feet, might help to reduce NLEA occurrence (32). Better assessment of comorbidities, in particular liver, renal, and chronic pulmonary comorbidities, might also improve the effectiveness of treatment of underlying conditions and prevent or mitigate NLEAs (33). Given that older adults with diabetes are likely in frequent contact with the health care system for ongoing treatment and management of their diabetes and complications, there are numerous opportunities to reduce the rates of NLEA with preventive foot care and early detection of foot problems (26,34).

This is a large study of Medicare FFS beneficiaries with diabetes between 2000 and 2017. The key strengths of this study are our ability to explore relatively infrequent events such as NLEAs and to calculate rates among smaller subgroups. There are, however, some limitations that should be discussed. First, our population may not be representative of all Medicare beneficiaries because we did not include Medicare Advantage enrollees or people who were not fully enrolled in each 24-month reference window. Second, the prevalence of diabetes identified from claims data is consistently higher than that obtained from self-reports, which may indicate misclassification of diabetes status (35). Third, diabetes and NLEAs were defined using ICD-9-CM between January 2000 and September 2015 and ICD-10-CM from October 2015 onward. A shift to ICD-10-CM in 2015 may have affected our observed rates. However, observed changes in trends occurred before this period, and therefore, the coding shift likely did not have a significant influence on the overall patterns observed in this study. Furthermore, our definition of diabetes does not include ICD codes of 249/E08/E09 (secondary diabetes mellitus) or E13 (other specified diabetes mellitus). This was done to ensure that our population included only those with primary diabetes (type 1 or type 2) and to ensure consistency between ICD-9-CM and ICD-10-CM coding systems over time. However, this may have resulted in some misclassification of the diabetes population. Further analyses indicate that including additional diabetes-related codes as indicated above would reclassify <1% of the population as diabetes. This level of misclassification is unlikely to have a significant impact on the findings of this study. Finally, we do not have information on diabetes duration or several other confounding variables, such as education, that may help with understanding the increase in NLEAs overtime.

In conclusion, this study of the U.S. Medicare FFS population shows that recent increases in diabetes-related NLEAs are occurring in the older population but at a less severe rate than previously shown among younger adults. Increased attention to preventive foot care across the age spectrum could benefit adults with diabetes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

References

1. Adler AI, Boyko EJ, Ahroni JH, Smith DG. Lower-extremity amputation in diabetes. The independent effects of peripheral vascular disease, sensory neuropathy, and foot ulcers. Diabetes Care 1999;22:1029–1035 [PubMed: 10388962]
2. Ahmad N, Thomas GN, Gill P, Torella F. The prevalence of major lower limb amputation in the diabetic and non-diabetic population of England 2003–2013. Diab Vasc Dis Res 2016;13:348–353 [PubMed: 27334482]
3. Carinci F, Massi Benedetti M, Klazinga NS, Uccioli L. Lower extremity amputation rates in people with diabetes as an indicator of health systems performance. A critical appraisal of the data collection 2000–2011 by the Organization for Economic Cooperation and Development (OECD). Acta Diabetol 2016;53:825–832 [PubMed: 27443839]
4. Jeffcoate WJ, van Houtum WH. Amputation as a marker of the quality of foot care in diabetes. Diabetologia 2004;47:2051–2058 [PubMed: 15662547]
5. Gregg EW, Li Y, Wang J, et al. Changes in diabetes-related complications in the United States, 1990–2010. N Engl J Med 2014;370:1514–1523 [PubMed: 24738668]
6. Geiss LS, Li Y, Hora I, Albright A, Rolka D, Gregg EW. Resurgence of diabetes-related nontraumatic lower-extremity amputation in the young and middle-aged adult U.S. population. Diabetes Care 2019;42:50–54 [PubMed: 30409811]
7. Centers for Medicare & Medicaid Services. Original Medicare (Part A and B) Eligibility and Enrollment, 2019. Accessed 22 July 2020. Available from https://www.cms.gov/Medicare/Eligibility-and-Enrollment/OrigMedicarePartABEligEnrol
8. Centers for Medicare & Medicaid Services. Inpatient or outpatient hospital status affects your costs, 2020. Accessed 22 July 2020. Available fromhttps://www.medicare.gov/what-medicare-covers/what-part-a-covers/inpatient-or-outpatient-hospital-status-affects-your-costs
9. Centers for Medicare & Medicaid Services. Chronic Conditions Data Warehouse, 2020. Accessed 22 July 2020. Available from https://www2.ccwdata.org/web/guest/condition-categories
10. National Cancer Institute Division of Cancer Control & Population Sciences National Cancer Institute. Joinpoint trend analysis software. Accessed 22 July 2020. Available from https://surveillance.cancer.gov/joinpoint/
11. Harding JL, Pavkov ME, Gregg EW, Burrows NR. Trends of nontraumatic lower-extremity amputation in end-stage renal disease and diabetes: United States, 2000–2015. Diabetes Care 2019;42:1430–1435 [PubMed: 31142496]
12. Diabetes UK. 26,378 diabetes-related lower limb amputations in the last three years, 2018. Accessed 22 July2020. Available from https://www.diabetes.org.uk/about_us/news/lower-limb-amputations
13. Claessen H, Avalosse H, Guillaume J, et al. Decreasing rates of major lower-extremity amputation in people with diabetes but not in those without: a nationwide study in Belgium. Diabetologia 2018;61:1966–1977 [PubMed: 29909501]
14. Claessen H, Narres M, Haastert B, et al. Lower-extremity amputations in people with and without diabetes in Germany, 2008–2012 - an analysis of more than 30 million inhabitants. Clin Epidemiol 2018;10:475–488 [PubMed: 29719421]
15. Ali MK, Bullard KM, Saaddine JB, Cowie CC, Imperatore G, Gregg EW. Achievement of goals in U.S. diabetes care, 1999–2010. N Engl J Med 2013;368:1613–1624 [PubMed: 23614587]
16. Epstein AJ, Polsky D, Yang F, Yang L, Groeneveld PW. Coronary revascularization trends in the United States, 2001–2008. JAMA 2011;305:1769–1776 [PubMed: 21540420]
17. Singh N, Armstrong DG, Lipsky BA. Preventing foot ulcers in patients with diabetes. JAMA 2005;293:217–228 [PubMed: 15644549]

18. Tricco AC, Ivers NM, Grimshaw JM, et al. Effectiveness of quality improvement strategies on the management of diabetes: a systematic review and meta-analysis. Lancet 2012;379:2252–2261 [PubMed: 22683130]

19. Margolis DJ, Hoffstad O, Nafash J, et al. Location, location, location: geographic clustering of lower-extremity amputation among Medicare beneficiaries with diabetes. Diabetes Care 2011;34:2363–2367 [PubMed: 21933906]

20. Goodney PP, Dzebisashvil N, Goodman DC, Bronner KK. Variation in the care of surgical conditions: diabetes and peripheral arterial disease: A Dartmouth Atlas of Health Care Series. The Dartmouth Institute, 2014

21. Lanting LC, Joung IM, Mackenbach JP, Lamberts SW, Bootsma AH. Ethnic differences in mortality, end-stage complications, and quality of care among diabetic patients: a review. Diabetes Care 2005;28:2280–2288 [PubMed: 16123507]

22. Golden SH, Brown A, Cauley JA, et al. Health disparities in endocrine disorders: biological, clinical, and nonclinical factors–an Endocrine Society scientific statement. J Clin Endocrinol Metab 2012;97:E1579–E1639 [PubMed: 22730516]

23. Spanakis EK, Shah N, Malhotra K, Kemmerer T, Yeh HC, Golden SH. Insulin requirements in non-critically ill hospitalized patients with diabetes and steroid-induced hyperglycemia. Hosp Pract (1995) 2014;42:23–30

24. Gregg EW, Hora I, Benoit SR. Resurgence in diabetes-related complications. JAMA 2019;321:1867–1868 [PubMed: 30985875]

25. Gurney JK, Stanley J, York S, Rosenbaum D, Sarfati D. Risk of lower limb amputation in a national prevalent cohort of patients with diabetes. Diabetologia 2018;61:626–635 [PubMed: 29101423]

26. Lavery LA, Hunt NA, Lafontaine J, Baxter CL, Ndip A, Boulton AJ. Diabetic foot prevention: a neglected opportunity in high-risk patients. Diabetes Care 2010;33:1460–1462 [PubMed: 20424223]

27. Schaper NC, Van Netten JJ, Apelqvist J, Lipsky BA, Bakker K; International Working Group on the Diabetic Foot (IWGDF). Prevention and management of foot problems in diabetes: a Summary Guidance for Daily Practice 2015, based on the IWGDF guidance documents. Diabetes Res Clin Pract 2017;124:84–92 [PubMed: 28119194]

28. Gregg EW, Sattar N, Ali MK. The changing face of diabetes complications. Lancet Diabetes Endocrinol 2016;4:537–547 [PubMed: 27156051]

29. Selvin E, Ali MK. Declines in the incidence of diabetes in the U.S.-real progress or artifact? Diabetes Care 2017;40:1139–1143 [PubMed: 28830954]

30. Nguyen AT, Sawant RV, Serna O, Esse T, Sansgiry SS. Medicare Part D insulin tiering change: impact on health outcomes. Am J Pharm Benefits 2016;8:e0

31. Riddle MC, Herman WH. The cost of diabetes care-an elephant in the room. Diabetes Care 2018;41:929–932 [PubMed: 29678864]

32. Paisey RB, Abbott A, Levenson R, et al. ; South-West Cardiovascular Strategic Clinical Network peer diabetic foot service review team. Diabetes-related major lower limb amputation incidence is strongly related to diabetic foot service provision and improves with enhancement of services: peer review of the South-West of England. Diabet Med 2018; 35:53–62 [PubMed: 29023974]

33. Piette JD, Kerr EA. The impact of comorbid chronic conditions on diabetes care. Diabetes Care 2006;29:725–731 [PubMed: 16505540]

34. Lavery LA, Wunderlich RP, Tredwell JL. Disease management for the diabetic foot: effectiveness of a diabetic foot prevention program to reduce amputations and hospitalizations. Diabetes Res Clin Pract 2005;70:31–37 [PubMed: 16126121]

35. Andes LJ, Li Y, Srinivasan M, Benoit SR, Gregg E, Rolka DB. Diabetes prevalence and incidence among Medicare beneficiaries - United States, 2001–2015.MMWR Morb Mortal Wkly Rep 2019;68:961–966

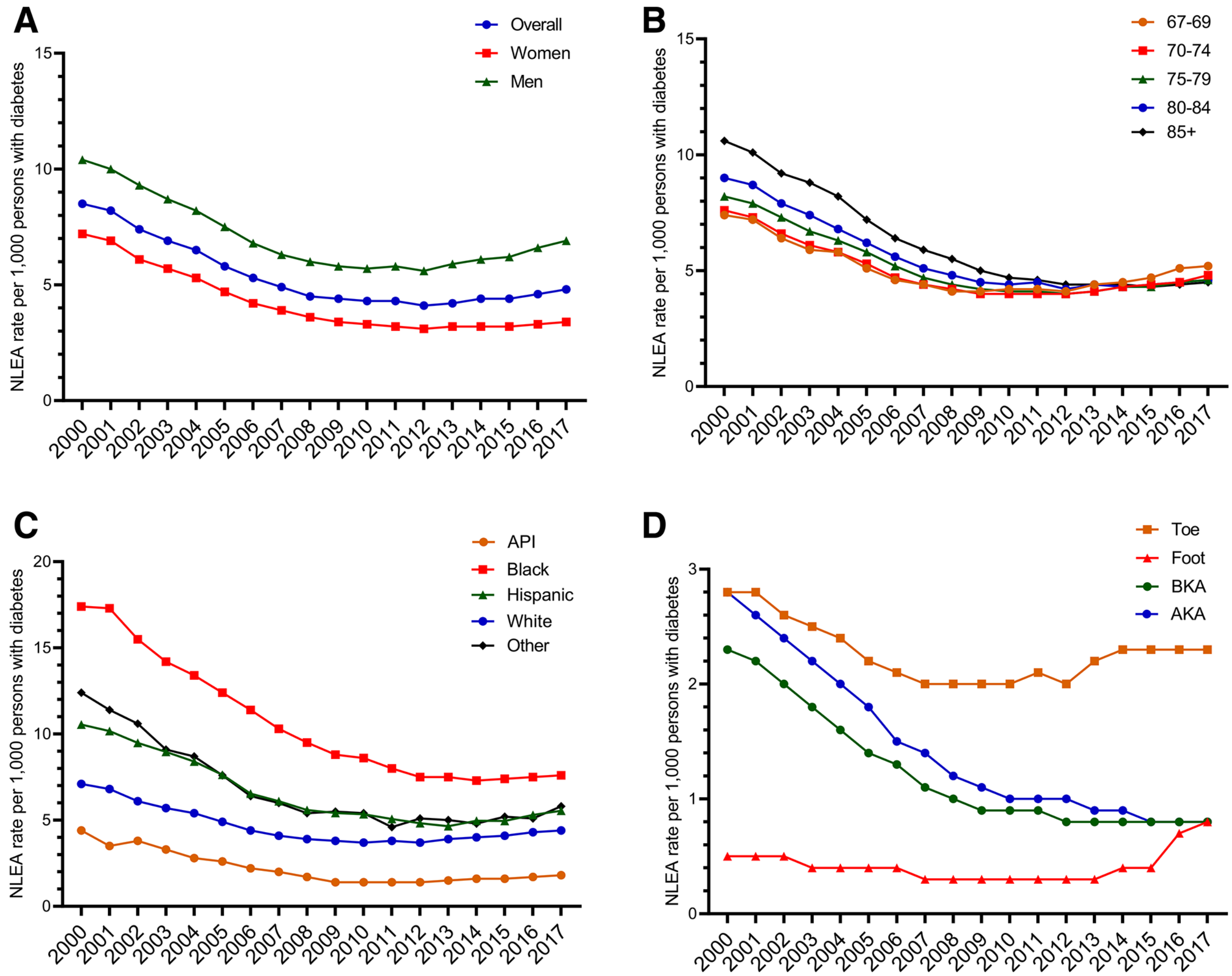

Figure 1—.

Trends in age- and sex-standardized NLEA rates among U.S. Medicare FFS beneficiaries with diabetes between 2000 and 2017 by sex (*A*), age-group (*B*), race/ethnicity (*C*), and NLEA level (*D*).

State	NLEA rates (per 1,000 people with diabetes) 2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Trend 1 Year	Trend 1 APC	Trend 2 Year	Trend 2 APC
National	8.5	8.2	7.4	6.9	6.5	5.8	5.3	4.9	4.5	4.4	4.3	4.3	4.1	4.2	4.4	4.4	4.6	4.8	2000-2009	-7.9	2009-2017	1.2
Louisiana	12.5	12.7	10.7	10.1	9.7	8.8	7.6	7.2	6.8	6.5	6.3	6.1	5.5	6	5.7	5.4	5.8	5.9	2000-2009	-7.9	2009-2017	-1.4
Mississippi	12.1	12.3	11.3	9.2	9.7	8.7	8.5	7.8	7.1	6.8	6.8	6.2	6.3	6.1	6.2	6	6	5.6	2000-2009	-6.6	2009-2017	-2.1
South Carolina	11.8	10.9	10	9.7	8.9	8.1	7.1	6.3	5	5.1	5.2	4.8	4.8	4.7	4.8	4.7	4.7	5	2000-2009	-9.4	2009-2017	-1
North Carolina	10.9	9.9	9	8.7	7.8	7.2	6.3	5.7	5.1	4.8	4.8	4.8	4.6	4.4	4.7	4.8	5	5.3	2000-2010	-8.5	2010-2017	1.8
Georgia	10.9	11.2	9.2	9	8.4	7.2	6.4	5.9	5	5	4.7	4.9	4.5	4.7	4.8	5	4.5	4.9	2000-2009	-9.4	2009-2017	-0.3
Texas	10.9	10.7	9.7	8.8	8.5	7.2	6.4	6	5.7	5.4	5.5	5.1	5.1	5	5.3	5.2	5.2	5.4	2000-2009	-8.3	2009-2017	0.1
Alabama	10	10.1	9.1	8.4	8.3	7.2	6.4	5.9	5.4	4.9	5.1	5.1	4.9	4.8	5	4.9	4.8	4.8	2000-2009	-8	2009-2017	-0.7
Arkansas	9.7	9.6	8.8	8.2	7.3	6.9	6.8	6.1	6	5.3	5.5	5	5	5	5.3	5	5.3	5.5	2000-2011	-6.2	2011-2017	1.8
Rhode Island	9.5	8.2	6.3	5.6	6.1	5.3	4.7	4.3	4.8	4.2	5	4.1	3.9	5.1	3.9	3.9	3.8	4.9	2000-2006	-10.6	2006-2017	-0.7
Pennsylvania	9.3	8.9	7.7	7.7	6.6	6.2	5.7	5.3	5	4.7	4.7	5.2	5	4.7	5.3	5.3	5.4	5.6	2000-2009	-7.6	2009-2017	2.4
Tennessee	9.3	8.8	7.8	7.7	6.8	6.1	5.5	5	5	4.5	4.4	4.1	4.1	4	4.5	4.2	4.6	4.5	2000-2010	-8	2010-2017	1.3
Wisconsin	9.2	8.8	7.2	6.6	6.7	6.6	5.7	5.3	5	5.3	5	5.2	5.1	5.1	5.4	5.9	5.6	5.7	2000-2008	-7.2	2008-2017	1.6
Virginia	9.1	9.3	7.8	7.8	7.2	6.2	6.1	5.7	5.4	5.1	4.8	4.5	4.4	4.7	4.7	4.5	5	5	2000-2011	-6.6	2011-2017	2
Maryland	9	9.2	7.7	7.6	7.3	6.3	5.7	5.3	5.1	5	4.9	4.2	4.3	4.6	4.4	4.5	4.7	4.6	2000-2011	-6.8	2011-2017	1.7
Massachusetts	8.6	8	6.8	6.5	6	5.2	4.7	4.4	3.8	3.9	3.8	3.7	3.8	3.9	3.9	4	4.5	4.3	2000-2009	-9.1	2009-2017	2.2
Connecticut	8.3	7.5	7.3	6.9	6.4	5.3	5.3	4.3	4.7	4	4.2	4.4	4.2	3.9	4.1	4.6	4.9	4	2000-2009	-7.8	2009-2017	1.1
Illinois	8.3	8.1	7.4	7	6.5	5.9	5.2	4.7	4.6	4.5	4.2	4.3	4.2	4.2	4.3	4.7	4.7	4.9	2000-2010	-7.2	2010-2017	2.6
Missouri	8.2	8.2	7.4	6.7	6.6	6.2	5.5	5.2	4.8	4.8	4.3	4.5	4.2	4.1	4.7	4.5	4.8	5.1	2000-2011	-6.3	2011-2017	3.3
Ohio	8.2	7.9	7.2	6.4	6.1	5.4	5.1	4.8	4.5	4	4.3	4.4	4.2	4.7	4.9	4.7	4.7	4.9	2000-2009	-7.5	2009-2017	2.4
Oklahoma	8.2	7.6	7.3	6.3	6.4	6.1	4.8	5	4.9	4.5	4.1	3.9	4.2	4.6	4.4	4.6	4.8	5.5	2000-2011	-6.5	2011-2017	5.2
Washington	8	6.6	6.8	6	5.7	5.3	4.8	4.5	4.4	4.5	3.9	4.4	4.4	4.7	4.8	4.3	4.6	5.1	2000-2008	-7.1	2008-2017	1.5
New Jersey	8	8	7	6.7	6.2	5.5	5	4.5	4.1	4	3.8	3.7	3.8	3.8	3.8	3.8	4.2	4.2	2000-2010	-8.1	2010-2017	2
West Virginia	7.9	7.3	6.8	5.6	5.6	4.9	4.6	4.9	4.1	4.2	3.7	4.2	3.8	4.2	4.4	4.5	4.4	4.9	2000-2010	-6.9	2010-2017	3.8
Kentucky	7.9	8	7.8	6.8	6.5	6.3	5.5	5.3	4.8	4.6	4.3	4.6	4.3	4.8	5.2	5	5	5.1	2000-2010	-6.3	2010-2017	2.5
Indiana	7.7	7.6	6.5	6.7	6	5.9	5.2	4.7	4.5	4.4	4.1	4.2	4.1	4.6	4.6	4.7	4.9	5.1	2000-2010	-6.5	2010-2017	3.3
Minnesota	7.6	6.8	5.8	5.9	5.1	5.5	4.5	3.7	4.5	4.7	4.5	4.4	4.5	4.9	4.9	5.6	6.1	6.4	2000-2007	-8.3	2007-2017	3.9
New York	7.6	7.3	6.7	6.5	5.9	5.2	4.7	4.3	4	3.7	3.5	3.6	3.5	3.5	3.4	3.5	3.8	3.9	2000-2010	-8.1	2010-2017	1.4
Delaware	7.6	7.8	7	6.4	5.4	5.6	5.4	4.7	4.5	3.6	3.9	3.7	3.5	4.2	4.3	4.3	3.9	4.3	2000-2010	-7.4	2010-2017	2
Colorado	7.6	6.9	6.7	5.7	5.8	5.2	4.5	4	4.5	4.4	4.7	4.7	4.4	4.4	4.4	4.7	4.9	4.6	2000-2007	-7.8	2007-2017	0.9
California	7.3	7	6.8	5.8	5.2	4.9	4.4	4.1	3.7	3.3	3.3	3.4	3.2	3.4	3.3	3.3	3.8	3.9	2000-2010	-8.5	2010-2017	2.7
Arizona	7.2	6.9	5.7	4.9	4.9	4.4	4	3.7	3.4	3.2	3.2	3.6	3.1	3.5	3.5	3.5	3.6	3.9	2000-2008	-9.5	2008-2017	1.5
Montana	7.2	7.4	6.2	5.1	4.8	5.3	3.5	6.2	4.7	4.4	4.6	3.9	3.9	4.3	4.2	4.8	4.8	5.8	2000-2012	-4.6	2012-2017	7.5
Vermont	6.9	9.3	7.6	6.7	6.4	5.3	5.7	4.9	5	5.3	5.7	4.9	5	4.9	5.3	5	5.6	5.2	2000-2007	-7	2007-2017	0.3
New Hampshire	6.9	5.5	6.3	6.3	5.6	5.1	4.9	4.2	4.7	3.6	3.7	4.3	3.7	4.8	3.7	4.6	4.7	4.6	2000-2010	-5.6	2010-2017	3.1
Florida	6.9	6.2	5.8	5.4	5.4	4.6	4	3.8	3.5	3.6	3.5	3.5	3.2	3.4	3.4	3.6	3.6	4	2000-2009	-7.8	2009-2017	1.5
New Mexico	6.8	7.9	6.8	5.7	6	5.1	4.8	3.8	4.1	4.5	4.3	4.1	4.1	4.1	4.5	3.5	4.5	5	2000-2008	-7.9	2008-2017	1.3
South Dakota	6.8	6.7	5.7	5.9	5.5	6.4	6.3	4.8	3.5	4.9	4.3	3.9	4.2	4	4.1	5.2	5.4	6.4	2000-2013	-4.4	2013-2017	13.4
Nebraska	6.8	7.6	6.9	5.4	6.1	5.5	4.6	5	5.3	5.7	5.4	5.3	4.5	4.4	5.6	5.1	5.4	6.6	2000-2013	-2.9	2013-2017	8
Hawaii	6.7	5.5	7.2	5.2	5.1	4.9	4.6	4.5	3.1	3.6	3.3	3.5	2.8	2.6	3.1	2.9	3.2	3.3	2000-2013	-6.8	2013-2017	5
Maine	6.7	8	6.6	6	5.7	5.2	4.7	4.4	4.4	4.2	3.6	4.2	5.2	5.4	5.4	6.1	5.6	5.4	2000-2009	-6.7	2009-2017	5.5
Oregon	6.6	5.9	6.1	5.6	5.4	5	4.4	4.2	4.8	3.7	3.6	4	4.4	4.2	4.8	4.7	4.9	5.5	2000-2010	-5.5	2010-2017	5.2
Kansas	6.6	7.2	7.3	5.9	5.7	5.5	4.8	4.4	4.3	3.8	4.4	3.9	3.9	3.9	4.5	4.7	4.7	4.8	2000-2009	-7.1	2009-2017	2.6
Iowa	6.5	6.3	6	5.4	5.1	4.9	5.3	4.8	3.9	3.9	4.1	4.1	3.6	4.1	3.8	4.7	4.4	4.6	2000-2012	-4.5	2012-2017	5
Idaho	6.5	5.2	4.9	6.1	5.3	3.6	4.4	4	4.2	3.8	3.2	3.7	4.2	3.9	4.8	5.2	5	5	2000-2010	-5.4	2010-2017	6.2
North Dakota	6.4	6	5	5	5	4.8	4.3	4.1	3.6	4.1	4.2	4.2	4.3	4.4	4.7	5.8	6.3	6.8	2000-2009	-5.7	2009-2017	7.4
Michigan	6.3	6	5.2	4.7	4.9	4.4	4	4	3.9	3.8	3.7	3.9	3.9	3.9	4.3	4.3	4.4	4.8	2000-2008	-6.4	2008-2017	2.5
Alaska	6.2	4.5	5.3	6	4.2	5.3	5.5	4	5.5	4.3	3.8	5.1	4	4.1	4.6	4.2	5.4	4.9	2000-2013	-2.3	2013-2017	5.5
Wyoming	6	7.5	4.9	5.1	6.3	6.2	5.4	5.2	4.2	4.2	4	5.1	3.6	4.6	4.5	4.2	5.6	5.8	2000-2012	-4.1	2012-2017	6.9
Utah	5.7	5.2	6.1	4.8	5.4	4.3	4.2	4.1	4.6	4.2	3.5	3.9	3.9	4.7	4.5	4.6	5.7	4.7	2000-2010	-4.2	2010-2017	4.6
Nevada	5.5	5.8	5.4	5	4.5	4.5	3.3	3.7	3.2	4.2	3.4	3.6	3.3	3.5	3.2	3.2	3.7	3.8	2000-2007	-7.4	2007-2017	-0.2

Abbreviations: APC: annual percent change; NLEA: non-traumatic lower extremity amputation

Legend

Heat Map of NLEA Rates

Max Value*	50th Percentile	Min Value	*Min and max values based on 2000 estimates

Direction of NLEA Trends

Decline, p<0.05	Non-significant decline, p>0.05	Non-significant increase, p>0.05	Increase, p<0.05

Figure 2—.

Heat map of trends in age- and sex-standardized NLEA rates among U.S. Medicare FFS beneficiaries with diabetes between 2000 and 2017 by state.

Table 1—

Demographic and comorbidity characteristics of the U.S. Medicare FFS population with diabetes between 2000 and 2017

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	APC
n (in millions)	4.6	4.8	5.2	5.6	5.9	6.2	6.3	6.3	6.3	6.4	6.5	6.7	6.8	6.8	6.8	6.8	6.9	6.9	—
Men	41.9	42.3	42.7	43.1	43.4	43.7	44.1	44.4	44.6	44.8	45.0	45.2	45.5	45.8	46.2	46.7	46.9	47.3	0.7*
Race/ethnicity																			
White	78.9	78.7	78.4	78.1	78.0	78.4	79.0	79.1	78.8	78.3	77.8	77.4	77.1	77.0	77.2	77.4	77.1	76.7	−0.2*
Black	11.2	11.2	11.3	11.3	11.3	11.2	10.9	10.5	10.4	10.5	10.6	10.8	10.9	10.9	10.8	10.8	10.8	10.7	−0.3*
Hispanic	7.5	7.7	7.7	7.8	7.7	7.3	6.8	6.8	7.0	7.1	7.3	7.4	7.4	7.4	7.2	7.0	7.1	7.3	−0.2*
API	1.6	1.7	1.8	1.9	2.0	2.2	2.3	2.5	2.7	2.8	2.9	3.0	3.1	3.2	3.2	3.2	3.4	3.6	7.5*
Other	0.8	0.8	0.8	0.9	0.9	1.0	1.1	1.1	1.2	1.3	1.3	1.4	1.4	1.5	1.6	1.6	1.7	1.7	7.3*
Age-group (years)																			
67–69	14.4	14.6	15.0	15.5	15.8	15.9	15.8	15.6	15.4	15.7	16.0	16.2	15.8	15.9	16.9	17.7	17.6	16.9	1.0*
70–74	27.5	27.0	26.6	26.2	26.0	25.7	25.6	25.6	25.9	25.9	25.8	25.9	26.3	26.5	26.4	26.2	26.9	27.8	0.1*
75–79	25.8	25.5	25.4	25.2	24.7	24.4	24.0	23.5	22.9	22.5	22.2	22.1	22.2	22.4	22.1	22.0	22.0	22.3	−0.8*
80–84	17.8	18.2	18.4	18.6	18.9	18.9	18.9	19.0	18.9	18.6	18.4	18.0	17.7	17.1	16.7	16.4	16.2	16.1	−0.6*
≥85	14.5	14.6	14.5	14.5	14.6	15.1	15.7	16.3	16.8	17.2	17.6	17.8	18.0	18.1	17.9	17.7	17.3	16.9	1.0*
Comorbidities																			
Liver	3.1	3.2	3.3	3.4	3.4	3.5	3.6	3.7	3.8	3.9	4.1	4.4	4.7	4.8	5.1	5.4	6.0	6.6	6.6*
PVD	17.9	18.2	18.5	18.7	19.0	19.4	19.9	20.2	20.5	20.9	21.1	21.5	21.7	21.5	21.3	21.8	23.6	23.9	2.0*
AMI	2.5	2.5	2.4	2.3	2.1	2.0	1.9	1.8	1.8	1.7	1.7	1.7	1.7	1.6	1.6	1.6	1.7	1.8	−1.7*
CKD	13.2	14.3	15.3	16.3	17.4	18.9	21.3	23.3	24.6	26.1	27.6	29.2	30.6	31.7	32.8	37.3	48.2	53.0	17.8*
COPD	14.4	14.6	14.8	15.2	15.3	15.8	15.7	15.7	15.6	15.6	15.6	16.3	16.2	16.2	15.9	16.3	16.4	16.6	0.9*
Hypertension	65.5	68.2	69.4	73.0	75.1	76.3	77.7	78.7	79.8	80.9	81.5	82.2	82.5	82.7	82.7	82.9	83.4	83.8	1.6*
Stroke	9.1	8.9	8.4	8.2	7.9	7.5	7.3	7.1	6.9	6.8	6.6	6.5	6.4	6.3	6.3	6.3	6.2	6.3	−1.8*
IHD	50.5	50.8	50.7	50.8	51.0	51.0	51.1	50.9	50.7	50.3	49.8	49.3	48.7	47.7	46.7	46.1	45.7	45.3	−0.6*

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	APC
Cancer	9.4	9.6	9.6	9.7	9.8	9.8	9.9	10.1	10.1	10.0	10.0	10.8	10.8	10.7	10.6	10.7	10.7	10.9	0.9*
Obesity	4.9	5.2	5.6	6.0	6.4	6.8	7.1	7.4	8.1	9.0	9.7	11.9	14.4	16.3	18.4	21.0	24.9	28.9	28.8*
Depression	10.0	10.5	10.8	11.3	11.5	11.5	11.9	12.3	13.2	13.7	14.3	15.9	16.6	17.1	17.8	18.7	19.0	19.9	5.8*
Hyperlipidemia	34.4	39.4	43.0	48.0	52.6	56.1	58.9	61.1	62.9	64.6	66.0	68.5	69.1	69.6	69.8	70.0	69.2	71.2	6.3*

Data are % unless otherwise indicated. AMI, acute myocardial infarction; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; IHD, ischemic heart disease; PVD, peripheral vascular disease.

* $P < 0.05$.