Mortality by Race Among Low-Income Adults With Early-Onset Insulin-Treated Diabetes

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OBJECTIVE—To determine if long-term mortality rates in early-onset insulin-treated diabetes differ by race among adults of similar socioeconomic status.

RESEARCH DESIGN AND METHODS—A total of 391 (299 African Americans, 92 whites) mostly low-income adults 40–79 years of age with insulin-treated diabetes diagnosed before 30 years of age were recruited from community health centers in the southeast U.S. Cox models were used to estimate hazard ratios (HRs) of all-cause mortality among African Americans compared with whites. Additionally, standardized mortality ratios (SMRs) were used to compare the mortality experience of the individuals with diabetes with both national and general community health center sex- and race-specific population norms.

RESULTS—Mean age at diabetes diagnosis and cohort entry, respectively, was 21 and 50 years in African Americans and 19 and 51 years in whites. During an average of 6.7 years of follow-up, 29% of African Americans and 35% of whites died. In multivariable analysis, no significant mortality difference was observed among African Americans compared with whites (HR 0.83 [95% CI 0.53–1.30]; $P = 0.51$). Compared with the race-specific U.S. general population, SMRs for those with diabetes were 5.7 in African Americans and 11.7 in whites. However, when compared with the same source population (i.e., the community health center population), SMRs were 3.5 and 3.7 in African Americans and whites, respectively.

CONCLUSIONS—Elevated mortality persists in men and women with long duration of early-onset insulin-treated diabetes, but given survival to 40 years of age and similarly low economic status and access to health care, our data do not suggest a racial disparity in mortality.

Diabetes Care 36:3107–3112, 2013

Population studies of young-onset insulin-treated diabetes consistently demonstrate that these individuals have a higher mortality relative to the general population (1–4). Age-standardized mortality rates range from two to five times higher in Western nations (2,5–8) compared with their respective national general population rates, with higher excess mortality rates generally observed in the U.S. than in Europe. The higher mortality rates in the U.S. compared with European countries have been suggested to be due to differences in access to health care and health care costs to the individual with type 1 diabetes (5).

Mortality rates in the U.S. have been reported to be more than three times as high in African Americans than in whites with insulin-treated young-onset diabetes (1,9). However, in the U.S., access to health care is delineated by socioeconomic status (SES) factors, and SES is confounded with race. African Americans account for only a small fraction of the type 1 diabetes cases observed in the U.S. and thus cannot explain the differential mortality excess observed between the U.S. and European populations. We have recently observed a fourfold excess mortality rate in a low-income, largely African American cohort with long duration of insulin-treated young-onset diabetes compared with similarly low-income individuals without diabetes and with similar access to care (10). The purpose of the current study is to help determine whether racial differences in mortality persist in African Americans and whites with long duration of insulin-treated young-onset diabetes when SES and access to care are similar. The study draws on a multicenter population from a relatively underserved and understudied racially diverse, but socioeconomically similar, population in the southeastern U.S. (i.e., individuals receiving health care from federally qualified health centers serving the socioeconomically disadvantaged).

RESEARCH DESIGN AND METHODS

The Southern Community Cohort Study (SCCS) is a population-based study designed to investigate causes of health disparities among African Americans and whites in the incidence and mortality of cancer and other chronic diseases. Details of the rationale, study design, and methods have been described previously (10). Briefly, between 2002 and 2009, 64,093 participants 40–79 years of age were recruited from community health centers from 12 states in the southeast U.S. Community health centers (i.e., federally qualified health centers) are government-funded health care facilities offering basic health care services to the medically underserved (11). Community health centers serve uninsured, underinsured, underserved, and socioeconomically disadvantaged individuals, with fees for services on a sliding scale based on family income and size.

After obtaining informed consent, participants completed a 40–60 min in-person interview that collected data on medical history, lifestyle, and socioeconomic factors. If participants answered "yes" to the question, "Has a doctor ever told you that you have diabetes or high blood sugar?", they were asked questions

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Received 25 January 2013 and accepted 17 April 2013.
DOI: 10.2337/dc13-0221
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about age at diabetes diagnosis, insulin use, and use of other hypoglycemic agents. Of the 13,843 individuals who reported having a physician diagnosis of diabetes, 1,149 indicated that they were diagnosed with diabetes before 30 years of age. Among these individuals, those on insulin therapy and using no other hypoglycemic agent at the time of their enrollment into the SCCS were classified as having early-onset insulin-treated (presumed mainly type 1) diabetes. After exclusion of 9 individuals reporting race/ethnicity other than white only or black/African American only, 391 individuals formed the main cohort for the analyses presented in this report. The 48,181 African Americans and whites without diabetes formed our reference population.

Mortality status was determined from linkages of the entire SCCS with the Social Security Administration administrative records and the National Death Index. National Death Index files were current only through 2010, while Social Security Administration files included deaths through 9 July 2012. Both sources were used to ensure the maximal amount of mortality ascertainment. Participants were followed until 9 July 2012, when mortality was censored.

General linear models were used to test for differences in continuous variables in the four sex/race groups, and χ^2 tests were used to test for differences in categorical data. Cox proportional hazards modeling, using age as the time scale, was used to estimate hazard ratios (HRs) and accompanying 95% CIs of mortality. Due to the small sample sizes in individual sex-race groups, groups were combined for multivariable analysis of predictors of mortality. The basic model included terms for race (African American, white) and sex, with a full model adding terms for BMI, BMI-squared, history of heart attack or coronary artery bypass surgery (yes/no), stroke/transient ischemic attack (TIA) (yes/no), hypertension (yes/no), high cholesterol (yes/no), education (<12 years, ≥12 years), annual household income (<$15,000, ≥$15,000), and a history of cigarette smoking (yes/no). Cox proportional hazards modeling, using age as the time scale, was also used to determine the overall impact of early-onset insulin-treated diabetes on mortality by comparing mortality risk with the 48,181 SCCS participants without diabetes. The criterion for statistical significance was a two-tailed *P* value of <0.10 for multiplicative interaction and <0.05 otherwise.

Standardized mortality ratios (SMRs) were calculated by dividing the numbers of deaths observed among the diabetes patients by the numbers expected based on the general U.S. population or SCCS rates and accompanying 95% CIs computed (12). Expected numbers of deaths among the cohort classified by sex and race were determined by multiplying the age-, sex-, and race-specific person-years of follow up of the diabetes cohort by two sets of standard rates: *1*) the age-, sex-, and race-specific total mortality rates in 2005 for the general U.S. population and *2*) the age-, sex-, and race-specific total mortality among SCCS participants (n = 64,093). Our diabetes cohort included only two participants in the 75–79-year age-range, both African American women, and thus SMRs were restricted to those 40–74 years of age.

RESULTS—Characteristics of the study participants by race and sex are presented in Table 1. On average, whites were slightly younger than African Americans at diabetes diagnosis (19 vs. 21 years) and had an ~4-year longer duration of diabetes at study baseline. Mean BMI did not differ by race (P = 0.70), but was significantly higher in females than in males ($P < 0.0001$). At an average of 50 years of age and an average duration of diabetes of 29 years at study baseline, prevalent comorbidities were common: 20% reported a history of heart attack or coronary artery bypass surgery, 15% stroke/TIA, 22% cataracts, 11% glaucoma, 79% hypertension, and 50% hypercholesterolemia. The prevalence of these conditions tended to differ by race, with whites more likely to report heart disease and hyperlipidemia and African Americans more likely to report hypertension. Thirty-eight percent of participants had less than a high school education, and 71% had an annual household income of <$15,000, with no differences observed by race (P = 0.27 for education and P = 0.89 for income).

During an average of 6.7 years of follow-up, 28.8% (n = 85) of the African American and 34.8% (n = 32) of the white population died. Median age at death was 53.4 years (53.4 years in African Americans and 53.3 years in whites). Univariate predictors of mortality in those with early-onset insulin-treated diabetes are presented in Table 2. Univariate predictors of mortality included sex, high cholesterol, and a history of smoking. A U-shaped relationship existed between BMI and mortality.

Multivariable predictors of mortality in those with diabetes are presented in Table 3. In analyses which controlled for sex, BMI, heart disease, stroke/TIA, hypertension, hypercholesterolemia, a history of smoking, education, and income, no significant difference in mortality was observed between African Americans and whites (HR 0.83 [95% CI 0.53–1.30]) (Table 3). Male sex and a history of stroke/TIA were significant predictors of mortality, while high cholesterol, hypertension, and ischemic heart disease were not. Formal tests of interaction suggested effect modification by race on the impact of a history of stroke/TIA on mortality ($P <$ 0.10). Whites with a history of stroke/TIA were three times more likely to die than those without a history of stroke/TIA (P = 0.005), whereas African Americans with a history of stroke/TIA were at an ~44% greater risk than African Americans without a history of stroke/TIA (P = 0.27) (data not depicted). Effect modification by income was also observed. In the ~70% of the participants with an annual household income of <$15,000, there was no difference in mortality risk in African Americans and whites (HR 0.96 [95% CI 0.57–1.61]; P = 0.87), whereas among those with annual household income of at least $15,000, African Americans had about a 60% lower risk (HR 0.38 [95% CI 0.18–0.81]; P = 0.01). No other effect modification by race was observed.

SMRs according to race and sex are presented in Table 4. The numbers of deaths were 11.7 times higher than expected in whites and 5.7 times higher in African Americans with insulin-treated young-onset diabetes than the general U.S. race-specific population. When the SCCS general community health center mortality experience was used as the reference, however, SMRs were similar across race groups: whites (SMR 3.7) and African Americans (SMR 3.5). Results similar to the general community health center–referent SMRs by race group were observed when analyses were run using unadjusted Cox models with age as the time scale to compute HRs comparing those with insulin-treated young-onset diabetes to the SCCS general community health center population without diabetes (Table 4).

Table 5 shows the independent effect of early-onset insulin-treated diabetes on

Table 1—*Baseline characteristics of the study population by sex and race*

	Males		Females		
	White (*n* = 25)	African Americans (*n* = 106)	White (*n* = 67)	African Americans (*n* = 193)	*P* value, group heterogeneity
Mean age (years)	50.0 (8.6)	48.6 (6.4)	51.7 (8.2)	50.5 (8.1)	0.06
Mean age at diagnosis (years)	18.4 (9.3)	21.8 (6.6)*	18.8 (8.0)	21.3 (6.6)	0.01
Mean diabetes duration (years)	31.0 (12.3)	26.3 (9.2)*	32.3 (10.9)	28.8 (10.2)	<0.01
Median BMI at age 21 years (kg/m^2)	25.4 (22.4–27.9)	25.8 (22.9–31.1)	22.4 (19.8–27.5)	24.4 (21.3–28.8)	0.08
Median current BMI (kg/m^2)	26.4 (24.5–31.9)	27.8 (24.5–32.7)	30.9 (26.2–37.4)*	32.9 (27.9–39.1)†	<0.01
Hypertension	60.0 (15)	80.2 (85)*	70.2 (47)	82.9 (160)†	0.02
Hypercholesterolemia	68.0 (17)	44.8 (47)*	59.7 (40)	47.7 (92)	0.06
Ischemic heart disease	36.0 (9)	20.0 (21)	31.3 (21)	14.0 (27)†	<0.01
Stroke/TIA	20.0 (5)	7.6 (8)	19.4 (13)	16.1 (31)	0.10
Glaucoma	4.0 (1)	11.3 (12)	13.6 (9)	11.5 (22)	0.64
Cataract	24.0 (6)	14.2 (15)	32.3 (21)	23.4 (45)	0.05
History of smoking	56.0 (14)	67.0 (71)	64.2 (43)	42.5 (82)	<0.01
Current smoker	32.0 (8)	42.5 (45)	37.3 (25)	25.4 (49)	0.02
Education <12 years	44.0 (11)	36.8 (39)	28.4 (19)	40.9 (79)	0.28
Annual household income <$15,000	60.0 (15)	70.9 (73)	74.2 (49)	71.9 (138)	0.60

Data are presented as mean (SD), median (IQR), or percent (*n*). *$P < 0.05$, †$P < 0.01$, with white males as the reference.

mortality risk. Using age as the time scale and accounting for sex, BMI, hypertension, high cholesterol, ischemic heart disease, stroke/TIA, a history of smoking, education, and income, in these patients mainly with presumed type 1 diabetes there was a fourfold increased mortality risk in African Americans and a fourfold increased risk in whites compared with the race-specific SCCS population without diabetes. This suggests there was no racial difference in the impact of presumed type 1 diabetes on mortality risk.

Table 2—*Univariable risk factors of mortality in African Americans and whites with type 1 diabetes, Cox proportional hazards models*

	HR (95% CI)
Race, African American	0.76 (0.51–1.15)
Sex, female	0.67 (0.46–0.96)
BMI*	0.85 (0.74–0.98)
BMI-squared*	1.04 (1.00–1.09)
Ischemic heart disease	1.25 (0.82–1.92)
Stroke/TIA	1.50 (0.95–2.36)
Hypertension	1.30 (0.80–2.09)
High cholesterol	1.47 (1.01–2.14)
History of smoking	1.55 (1.07–2.25)
Education <12 years	1.04 (0.71–1.51)
Annual household income <$15,000	1.28 (0.84–1.95)

*Normalized BMI = (BMI − median BMI)/5.

CONCLUSIONS—African Americans with insulin-treated young-onset diabetes have reported mortality rates more than three times as high as their similarly aged white counterparts, despite nearly all deaths in the African Americans being diabetes-related (8,13). Little mortality data are available, however, on African Americans with insulin-treated young-onset diabetes of long duration. In this report, we have documented the mortality experience of middle-aged and elderly individuals with insulin-treated young-onset diabetes recruited from government-funded community health centers in the southeast U.S. who survived to at least 40 years of age. Although we found a high prevalence of cardiovascular and other comorbidities that appeared to vary by race, we did not find a racial difference in risk of mortality in this population with mainly presumed type 1 diabetes. Our data indicate that when SES and access to care are similar, among long-term survivors of early-onset insulin-treated diabetes over 40 years of age, the racial disparity in subsequent mortality is not apparent.

Population-based studies of type 1 diabetes in the U.S. have consistently shown increased mortality rates compared with the general population (1–4,6,14). In the New Jersey 725, a population of African Americans with type 1 diabetes, mortality rates were 6 and 12 times higher for men and women, respectively, compared with the general U.S. African American male and female population (4). A recent report from Allegheny County, PA revealed similar fivefold or greater excess mortality, compared with general population norms, among both African Americans and whites with type 1 diabetes surviving ≥30 years (8). However, only 52% of the African American but 82% of the white patients were still alive after this length of follow-up. African Americans with type 1 diabetes were more likely than whites to die of acute complications, and all deaths among African Americans compared with 83% among whites were diabetes related (13). Mortality after short duration of diabetes is more likely to be due to acute complications. This too may be confounded by SES, and our data cannot directly address whether short-term

Table 3—*Multivariable risk of mortality in African Americans and whites with type 1 diabetes, Cox proportional hazards models*

	Base model	Full model
Race, African American	0.75 (0.50–1.13)	0.83 (0.53–1.30)
Sex, female	0.67 (0.46–0.97)	0.64 (0.43–0.97)
BMI*		0.87 (0.75–1.02)
BMI-squared*		1.05 (1.01–1.10)
Ischemic heart disease		1.09 (0.69–1.72)
Stroke/TIA		1.69 (1.02–2.80)
Hypertension		1.15 (0.69–1.93)
High cholesterol		1.37 (0.91–2.07)
History of smoking		1.29 (0.86–1.93)
Education <12 years		0.88 (0.59–1.31)
Annual household income <$15,000		1.22 (0.78–1.91)

Data are HR (95% CI). *Normalized BMI = (BMI − median BMI)/5.

versus long-term mortality varies by race. However, in our population of socioeconomically similar patients, the mortality risk among long-term survivors of early-onset insulin-treated diabetes was similar between African Americans and whites, whereas SMRs compared with the race-specific general U.S. population were greater in whites. When the reference population was restricted to the more specific SCCS community health center source population, however, African Americans and whites were at a similar three- to fourfold increased risk compared with the sex- and race-specific SCCS community health center general population. These findings suggest that SES accounts for the bulk of the racial differences in mortality within U.S.-based type 1 diabetes populations.

We hypothesized that within the U.S., ethnic differences in mortality in individuals with type 1 diabetes might be related to health care access and/or cost. A major strength of the current study design was that by recruiting from community health centers, we were able to control for both SES and access to health care in comparisons of mortality by race (i.e., all of our study participants were of similarly low SES and were also receiving health care at similar facilities). Our finding of no increased mortality risk in African Americans compared with whites with insulin-treated young-onset diabetes thus strongly suggests that if whites are of similarly low economic status and have similar health care as African Americans, mortality in whites with type 1 diabetes is equally high.

We have refrained from calling our population a type 1 diabetes population due to the likelihood of some misclassification of diabetes type, particularly in our African American participants. African Americans are more likely to present with atypical diabetes (15,16) (i.e., diabetes with the clinical features of type 1 diabetes but absence of diabetes autoantibodies) as well type 1.5 diabetes (16) (i.e., the hybrid diabetes with the clinical, laboratory, and genetic admixture of features classic for both type 1 and type 2 diabetes) (17,18). African Americans are also more likely than whites to present with young-onset type 2 diabetes (19,20). We did not have data on date or age of insulin therapy initiation or data on C-peptide levels, and thus misclassification of diabetes type would be likely in some of our participants. Data on GAD antibodies were also unavailable; however, this is not likely to be of relevance in this population with an average diabetes duration of ~30 years. It should be noted, however, that reports indicating much higher mortality rates in African Americans compared with their white counterparts also did not have biochemical or immunological data on diabetes type, but were based on simple clinical definition (i.e., age at diabetes diagnosis and initiation of insulin therapy at diagnosis) (21).

A limitation of the study is the relatively small number of deaths observed (117 deaths), precluding calculation of race- or sex-specific rates by specific causes of death. This also limited our power to detect racial differences in mortality risk and risk factors as evidenced by the rather wide CIs. However, when stratified by very low income (i.e., <$15,000 per annum), the effect size was essentially unity for African Americans compared with whites in this very low-income category. The mortality benefit observed for African Americans was only observed in the minority, 29%, with an annual household income of at least $15,000. We have recently shown, however, that African Americans diagnosed with diabetes at or after 30 years of age have a significantly lower mortality rate than their white counterparts receiving care from community health centers, whereas no overall racial difference in mortality was observed in the general community health center population (22). Another limitation of our study was that ascertainment of diabetes was based on self-report, although review of medical records and HbA_{1c} levels for a sample of those reporting diabetes (not distinguishing by age at diagnosis) revealed that >96% of the cases were

Table 4—*SMRs (95% CI) and HRs (95% CI) by race in the SCCS type 1 diabetes population compared with the general population*

	Reference population			
	U.S. general population SMR (95% CI)	SCCS general health center population SMR (95% CI)	SCCS general health center population* HR (95% CI)	SCCS general health center population** HR (95% CI)
African Americans	5.7 (1.0–10.3)	3.5 (−0.18 to 7.11)	3.9 (3.1–4.8)	4.0 (3.19–4.98)
Whites	11.7 (5.0–18.4)	3.7 (−0.07 to 7.5)	4.1 (2.9–5.9)	4.0 (2.76–5.71)

*Those with diabetes not included in the reference population. **Adjusted for sex, baseline ischemic heart disease, stroke/TIA, high cholesterol, hypertension, BMI, a history of smoking, education, and income.

Table 5—*Multivariable-adjusted risk of mortality by race in those with type 1 diabetes versus those without diabetes**

	African Americans	Whites
Type 1 diabetes	3.99 (3.19–4.98)	3.97 (2.76–5.71)
Sex, female	0.57 (0.53–0.62)	0.54 (0.48–0.60)
BMI	0.81 (0.78–0.83)	0.88 (0.84–0.92)
BMI-squared	1.05 (1.04–1.06)	1.05 (1.04–1.07)
Ischemic disease	1.60 (1.41–1.81)	1.41 (1.20–1.67)
Stroke/TIA	1.36 (1.20–1.55)	1.47 (1.25–1.73)
Hypertension	1.56 (1.44–1.68)	1.35 (1.20–1.52)
High cholesterol	0.80 (0.73–0.87)	0.78 (0.69–0.88)
A history of smoking	1.43 (1.31–1.57)	1.83 (1.57–2.13)
Education <12 years	1.18 (1.09–1.27)	0.98 (0.88–1.11)
Annual household income <$15,000	1.50 (1.38–1.63)	1.78 (1.57–2.02)

Data are HR (95% CI). *Only those without diabetes were included in this reference population.

confirmed (23). Finally, participants were required to be a minimum of 40 years old at enrollment, and thus, we were studying only individuals with long duration of early-onset insulin-treated diabetes who survived to at least 40 years of age and could not evaluate racial differences in childhood or young adulthood. As this was a relatively long-duration cohort at baseline, the cohort likely suffers from survival bias. Survival bias would result in a cohort enriched with factors that rendered its members more resistant to the acute effects of diabetes or other mortality risk factors on mortality. If this bias was greater in African Americans than in whites, this may also have accounted for the null to nonsignificantly protective findings observed in African Americans in our study. However, given the increasing longevity of individuals with type 1 diabetes, understanding survival risk factors in the type 1 diabetes population surviving to middle age is important.

In conclusion, in middle-aged and elderly African Americans and whites with long duration of insulin-treated young-onset diabetes and similarly low SES and access to care, our data do not suggest a racial disparity in mortality.

Acknowledgments—The SCCS is supported by Grant R01-CA-092447 from the National Cancer Institute.

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

B.N.C. wrote the manuscript and analyzed the data. T.A.E. and M.E.M. reviewed the manuscript and contributed to the discussion. W.J.B. collected the data, contributed to the research design and methods and discussion, and reviewed and edited the manuscript for scientific content. B.N.C. 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.

Parts of this study were presented in abstract form at the 73rd Scientific Sessions of the American Diabetes Association, Chicago, Illinois, 21–25 June 2013.

The authors thank Ms. Xijing Han, International Epidemiology Institute, for statistical review and the participants of the SCCS for making this work possible.

References

1. Bosnyak Z, Nishimura R, Hagan Hughes M, et al. Excess mortality in Black compared with White patients with Type 1 diabetes: an examination of underlying causes. Diabet Med 2005;22:1636–1641
2. Skrivarhaug T, Bangstad H-J, Stene LC, Sandvik L, Hanssen KF, Joner G. Long-term mortality in a nationwide cohort of childhood-onset type 1 diabetic patients in Norway. Diabetologia 2006;49:298–305
3. Dawson SI, Willis J, Florkowski CM, Scott RS. Cause-specific mortality in insulin-treated diabetic patients: a 20-year follow-up. Diabetes Res Clin Pract 2008; 80:16–23
4. Roy M, Rendas-Baum R, Skurnick J. Mortality in African-Americans with Type 1 diabetes: The New Jersey 725. Diabet Med 2006;23:698–706
5. DERI Mortality Study Group. International analysis of insulin-dependent diabetes mellitus mortality: a preventable mortality perspective. The Diabetes Epidemiology Research International (DERI) Study. Am J Epidemiol 1995;142:612–618
6. Dahlquist G, Källén B. Mortality in childhood-onset type 1 diabetes: a population-based study. Diabetes Care 2005;28:2384–2387
7. Nishimura R, LaPorte RE, Dorman JS, Tajima N, Becker D, Orchard TJ. Mortality trends in type 1 diabetes. The Allegheny County (Pennsylvania) Registry 1965-1999. Diabetes Care 2001;24:823–827
8. Secrest AM, Becker DJ, Kelsey SF, LaPorte RE, Orchard TJ. All-cause mortality trends in a large population-based cohort with long-standing childhood-onset type 1 diabetes: the Allegheny County type 1 diabetes registry. Diabetes Care 2010;33: 2573–2579
9. Tull ES, Barinas E; Pittsburgh DERI Mortality Study Group. A twofold excess mortality among black compared with white IDDM patients in Allegheny county, Pennsylvania. Diabetes Care 1996;19: 1344–1347
10. Signorello LB, Hargreaves MK, Blot WJ. The Southern Community Cohort Study: investigating health disparities. J Health Care Poor Underserved 2010;21(Suppl.): 26–37
11. Hargreaves MK, Arnold CW, Blot WJ. Community health centers: their role in the treatment of minorities and in health disparities research. In *Multicultural Medicine and Health Disparities*. Satcher D, Pamies R, Eds. Columbus, The McGraw-Hill Companies, 2006
12. Woodward M. *Epidemiology: Study Design and Data Analysis*. Boca Raton, Chapman & Hall/CRC, 1999
13. Secrest AM, Becker DJ, Kelsey SF, Laporte RE, Orchard TJ. Cause-specific mortality trends in a large population-based cohort with long-standing childhood-onset type 1 diabetes. Diabetes 2010;59:3216–3222
14. Secrest A, Orchard T. Dramatically increased mortality in women and African Americans with long-standing type 1 diabetes. Diabetes 2010;59(Suppl. 1):A87
15. American Diabetes Association. Diagnosis and Classification of Diabetes Mellitus. Diabetes Care 2006;34(Suppl. 1):S62–S69
16. American Diabetes Association. Type 2 diabetes in children and adolescents. Diabetes Care 2000;23:381–389
17. Pozzilli P, Guglielmi C, Pronina E, Petraikina E. Double or hybrid diabetes associated with an increase in type 1 and type 2 diabetes in children and youths. Pediatr Diabetes 2007;8(Suppl. 9):88–95
18. Gilliam LK, Brooks-Worrell BM, Palmer JP, Greenbaum CJ, Pihoker C. Autoimmunity and clinical course in children with type 1, type 2, and type 1.5 diabetes. J Autoimmun 2005;25:244–250
19. Libman I, Arslanian S. Type 2 diabetes in childhood: the American perspective. Horm Res 2003;59(Suppl. 1):69–76
20. Liese AD, D'Agostino RB Jr, Hamman RF, et al.; SEARCH for Diabetes in Youth Study Group. The burden of diabetes mellitus among US youth: prevalence estimates from the SEARCH for Diabetes in Youth Study. Pediatrics 2006;118:1510–1518

21. Tajima N, LaPorte RE, Hibi I, Kitagawa T, Fujita H, Drash AL. A comparison of the epidemiology of youth-onset insulin-dependent diabetes mellitus between Japan and the United States (Allegheny County, Pennsylvania). Diabetes Care 1985;8(Suppl. 1):17–23
22. Conway BN, May ME, Blot WJ. Mortality among low-income African Americans and whites with diabetes. Diabetes Care 2012;35:2293–2299
23. Huizinga M, Elasy T, Villegas R, Signorello L, Blot W, Cavanaugh K. Validation of diabetes self-report and characteristics of undiagnosed diabetes in the Southern Community Cohort Study. Diabetes 2009;58(Suppl. 1):A279