Diabetes Mortality in Persons under 45 Years of Age

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Abstract: A detailed review of death certificates in Washington State for the years 1968–1979 was undertaken to analyze diabetes mortality for persons under 45 years of age. Diabetics in this age group had a mortality rate from medical causes eight times higher than that of the comparable general population. Almost one-third of the deaths were due to acute complications for which there is definitive medical therapy. Over the 12-year period there was no consistent decline in mortality rates or in deaths from acute complications, nor was there evidence of increased survivorship as reflected in the average age at death. Although residence in areas of sparse medical resources was not associated with high mortality rates, a significant proportion of deaths in all geographical areas occurred at home or before arrival at a hospital. Mortality rates and the proportion of deaths from acute, potentially preventable causes were higher in this study than in other recently published series, suggesting that early diabetes mortality may be a more serious problem than has been previously recognized. Diabetes mortality in this age group can be considered a "sentinel health event" and should call attention to potential problems in health care delivery. (*Am J Public Health* 1983; 73:1174–1177.)

Introduction

Despite advances in the treatment and understanding of diabetes mellitus (DM), many diabetics continue to die prematurely. In recognition of this problem, the National Diabetes Advisory Board has formulated national goals for the reduction of mortality from diabetes, particularly among the young[1]. As one approach to these goals, the Centers for Disease Control were instructed to establish, in selected states, demonstration projects whose purpose is to identify problems related to illness, mortality, and care patterns for diabetics and to implement programs to reduce detected problems. Washington State began its Diabetes Demonstration Control Project in late 1979. As part of the effort to assess the magnitude and distribution of DM-related problems in the state, a study was made of all deaths from 1968 through 1979 where DM was mentioned on the death certificate either as the underlying or as a contributory cause.[2] While that study showed a decline, over this time period, in both age-specific and age-adjusted death rates, the decline in persons under age 45 was not statistically significant and tended to flatten out after 1970. It was also evident that there was still considerable loss of life in this age group, and that diabetes as an underlying cause, and diabetic ketoacidosis (DKA) in particular, played a proportionately large role in these young deaths. We therefore decided to undertake a detailed review of all death certificates in Washington State during this 12-year time period for persons dying of diabetes under 45 years of age.

Although numerous studies of diabetes mortality in the United States have focused on patients associated with highly specialized treatment centers,[3,4] single, unique communities[5–7] or life insurance applicants,[8] the biases inherent in these studies preclude application of their results to a general population.

There were three purposes for this population-based study: 1) to estimate the magnitude and characterize the distribution of these deaths; 2) to examine trends over the 12-year study period; and 3) to examine, using available data, factors which may be related to early diabetic deaths.

Methods

The computerized file of death certificates for the years 1968 to 1979 maintained by the Washington State Department of Vital Statistics was used to identify diabetic deaths. If diabetes was mentioned as either the underlying or a contributory cause of death and if the decedent was under 45 years at the time of death, the death certificate was located and a copy was made. Of the 607 death certificates identified in this way, 15 were eliminated from the study because either they were incorrectly coded (e.g., diabetes insipidus, hyperglycinemia) or because the mention of diabetes was vague (e.g., "possible" diabetes, "family history of diabetes"). A hand search of all 1979 death certificates for persons under age 45 was made to detect how often diabetes appeared anywhere on the certificate but was not coded on the computer file used to identify cases. Two such occurrences were found, a 3.4 per cent underrecording rate. Because of this small error rate and the large expenditure of time and resources required for a hand search of all 12 years, we elected to not include such certificates in this study.

The selected 592 cases included all resident deaths as well as deaths of nonresidents which occurred in Washington State. Almost all of the certificates for out-of-state residents (n = 28) or out-of-state deaths of Washington residents (n = 23) involved the bordering states of Oregon and Idaho. Population-based rates were computed using only the 564 resident deaths.

All information on the death certificates, including written comments, was used to recode the cause of death. Each death was attributed to one, and only one, of the recoded causes. Death was attributed to: 1) diabetic ketoacidosis or acidosis (DKA/DA), 2) infection (including pneumonia), or 3) hypoglycemia when it appeared that one of these was, on the basis of pathogenesis or the sequence of events indicated on the death certificate, the first or primary condition leading to death. Likewise, death was classified as being due to 4) heart disease, 5) renal disease, or 6) cerebrovascular accident (CVA), depending on the most likely pathogenic sequence of the listed causes, diagnoses, and/or comments. For heart disease, in particular, we required that a reasonably specific diagnosis such as "myocardial infarc-

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tion" or "atherosclerotic heart disease" be mentioned. "Cardiac arrest" or similar terms were not sufficient.

In 29 cases, "diabetes" was listed as the only cause of death, with no mention of acidosis, ketoacidosis, coma, or any other accompanying condition. Although these deaths were presumptively due to metabolic crises, the exact etiology of these deaths could not be determined from the information given and these cases were classified separately as 7) "DM-only." Finally, in 56 cases, diabetes was mentioned as a contributory cause of death along with a more immediate condition which could not be considered as related to diabetes (e.g., cancer); this group was also classified separately as 8) "Non-DM."

When more than one reclassified cause might apply, we assigned the one which appeared to be the initiator of the chain of events leading to death. For example, if a certificate noted that ketoacidosis occurred following a myocardial infarction, we attributed the death to the initiating event, myocardial infarction. This resulted in a conservatively low estimate of acidosis and infections as causes of death. A similar problem arose in the case of persons who had both renal failure and myocardial infarctions (MI) (n = 20). These deaths were attributed to the MI, therefore underestimating the degree to which renal disease may have contributed to premature demise (Table 1).

Demographic data on the state population for each year between 1968–1979 were obtained from the state Office of Fiscal Management and from the Office of Public Health Laboratories and Epidemiology. Prevalence estimates by age group and sex from the National Health Interview Survey of 1978 (for the West) were applied to these population statistics to estimate the prevalence of diabetes in Washington State among persons under 45 years of age.[9] Together, these population and prevalence estimates provided the means to compute mortality rates both for the general population and for the estimated diabetic population in the under 45 age group.

Statistical analysis was performed using the MINITAB interactive statistical package. Unpaired t-tests were used to compare mean values; chi-square tests were used to evaluate contingency tables and to compare rates and ratios; and simple linear regression was used to test whether trend lines were significantly different from zero (no trend).

Results

The 564 resident deaths are equivalent to a mortality rate of 1.9 per 100,000 persons 0–44 years. If the three deaths in this series noted to be attributable to suicide (1) or complications of accidents (2) are omitted, the minimal mortality rate among diabetics from medical causes* was 408 per 100,000 diabetics, approximately eight times the death rate from medical causes for the equivalent general populations in Washington State during this time (52.4 per 100,000).

Table 2 shows the distribution of deaths by recoded cause. Cardiac and renal causes were responsible for the majority of deaths. DKA/DA and hypoglycemia accounted for 20.3 per cent, however, and the deaths due to infections and "DM-only" contributed an additional 12.3 per cent, suggesting that as many as one-third of the deaths in this age group may have been due to potentially reversible causes. When analyzed by age categories, the distributions of cause of death are quite distinct: acute complications are the principal causes for persons under 25 years; renal disease is the single most important cause among the 25 to 34 year old group; and heart disease becomes most significant starting with the group 35 years and over.

TABLE 1—Comparison of Frequency of Certain Complications Recorded on Death Certificates vs Assigned as a Cause of Death

Complication	Proportion of Deaths with Complication Noted Anywhere on Certificate	Proportion of Deaths Recoded as Due to Complication
	%	%
Acidosis/Coma	18	16
Infection	15	7
Cardiovascular Disease	29	27
Renal Disease/Failure	34	25

Although more deaths occurred among males, mortality rates for diabetics, based on the estimated prevalence of diabetes, were higher for females for all major categories except macrovascular complications (Table 3). Furthermore, the average age of death was lower for females for all major categories, and these differences were statistically significant when all categories were combined.

Ninety-four per cent of the deaths were among persons of the Caucasian race, which is almost exactly their proportion in the state. Among minorities, the distribution of deaths also paralleled the population distribution of the various non-White groups. The proportion of deaths due to certain acute, complications (DKA, hypoglycemia, and infection) was higher among Blacks and Native Americans (46.0 per cent) than among other races (31.8 per cent), but this difference was not statistically significant. The average age at the time of death did not differ by race.

Because of the higher concentration of medical resources in urban areas, we expected to find lower mortality rates and fewer deaths due to acute complications in metropolitan counties (SMSAs), in larger cities (population over 150,000), and particularly in the largest city in the state, Seattle. None of these expectations were supported by the data: mortality rates, as well as the proportion of deaths due to acute complications, were unrelated to area of residence, rural and urban rates being similar.

We expected to see a decline in mortality during the 12-year study period, reflecting improved understanding and treatment of diabetes during this time. Except for an observable decline in estimated prevalence-based mortality rates between 1968–69 and 1970–71 (Figure 1), no clear trend is apparent. Furthermore, when deaths are grouped by recoded cause, no discernible decrease is evident for any of the individual causes. We also found that the average age at death remained unchanged during the 12-year period for each of the eight recoded causes and for all causes combined.

Altogether, 23 per cent of the 592 deaths occurred at home or en route to the hospital; heart disease was responsible for 66 per cent of these deaths. Of the deaths from renal disease or stroke, however, only 7 per cent occurred at home, compared with almost one-third (29 per cent) of deaths due to acute diabetic complications (DKA, hypoglycemia, and "DM-only"). These proportions did not vary

*excluding deaths from accidents, suicides, and homicides.

TABLE 2—Distribution of Diabetes Deaths by Cause and Age

Cause of Death	Age Group 0–24 (n = 79) %	25–34 (n = 179) %	35–44 (n = 337) %	TOTAL (n = 592) %
DKA/DA	50.6	13.6	9.2	16.0
Infection	15.2	8.0	5.3	7.4
Hypoglycemia	6.3	2.8	4.5	4.2
Heart Disease	2.5	15.3	38.9	27.0
Renal Disease	10.1	44.3	19.0	25.3
Cerebrovascular Accident	—	5.7	6.8	5.6
"DM Only"	8.9	6.3	3.3	4.9
"Non DM-Related"	6.3	4.0	13.1	9.5
TOTAL	100	100	100	100

significantly between urban and rural areas or over the 12-year study period.

Discussion

Comparison of our data with standards or, at least, similar data from other sources is desirable. Such data are difficult to find, and comparing our results to others is hazardous due to difference in population characteristics, measurement, and classification systems. Nevertheless, comparison of mortality rates in this study with rates from a recently published report from the United Kingdom[10] indicates that diabetes mortality in the young in Washington State is conservatively 1½ to 2 times the British rate for a similar age group.

In this country, the most widely quoted data on diabetes outcomes has been generated from various series of patients from the Joslin Clinic. Based on an analysis of 9,214 deaths reported between 1956 and 1968, Marks and Krall noted that diabetic coma was responsible "in recent years" for only 1 per cent of deaths, and concluded that "in all age groups the proportion of deaths from diabetic coma is insignificant."[4] In this same series, infections, another potentially preventable cause of death, also accounted for less than 1 per cent of the deaths in the younger age groups.

Schenfield, *et al,* reviewed 1,274 diabetic deaths in Edinburgh and were able to reassure readers that in their population "death from coma is a comparatively rare event in known treated diabetic patients."[11] In that study, only three out of 22 coma fatalities were in patients under 45 years of age.

These data are strikingly different from the rates and proportions found in this study suggesting that diabetic mortality under 45 years of age in a general, unselected population is a more serious problem than has been previously recognized. Patients attending the Joslin Clinic are not representative of the larger population from which they are drawn.

The large proportion of deaths in our population due to acute causes is particularly disturbing. Unlike complications such as renal disease and myocardial infarction whose prevention is still controversial, there is no doubt that definitive medical therapy exists for the successful prevention and treatment of both diabetic acidosis and hypoglycemia.[12,13] This also could be true for some of the deaths attributed to infections and "DM-only."

We found no relationship between mortality and residence in areas of high availability of medical resources, suggesting that the problem is not simply a reflection of resource or specialized facility shortage. Likewise, the absence of a clear downward trend in mortality during the 12-year study period suggests that improvements in medical care during this time did not affect either mortality rates or the proportion of deaths due to acute causes (DKA, hypoglycemia).

Our data yield some evidence that there may be problems with regard to the process of care. A significant proportion of deaths from acute complications occurred at home or before arrival in the hospital, thus precluding the use of potentially lifesaving hospital-based treatment. Whether these out-of-hospital deaths were due to problems

TABLE 3—Comparison of Diabetes Mortality by Sex

	Males			Females		
	n	*Rate*[1]	*Mean Age*	*n*	*Rate*[1]	*Mean Age*
Acute Complications (DKA, "DM Only," Hypoglycemia)	81	84*	30.1	68	126*	27.6
Renal Failure/Disease	77	85*	33.9	73	130*	32.9
Macrovascular Disease (MI, CVA)	124	143	38.6	69	126	37.7
Other (Infections, "Non DM")	52	57	34.6	48	85	34.3
TOTAL	334	370*	34.8†	258	468*	33.1†

[1]based on resident deaths per 100,000 diabetics (estimated).
*difference between rates significant, $p < 0.05$.
†difference between mean age significant, $p = .0146$.

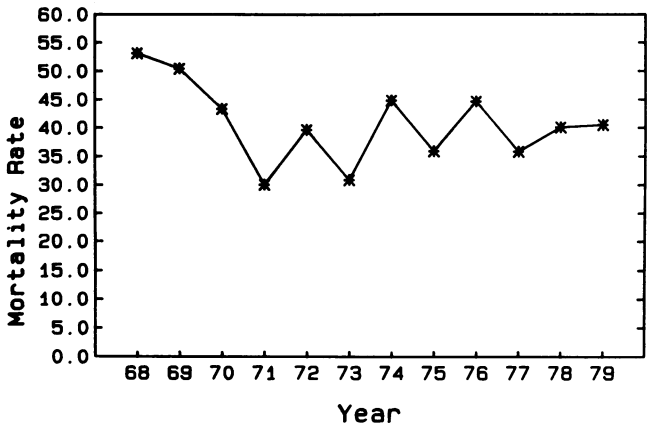

FIGURE 1—Mortality Rate per 10,000 Estimated Diabetics, Washington State, 1968–79

in access to care, problems with disease self-management, psychosocial difficulties, or poor treatment by providers is impossible to determine from death certificates.

The data for this study were derived from death certificates. Numerous authors have stressed the unreliability and marked underreporting of diabetes on death certificates.[8,14,15] Other authors[4,16,17] have indicated that underreporting is less of a problem among younger diabetics. Our data should be considered a conservative, possibly underestimating assessment of the magnitude of the problem.

Another potential source of error in our findings concerns our use of prevalence estimates. Insofar as these estimates are higher or lower than actual prevalence, our mortality rates (based on these estimates) will be biased downward or upward, respectively. Estimates from the National Health Interview Surveys indicate that prevalence rates of diabetes (<45 years of age) have increased nationally from 5.5 per 1000 in 1973 to 6.4 per 1000 in 1978.[18] On the other hand, the same surveys have shown an inconsistent pattern for the Western Region: for the 15 to 44 age group, the rate has actually declined somewhat from 10.6 per 1000 in 1973 to 8.9 per 1000 in 1978. For persons 0–44, the estimate was 5.2 per 1000 in 1975, 7.1 per 1000 in 1976, and 4.5 per 1000 in 1978.

Since it was not clear whether adjustments for potential temporal changes should be made on the basis of the more reliable national figures or the more appropriate regional figures, we chose, instead, to use a single non-varying prevalence rate estimate as the basis for our calculations. Recalculation of the prevalence based mortality rates in this study based on either national or regional trends in prevalence did not change the basic finding that there was no statistically significant trend in mortality rates (upward or downward) from 1970 to 1979.

It is also possible that during the study period changes in recording practices may have resulted in a bias of mortality rates, either upward or downward, although it seems unlikely that this would apply to the reporting of the acute (DKA, hypoglycemia) deaths.

The major component of the eightfold risk of death for diabetics compared to non-diabetics in this population was unquestionably due to biological factors which medical science is still searching for means to control. Nevertheless, the findings of this study suggest that a substantial proportion of these untimely deaths might be prevented by known medical therapy. We concur with Rutstein, *et al,* that "The occurrence of an unnecessary disease, disability or untimely death is a sentinel health event that justifies carefully controlled scientific search for remediable underlying causes."[19] This approach, as these same authors go on to illustrate, has been dramatically successful in reducing maternal mortality in this country and internationally. The opportunity exists to apply these principles to diabetes mortality as well. Studies are now underway in Washington State, as well as other states with CDC Diabetes Control Projects, to further identify factors associated with adverse diabetes outcomes. Careful investigation of untimely or potentially preventable diabetic deaths on a case-by-case basis may, as in the case of maternal deaths, be efficacious by itself in reducing mortality. Furthermore, based on this kind of information, programs can and have been implemented to promote better and more accessible care for diabetics, to provide quality patient education and improve the outlook for the ten million diabetics in the US.

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