OBSERVATIONS

Drug Costs in Prediabetes and Undetected Diabetes Compared With Diagnosed Diabetes and Normal Glucose Tolerance: Results From the Population-Based KORA Survey in Germany

Andrea Icks, MD[1,2]
Heiner Claessen, PHD[2]
Klaus Strassburger, PHD[2]
Michael Tepel[2]
Regina Waldeyer, MSC[2]
Nadja Chernyak, PHD[1,2]
Bernd Albers, MSCN[2]
Christina Baechle, MSC[2]
Wolfgang Rathmann, PHD[2]
Christa Meisinger, MD[3]
Barbara Thorand, PHD[3]
Matthias Hunger, MSC[4]
Michaela Schunk, PHD[4]
Renée Stark, MD[4]
Ina-Maria Rückert, MPH[3]
Annette Peters, PHD[3]
Cornelia Huth, PHD[3]
Doris Stöckl, MD[3]
Guido Giani, PHD[2]
Rolf Holle, PHD[4]

From the [1]Department of Public Health, Faculty of Medicine, Heinrich-Heine-University, Düsseldorf, Germany; the [2]Institute of Biometrics and Epidemiology, German Diabetes Center at the Heinrich-Heine-University, Leibniz Center for Diabetes Research, Düsseldorf, Germany; the [3]Institute of Epidemiology II, Helmholtz Zentrum München, German Research Center for Environmental Health, Neuherberg, Germany; and the [4]Institute of Health Economics and Health Care Management, Helmholtz Zentrum München, Neuherberg, Germany.

Corresponding author: Andrea Icks, icks@ddz.uni-duesseldorf.de.

DOI: 10.2337/dc12-0997

Undetected diabetes and prediabetes are common (1–3). In decision analytic models of diabetes prevention and screening in particular, the differentiation in costs of detected, undetected, and prediabetic cases are important (4). To the best of our knowledge, no study has determined costs using population-based data with oral glucose tolerance test (OGTT)–based diabetes diagnosis.

We used the population-based Cooperative Health Research in the Region of Augsburg (KORA) follow-up survey, conducted in 2006–2008 in southern Germany (2,3) (n = 2,611, aged 40–82 years). By means of participants' self report and an OGTT, we identified individuals with previously diagnosed diabetes (n = 233, 57.9% male, mean age 67.8 ± 8.7), undetected diabetes (n = 109, 56.9% male, mean age 65.3 ± 10.4), and prediabetes (i.e., impaired glucose tolerance and/or impaired fasting glucose) (n = 489, 53.2% male, mean age 63.7 ± 10.4), and those with normal blood glucose values (n = 1,780, 45.6% male, mean age 56.3 ± 11.0) using the criteria suggested by the World Health Organization. Individuals with diagnosed diabetes have the lowest socioeconomic position and were most likely to be obese and to have cardiovascular disease (hypertension, angina pectoris, or a history of myocardial infarction or stroke) (2,3).

Using a well-established computer-assisted system (2,3), we assessed all medications taken regularly, including over-the-counter medication. Drug costs were taken from the official German price list (German equivalent of the Physicians' Desk Reference) on 1 April 2008, which was the end of the survey. We calculated mean crude and age- and sex-standardized medication costs per person and year, along with 95% CIs using bias-corrected accelerated bootstrapping procedures. Differences between the diabetes states by age- and sex-adjusted cost ratios for total as well as total without antihyperglycemic drugs and cardiovascular medication were estimated using multiple two-part regression models (5). We further adjusted for cardiovascular disease, BMI, and socioeconomic status, defined by educational level.

Costs (in euros) per person and year (95% CI) were 1,435.57 (1,041.56–2,880.98), 617.79 (489.79–797.29), 499.57 (428.78–600.04), and 332.37 (294.88–396.72) in participants with diagnosed diabetes, undetected diabetes, prediabetes, and normal glucose tolerance, respectively, and 1,277.64 (927.88–2,145.07), 501.41 (364.30–726.42), 451.66 (356.46–684.52), and 332.37 (295.50–396.71), respectively, after standardization. In the multivariate models, compared with individuals with normal glucose values, cost ratios were significantly increased in diagnosed diabetes (2.98 [95% CI 2.50–3.56]) and when antihyperglycemic drugs were excluded (2.30 [1.91–2.76]). They were also significantly increased in undetected diabetes and prediabetes (cost ratios for all medications 1.44 [1.13–1.83], 1.23 [1.06–1.42]), in particular for cardiovascular drug costs (1.84 [1.42–2.37], 1.49 [1.25–1.77]). Compared with individuals with diagnosed diabetes, costs were lower in both groups; this was also the case when antihyperglycemic medication was excluded (0.62 [0.47–0.81] and 0.53 [0.43–0.64]). Cost ratios differed markedly with age, with greater differences in participants aged 40–59 years compared with those aged 60–82 years, but not with sex. They decreased substantially after adjustment for cardiovascular diseases but remained mostly significant. Adjustment for BMI and socioeconomic status did not alter cost ratios.

Although the number of participants is limited, in the group with undetected diabetes in particular clear differences between the glucose tolerance stages could be observed. The strength of our study is the population-based sample and the identification of glucose tolerance stage by OGTT. Hence, these results may help to more validly estimate cost-effectiveness of screening and early treatment or prevention of diabetes.

Acknowledgments—No potential conflicts of interest relevant to this article were reported.

A.I. initiated the study, developed the study protocol, provided clinical expertise, and wrote the manuscript. H.C. performed the statistical analysis. K.S., M.H., and G.G. provided statistical expertise. M.T., B.A., and C.B. coordinated and performed the data management and analysis. R.W. and N.C. provided health economic expertise. W.R., I.-M.R., C.H., and D.S. contributed substantially to the discussion. C.M., B.T., and A.P. contributed to the acquisition of data. M.S. contributed to the data management and analysis. R.S. provided advice regarding medications. R.H. provided statistical expertise and coordinated and performed the data management and analysis. All authors commented on drafts of the manuscript. A.I. 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.

References

1. International Diabetes Federation. *The IDF Diabetes Atlas*. 5th ed. Brussels, International Diabetes Federation, 2011
2. Rathmann W, Haastert B, Icks A, et al. High prevalence of undiagnosed diabetes mellitus in Southern Germany: target populations for efficient screening. The KORA survey 2000. Diabetologia 2003;46:182–189
3. Meisinger C, Strassburger K, Heier M, et al. Prevalence of undiagnosed diabetes and impaired glucose regulation in 35-59-year-old individuals in Southern Germany: the KORA F4 Study. Diabet Med 2010;27:360–362
4. Gillies CL, Lambert PC, Abrams KR, et al. Different strategies for screening and prevention of type 2 diabetes in adults: cost effectiveness analysis. BMJ 2008;336:1180–1185
5. Welsh AH, Zhou XH. A computer program for estimating the re-transformed mean in heteroscedastic two-part models. Comput Methods Programs Biomed 2008;90:210–216