The Natural History of Diabetes

I. Mortality

Tomio Hirohata, M.D., Brian MacMahon, M.D., and Howard F. Root, M.D., Boston

SUMMARY

Survival data are presented for five groups of diabetic patients seen at the Joslin Clinic, Boston, between 1939 and 1959. Patients were white, Massachusetts residents, and diagnosed diabetic within twelve months of first visit to the Clinic. The data are analyzed in terms of crude survival rates, relative survival ratios and mortality "attributable" to diabetes after the elimination of competing causes.

The excess mortality rate experienced by diabetic patients increases with duration of diabetes. While persons with juvenile onset experience virtually no excess mortality in the first fifteen years of the disease, between the fifteenth and the twenty-fourth year they have an excess death rate of 1 to 1.5 per cent per year. In the older age groups the excess is larger and appears earlier.

The mortality attributable to diabetes increases with increasing age of onset. Females have higher attributable mortality rates than males, particularly among cases with onset after forty years of age.

Patients first seen in 1944 had substantially better survival rates than those first seen in 1939. However, between 1944 and 1959 no further improvement has been evident. This leveling off in the former decline in diabetes mortality has occurred at a point when diabetic patients still experience an *excess* mortality of approximately 30 per cent within the first twenty-five years of their disease. DIABETES *16*:875-81, December, 1967.

A study has been conducted of the recent state of health of selected groups of diabetic patients seen at the Joslin Clinic, Boston, since 1939. Five starting cohorts of patients were defined from patients who were first seen 25, 20, 15, 10 and 5 years previously. Representative samples of the survivors of these cohorts were examined at the Clinic between October 1963 and June 1965. As a background to the interpretation of the morbidity found in the survivors, it seemed desirable to examine mortality rates in the five cohorts. The analysis of mortality rates has also more general interest in that, although there have been a number of previous studies of mortality of diabetic patients, notably those conducted on the entire population of this same Clinic by the Metropolitan Life Insurance Company,[1,3] the present data derive from a series that is generally more homogeneous, in terms of stage of disease and area of residence, and which relates more closely to the population from which expected mortality is computed.

From the Joslin Research Foundation and the Department of Epidemiology, Harvard School of Public Health, Boston, Massachusetts.

METHOD

The five cohorts, identified as the cohorts of 1939, 1944, 1949, 1954 and 1959, consisted of patients whose first visit to the Joslin Clinic occurred during an eighteen-month period centering on the index year. Thus, the cohort of 1939 included patients whose first visit occurred between Oct. 1, 1938 and March 31, 1940.

Attention was restricted to patients satisfying the following criteria:

1. Resident of Massachusetts
2. White
3. Having a definite diagnosis of diabetes mellitus made not more than one year prior to or subsequent to their first visit to the Joslin Clinic.

During the last forty years at the Joslin Clinic, every patient with suspicion of diabetes has had a history taken on a standard form and has had standard blood and urine tests. The final diagnosis of diabetes has been made by one of two persons (Dr. Elliott Joslin or HFR) after reviewing the data. The diagnosis has been based on chemical measurements of blood and urine indicating the presence of hyperglycemia and glycosuria. A history of typical diabetic symptoms such as polyuria or polydipsia anteceding the actual analyses of blood and urine has been used in estimating the date of onset of diabetes. Venous blood sugar values are used in establishing the diagnosis of diabetes in an individual with glycosuria as listed in the following table.

Downloaded from http://diabetesjournals.org/diabetes/article-pdf/16/12/875/335915/16-12-875.pdf by guest on 26 November 2022

Blood sugar levels (venous) diagnostic of diabetes during glucose tolerance tests

	"True glucose" (Somogyi-Nelson) (mg. per 100 ml.)	Folin-Wu values (mg. per 100 ml.)
Fasting	110	130
Peak value	150	170
Two-hour value	110	130

Glucose tolerance tests were seldom necessary for the diagnosis of diabetes, since glycosuria and fasting or random blood sugar levels above those in the preceding table were present in nearly all cases.

During the relevant time period (1939-1959), approximately 30 per cent of Joslin Clinic patients were not Massachusetts residents, and 47 per cent of Massachusetts residents attending the Clinic for the first time had had a diagnosis of diabetes made elsewhere a year or more previously. The first group is excluded because it is probably weighted with well-to-do and serious cases, and because of the difficulty of defining a comparable population for estimation of expected mortality rates. The second group is excluded because it overrepresents patients in whom complications have developed and precipitated contact with the Clinic.

Numbers of patients by age, sex and cohort are shown in table 1.

Follow-up was attempted by a variety of methods, including several mailings to and attempted telephone contacts with patients and referring physicians, search of death certificate files, town directories and motor vehicle registrations. Follow-up to Oct. 1, 1963 was obtained for 96.2 per cent. Most of the loss to follow-up occurred after 1961 when the Clinic temporarily discontinued its periodic follow-up mailings to patients. The loss did not vary substantially by cohort, except that the 1939 cohort had a lower percentage (2.4 per cent) than the other four (4.1, 4.0, 4.2 and 3.5 per cent, respectively).

The analysis was by standard life table technics, with special programming for a 7090 IBM computer. The following measures were computed:

1. *Effective number at risk of death (L'_x)*

The number alive at the beginning of the interval (L_x) less the product of the number of patients lost to follow-up during the interval and the proportion of the total interval during which they were lost. "Lost" includes persons alive on Oct. 1, 1963 but not followed to the specific anniversary month of their first clinic visit.

2. *Survival rate (P_x) and cumulative survival rate (CP_x)*

Number alive at the end of the interval as a percentage of L'_x. P_x was computed for each individual year of follow-up. Cumulative survival rates for intervals of several years are the products of the P_x's in the individual years.

3. *Expected survival rate (EP_x) and cumulative expected survival rate (CEP_x)*

For each individual in a group, survival probabilities were determined from Massachusetts life tables. Sex and single years of age and of time were considered, with increments of single years of age throughout the interval. Life tables were available by sex and single years of age for each decade, and linear interpolations were made for the years between. Survival probabilities of individuals were averaged to derive EP_x for the group. CEP_x is the product of the EP_x's in the individual years comprising the period.

4. *Relative survival ratio (RP_x) and cumulative relative survival ratio*

$$(CRP_x) = \frac{P_x}{EP_x} \text{ or } \frac{CP_x}{CEP_x}.$$

5. *Mortality rate attributable to (more strictly, associated with) diabetes (q_2)*

In the presence of two independent and competing causes of death,

TABLE 1

Number of patients by cohort (year of first visit), age and sex

Age (years)	1939 M	1939 F	1944 M	1944 F	1949 M	1949 F	1954 M	1954 F	1959 M	1959 F
0-19	27	42	46	43	35	49	58	43	86	70
20-39	41	42	103	42	44	39	57	37	60	40
40-59	92	106	190	199	190	181	176	160	184	165
60-79	48	90	79	139	110	168	115	147	113	151
80+	2	4	2	4	5	7	4	7	4	7
Total	210	284	420	427	384	444	410	394	447	433

Downloaded from http://diabetesjournals.org/diabetes/article-pdf/16/12/875/335915/16-12-875.pdf by guest on 26 November 2022

$$q_2 = \frac{Q - q_1}{I - q_1},$$

where q_1 and q_2 are the independent probabilities and Q is the total probability of dying from either or both.[4] In the present terms, Q is the complement of CP_x, and q_1 (the probability of death from causes other than diabetes) is the complement of CEP_x.

The formula reduces to:

$$q_2 = \frac{CEP_x - CP_x}{CEP_x}.$$

Standard errors were computed by conventional formulae for Items 2, and 4. These values are given in Appendix Tables A & B, page 881.

Date of first visit to the Clinic was used as the zero point. In this presentation, particular use is made of cumulative survival rates and cumulative relative survival ratios for the intervals 0-5, 0-10, 0-15, 0-20, and 0-25 years after first visit (i.e., percentage of survivors at the 5th, 10th, 15th, 20th and 25th anniversaries) and of cumulated mortality rates due to diabetes for the intervals 0-4, 5-9, 10-14, 15-19, and 20-24 years after first visit. Data for individual years of follow-up and for various other combinations of intervals are available.

In tables 2, 3 and 4, rates are shown for four broad age groups and for all ages combined. In addition, total age-adjusted rates are shown; these are in fact the means of the values for the four individual age groups; that is, they represent a total rate adjusted to a standard population with equal numbers in each of the four age groups.

RESULTS

Survival rates

Table 2 shows the percentages of the original cohorts surviving at successive quinquennial anniversaries of the first visit. These percentages are estimates of the probability of survival for patients of particular age and sex groups, but do not distinguish between the effects of diabetes and the general mortality to which the indi-

TABLE 2

Percentage of survivors (CP_x) at quinquennial anniversaries of the first visit, by cohort, sex and age

Age (years)	Anniversary (years)	Males: Year of first visit 1939	1944	1949	1954	1959	Males: All cohorts	Females: Year of first visit 1939	1944	1949	1954	1959	Females: All cohorts
0-19	5	100.0	100.0	100.0	98.3	98.8	99.2	97.6	95.3	98.0	97.7	95.4	96.7
	10	100.0	97.8	97.1	94.8	—	96.8	95.2	95.3	95.9	97.7	—	95.0
	15	100.0	95.7	97.1	—	—	95.9	92.9	95.3	95.9	—	—	94.7
	20	92.6	84.8	—	—	—	86.9	85.7	85.4	—	—	—	86.3
	25	85.2	—	—	—	—	80.0	80.9	—	—	—	—	81.7
20-39	5	95.1	99.0	100.0	100.0	98.2	98.7	92.7	97.6	94.9	97.3	97.4	95.9
	10	82.9	97.0	100.0	98.2	—	95.4	85.4	97.6	94.9	97.3	—	94.0
	15	80.5	91.9	97.7	—	—	90.5	80.5	88.1	94.9	—	—	88.8
	20	65.9	82.6	—	—	—	78.0	80.5	82.8	—	—	—	83.6
	25	58.3	—	—	—	—	68.1	75.3	—	—	—	—	78.2
40-59	5	88.0	89.5	92.1	93.8	85.5	90.0	90.6	92.9	92.2	93.1	91.3	92.2
	10	68.5	79.5	75.6	80.1	—	76.1	80.2	76.8	81.5	80.9	—	79.5
	15	57.6	64.1	55.7	—	—	58.5	66.0	61.2	62.9	—	—	61.5
	20	44.6	44.0	—	—	—	42.4	45.3	42.2	—	—	—	42.5
	25	28.6	—	—	—	—	29.9	31.4	—	—	—	—	28.0
60-79	5	68.8	81.0	72.5	73.8	79.0	75.4	71.9	64.6	79.8	72.3	77.8	73.8
	10	38.0	51.9	46.8	43.9	—	46.1	47.2	43.6	52.2	45.4	—	48.3
	15	18.0	26.7	29.2	—	—	24.1	21.5	26.1	30.1	—	—	26.5
	20	(4.0)	(13.4)	—	—	—	7.4	(5.4)	(10.9)	—	—	—	9.3
	25	(2.0)	—	—	—	—	3.7	(2.2)	—	—	—	—	3.3
All ages (crude)	5	86.7	91.4	87.5	89.3	87.3	88.6	85.1	84.2	87.2	85.4	87.5	86.0
	10	68.1	80.1	71.6	73.9	—	73.9	71.6	69.1	71.8	69.6	—	70.8
	15	58.1	67.1	56.2	—	—	60.2	57.5	55.5	56.3	—	—	56.1
	20	45.2	52.0	—	—	—	46.4	43.3	39.8	—	—	—	40.8
	25	35.4	—	—	—	—	37.4	35.5	—	—	—	—	32.5
All ages (adjusted)	5	88.0	92.4	91.2	91.5	90.4	90.8	88.2	87.6	91.2	90.1	90.5	89.7
	10	72.4	81.6	79.9	79.3	—	78.6	77.0	78.3	81.1	80.3	—	79.2
	15	64.0	69.6	69.9	—	—	67.3	65.2	67.7	71.0	—	—	67.9
	20	51.8	56.2	—	—	—	53.7	54.2	55.3	—	—	—	55.4
	25	43.5	—	—	—	—	45.4	47.5	—	—	—	—	47.8

Downloaded from http://diabetesjournals.org/diabetes/article-pdf/16/12/875/335915/16-12-875.pdf by guest on 26 November 2022

TABLE 3

Cumulative relative survival ratios (CRP_x) at quinquennial anniversaries of the first visit, by cohort, sex and age

Age (years)	Anniversary (years)	Males Year of first visit 1939	1944	1949	1954	1959	All cohorts	Females Year of first visit 1939	1944	1949	1954	1959	All cohorts
0-19	5	100.6	100.5	100.4	98.7	99.2	99.6	98.0	95.5	98.2	97.9	95.6	96.9
	10	101.2	98.8	98.1	95.6	—	97.7	96.0	95.8	96.3	98.1	—	95.5
	15	101.8	97.2	98.7	—	—	97.4	93.9	96.1	96.6	—	—	95.4
	20	95.0	86.8	—	—	—	88.9	87.1	86.5	—	—	—	87.4
	25	88.3	—	—	—	—	82.6	82.7	—	—	—	—	83.2
20-39	5	96.8	100.5	101.3	101.1	99.3	100.0	93.8	98.5	95.5	98.0	97.9	96.7
	10	86.3	100.5	103.1	100.8	—	98.5	87.6	99.7	96.2	98.9	—	95.7
	15	86.5	98.3	103.7	—	—	96.7	84.1	91.4	97.4	—	—	92.1
	20	74.4	92.8	—	—	—	87.6	86.2	87.8	—	—	—	89.0
	25	70.9	—	—	—	—	82.6	83.6	—	—	—	—	86.3
40-59	5	94.9	97.0	99.4	101.0	91.8	97.0	96.4	97.9	97.1	96.4	95.0	96.6
	10	82.0	96.7	91.2	96.3	—	91.6	92.8	86.8	92.2	89.0	—	89.3
	15	79.8	92.0	78.8	—	—	83.8	85.7	76.5	79.2	—	—	78.0
	20	75.8	79.6	—	—	—	76.7	69.3	61.1	—	—	—	63.9
	25	64.7	—	—	—	—	75.0	61.7	—	—	—	—	55.1
60-79	5	93.2	105.1	94.4	95.5	103.3	98.4	88.7	79.2	95.4	85.0	93.8	88.4
	10	78.8	95.3	87.3	80.9	—	87.2	77.6	70.5	80.4	67.9	—	75.2
	15	62.9	81.0	93.0	—	—	77.1	54.9	64.6	70.0	—	—	62.8
	20	(28.4)	(79.0)	—	—	—	47.8	(24.8)	(48.9)	—	—	—	40.3
	25	(38.3)	—	—	—	—	62.9	(24.7)	—	—	—	—	35.1
All ages (crude)	5	96.4	99.9	98.5	99.4	96.6	98.3	94.0	92.5	95.9	93.1	94.9	94.1
	10	85.6	97.8	93.4	94.0	—	93.2	88.7	85.2	89.3	85.0	—	86.9
	15	83.9	93.7	87.5	—	—	88.4	81.5	78.9	81.7	—	—	79.7
	20	76.7	85.5	—	—	—	81.7	72.2	67.6	—	—	—	69.7
	25	72.1	—	—	—	—	80.9	71.5	—	—	—	—	69.3
All ages (adjusted)	5	96.4	100.8	98.9	99.1	98.4	98.8	94.2	92.8	96.6	94.3	95.6	94.7
	10	87.1	97.8	94.9	93.4	—	93.8	88.5	88.2	91.3	88.5	—	88.9
	15	82.8	92.1	93.6	—	—	88.8	79.7	82.2	85.8	—	—	82.1
	20	68.4	84.6	—	—	—	75.3	66.9	71.1	—	—	—	70.2
	25	65.6	—	—	—	—	75.8	63.2	—	—	—	—	64.9

viduals would be exposed whether or not they had diabetes.

As might be expected from the last comment, prognosis is markedly affected by age. Over 95 per cent of patients under twenty years of age survive for ten years after the diagnosis of diabetes, but less than half of those over sixty years of age do so. This relationship is too obvious to warrant further comment, although the specific percentages may be useful as broad guidelines for clinical prognostic purposes.

There is no consistent difference in survival between the sexes. The slightly better survival for males seen in the total for all ages must reflect the more favorable age distribution of the male patients, since it is not seen in the age-adjusted rates. The 1939 cohort of males, in all age groups except the youngest, has lower survival rates than the subsequent cohorts. Otherwise, there are no trends in survival rates over time.

Relative survival ratios

The relative survival ratios shown in table 3 express the number of survivors in each group as a proportion of the number expected to survive on the basis of the life expectancy of persons of similar age and sex in the general population. They are, therefore, a measure of the extent to which survival is reduced by the diabetes itself. A group with a relative survival ratio of 100 per cent has experienced no excess mortality over general population rates.

The following observations may be made:

1. Patients under twenty years of age at diagnosis, particularly males, experience virtually no excess mortality from diabetes during the first fifteen years after diagnosis. In other age groups, excess mortality is small in the first five years after diagnosis, except in the case of females over sixty years of age who experience a 12 per cent excess mortality even in the first five years after diagnosis.

2. Excess mortality becomes substantial for the youngest group of patients fifteen years after diagnosis. Between the fifteenth and twenty-fifth anniversaries, the excess mortality amounts to 12 to 13 per cent. Higher rates appear in the other age groups.

Downloaded from http://diabetesjournals.org/diabetes/article-pdf/16/12/875/335915/16-12-875.pdf by guest on 26 November 2022

TABLE 4

Mortality rate attributable to diabetes (q_2) by cohort, age and sex (See text for method of computation)

Age (years)	Period after first visit (years)	Males						Females					
		1939	1944	1949	1954	1959	Mean (all cohorts)	1939	1944	1949	1954	1959	Mean (all cohorts)
0-19	0-4	−0.6	−0.5	−0.4	1.3	0.8	0.1	2.0	4.5	1.8	2.1	4.4	3.0
	5-9	−0.6	1.7	2.4	3.1	—	1.7	2.1	−0.3	1.9	−0.2	—	0.9
	10-14	−0.6	1.6	−0.6	—	—	0.1	2.1	−0.3	−0.3	—	—	0.5
	15-19	6.7	10.7	—	—	—	8.7	7.3	10.1	—	—	—	8.7
	20-24	7.1	—	—	—	—	7.1	5.1	—	—	—	—	5.1
20-39	0-4	3.3	−0.5	−1.2	−1.1	0.7	0.2	6.2	1.5	4.5	2.0	2.1	3.3
	5-9	10.8	−0.1	−1.9	0.3	—	2.3	6.6	−1.2	−0.8	−0.9	—	0.9
	10-14	−0.2	2.2	−0.6	—	—	0.5	4.0	8.3	−1.2	—	—	3.7
	15-19	14.1	5.5	—	—	—	9.8	−2.5	3.9	—	—	—	0.7
	20-24	4.2	—	—	—	—	4.2	3.0	—	—	—	—	3.0
40-59	0-4	5.1	3.0	0.6	−0.9	8.2	3.2	3.6	2.1	2.9	3.6	5.0	3.4
	5-9	13.8	0.4	8.3	4.6	—	6.8	3.7	11.4	5.1	7.6	—	7.0
	10-14	4.1	5.1	13.5	—	—	7.6	7.4	12.0	14.2	—	—	11.2
	15-19	6.6	13.6	—	—	—	10.1	18.8	20.5	—	—	—	19.7
	20-24	14.7	—	—	—	—	14.7	10.1	—	—	—	—	10.1
60-79	0-4	6.8	−5.1	5.6	4.5	−3.3	1.7	11.3	20.8	4.6	15.0	6.2	11.6
	5-9	20.1	9.2	8.2	15.1	—	13.2	12.0	12.5	15.2	21.1	—	15.2
	10-14	17.6	14.0	−1.6	—	—	10.0	30.0	10.4	13.3	—	—	17.9
All ages (crude)	0-4	3.6	0.1	1.5	0.6	3.4	1.8	6.0	7.5	4.1	6.9	5.1	5.9
	5-9	11.3	1.8	5.8	5.6	—	6.0	5.9	8.9	7.2	9.6	—	7.9
	10-14	3.3	4.4	6.8	—	—	4.5	9.2	9.2	9.7	—	—	9.4
	15-19	10.9	9.6	—	—	—	10.3	13.6	16.5	—	—	—	15.1
	20-24	8.6	—	—	—	—	8.6	6.2	—	—	—	—	6.2
All ages (adjusted)	0-4	3.7	−0.8	1.2	1.0	1.6	1.3	5.8	7.2	3.5	5.7	4.4	5.3
	5-9	11.0	2.8	4.3	5.8	—	6.0	6.1	5.6	5.4	6.9	—	6.0
	10-14	5.2	5.7	2.7	—	—	4.6	10.9	7.6	6.5	—	—	8.3
	15-19	9.1	9.9	—	—	—	9.5	7.9	11.5	—	—	—	9.7
	20-24	8.7	—	—	—	—	8.7	6.1	—	—	—	—	6.1

3. Relative survival ratios decrease with increasing age. Thus, the over-all decline in survival with age, noted in table 2, is only in part explained by the general increase in mortality with age.

4. In fifteen of the twenty age-cohort groups, and in the totals for all ages, relative survival ratios are consistently better for males than for females. The more favorable position of males is most marked in the highest age group.

Mortality rate attributable to diabetes

The rates shown in table 4 are estimates of the mortality rate that would occur from the diabetes alone, in the theoretical situation in which there were no mortality from other causes. They are the most direct measure of the prognostic implication of the diabetes itself.

The inferences from the data in table 3 are reinforced and become clearer:

1. The prognostic significance of diabetes increases with increasing duration of the disease. After fifteen years of diabetes it is substantial in all age groups. In the youngest group, the excess mortality between the fifteenth and twenty-fifth year is 1 to 1.5 per cent per year. For patients over forty years of age at diagnosis the excess annual mortality after the fifteenth year is 2 to 4 per cent.

2. Mortality increases with age at diagnosis. The probability of a patient under twenty years of age dying of diabetes within twenty-five years of the diagnosis is only one third of the same figure for a person diagnosed between forty and fifty-nine years of age.

3. For persons diagnosed over forty years of age, mortality rates are higher for females than for males.

4. The cohort of 1939 had substantially higher mortality rates than any subsequent cohort. However, there was virtually no change in mortality between the cohorts of 1944 and 1959.

DISCUSSION

Entmacher et al.[3] reported recently that in diabetic patients treated at the Joslin Clinic since 1930 there was a downward trend in mortality with corresponding improvement in survivorship. The conclusion was based

Downloaded from http://diabetesjournals.org/diabetes/article-pdf/16/12/875/335915/16-12-875.pdf by guest on 26 November 2022

on a comparison of patients first seen in the three decades 1930-39, 1940-49, and 1950-58. Inspection of the rates published by these authors indicates, however, that the major fall in mortality occurred between 1930-39 and 1940-49 and that there was little difference between rates for 1940-49 and for 1950-58. The data are therefore quite consistent with the conclusion from the present study, based on a more narrowly defined group of patients, that the decline in mortality was primarily a pre-1945 phenomenon, and that since the Second World War there has been no further reduction in mortality from diabetes. This leveling off in progress in the control of diabetes mortality has come at a time when the excess mortality of diabetics is still substantial. In the fifteen years after diagnosis the mortality of the patients in the present study, in excess of that experienced by the general population, was 12 per cent for males and 20 per cent for females. Within twenty-five years of diagnosis the excess mortality was of the order of 30 per cent.

The finding that the mortality attributable to diabetes increases with age at diagnosis of the disease is, at first sight, at variance with clinical experience. It relates, however, to patients generally under medical control and, by and large, receiving therapy as required. A quite different picture might well be evident in the absence of such measures.

Higher mortality rates attributable to diabetes in female than in male patients, evident particularly in the higher age groups, have not previously been reported. But previous analyses have not adequately separated the mortality attributable to diabetes from that expected in a nondiabetic population. Since general population death rates are substantially higher for males than for females at the present time, the over-all mortality rate for diabetic males is similar to that of diabetic females, in spite of the apparent greater lethality of the diabetes itself to females.

It might be added that, while no claim can be made that Joslin Clinic patients comprise a representative sample of diabetic patients, their very number suggests that they are not highly unrepresentative, at least of diabetic patients in Massachusetts. On the basis of age and sex-specific prevalence rates of diabetes reported from the National Health Survey,[5] it can be estimated that there were 46,186 diabetics over twenty-five years of age in Massachusetts in 1960. (Ages under twenty-five are omitted, since rates in these ages are believed by the authors of the survey to have been overestimated.) We estimate that there were approximately 11,400 Joslin Clinic patients over twenty-five years of age, Massachusetts residents, alive and under follow-up as of Jan. 1, 1953. These would therefore comprise about 25 per cent of the total number of diabetics in Massachusetts on the basis of the National Health Survey estimates.

ACKNOWLEDGMENT

This study was aided by a Research Grant 5 ROI AM 1907 and a Research Training Grant 5 TOI GM 00007 from the National Institutes of Health, U.S. Public Health Service.

We are indebted to the staff of the Harvard School of Public Health data processing center for computer programming and data processing.

The physicians of the Joslin Clinic made their records freely available. The study was made possible by the existing follow-up program maintained by the Clinic staff.

REFERENCES

[1] Editorial. Longevity of diabetics. Statist. Bull. Metropol. Life Ins. Comp., *38*:1-4, March 1957.

[2] Editorial. Current morbidity and mortality from diabetes. Statist. Bull. Metropol. Life Ins. Comp., *41*:3-6, November 1960.

[3] Entmacher, P. S., Root, H. F., and Marks, H. H.: Longevity of diabetic patients in recent years. Diabetes *13*:373-77, July-August, 1964.

[4] Berkson, J., and Elveback, L.: Competing exponential risks, with particular reference to the study of smoking and lung cancer. J. Amer. Stat. Ass. *55*:415-28, September 1960.

[5] Bollo, L. E.: Diabetes Reported in Interviews, United States July 1957-June 1959. Health Statistics from the U.S. National Health Survey. Series B—No. 21, Washington, D.C. U.S. Govt. Printing Office, September 1960.

Downloaded from http://diabetesjournals.org/diabetes/article-pdf/16/12/875/335915/16-12-875.pdf by guest on 26 November 2022

APPENDIX TABLE A

Standard errors of the values of CP_x given in table 2

Age (years)	Anniversary (years)	Males Year of first visit 1939	1944	1949	1954	1959	All cohorts	Females Year of first visit 1939	1944	1949	1954	1959	All cohorts
0-19	5	—	—	—	1.7	1.2	0.6	2.4	3.3	2.0	2.3	2.6	1.2
	10	—	2.2	2.8	3.0	—	1.3	3.3	3.3	2.8	2.3	—	1.5
	15	—	3.0	2.8	—	—	1.6	4.0	3.3	2.8	—	—	1.6
	20	5.0	5.3	—	—	—	3.6	5.4	5.5	—	—	—	3.4
	25	6.8	—	—	—	—	5.7	6.1	—	—	—	—	4.5
20-39	5	3.4	1.0	—	—	1.8	0.7	4.1	2.4	3.5	2.7	2.6	1.4
	10	5.9	1.7	—	1.8	—	1.3	5.5	2.4	3.5	2.7	—	1.8
	15	6.2	2.7	2.3	—	—	2.0	6.2	5.0	3.5	—	—	2.7
	20	7.4	3.8	—	—	—	3.3	6.2	6.0	—	—	—	3.5
	25	7.7	—	—	—	—	5.7	6.8	—	—	—	—	5.0
40-59	5	3.4	2.2	2.0	1.8	2.6	1.1	2.8	1.8	2.0	2.0	2.2	1.0
	10	4.8	2.9	3.1	3.1	—	1.6	3.9	3.0	2.9	3.1	—	1.5
	15	5.2	3.5	3.7	—	—	2.0	4.6	3.5	3.7	—	—	2.0
	20	5.2	3.7	—	—	—	2.5	4.8	3.6	—	—	—	2.5
	25	4.8	—	—	—	—	3.3	4.6	—	—	—	—	3.2
60-79	5	6.7	4.4	4.3	4.1	3.9	2.0	4.8	4.1	3.1	3.7	3.4	1.7
	10	6.9	5.6	4.8	4.7	—	2.6	5.3	4.2	3.9	4.2	—	2.1
	15	5.4	5.0	4.3	—	—	2.7	4.3	3.7	3.5	—	—	2.1
	20	2.8	3.9	—	—	—	2.3	2.3	2.7	—	—	—	1.9
	25	2.0	—	—	—	—	2.8	1.5	—	—	—	—	2.0
All Ages (crude)	5	2.4	1.4	1.7	1.5	1.6	0.7	2.1	1.8	1.6	1.8	1.6	0.8
	10	3.2	2.0	2.3	2.2	—	1.1	2.7	2.2	2.1	2.4	—	1.1
	15	3.4	2.3	2.6	—	—	1.4	2.9	2.4	2.4	—	—	1.3
	20	3.4	2.5	—	—	—	1.7	3.0	2.4	—	—	—	1.6
	25	3.3	—	—	—	—	2.2	2.9	—	—	—	—	1.9

APPENDIX TABLE B

Standard errors of the values of CRP_x given in table 3

Age (years)	Anniversary (years)	Males Year of first visit 1939	1944	1949	1954	1959	All cohorts	Females Year of first visit 1939	1944	1949	1954	1959	All cohorts
0-19	5	—	—	—	1.7	1.2	0.6	2.4	3.3	2.0	2.3	2.6	1.2
	10	—	2.2	2.8	3.0	—	1.3	3.3	3.3	2.8	2.3	—	1.5
	15	—	3.1	2.9	—	—	1.6	4.0	3.3	2.9	—	—	1.6
	20	5.2	5.4	—	—	—	3.6	5.5	5.6	—	—	—	3.4
	25	7.1	—	—	—	—	5.9	6.2	—	—	—	—	4.6
20-39	5	3.4	1.0	—	—	1.8	0.7	4.1	2.4	3.6	2.7	2.6	1.4
	10	6.1	1.8	—	1.9	—	1.4	5.7	2.4	3.6	2.7	—	1.8
	15	6.7	2.9	2.5	—	—	2.2	6.5	5.2	3.6	—	—	2.8
	20	8.4	4.3	—	—	—	3.7	6.6	6.3	—	—	—	3.8
	25	9.4	—	—	—	—	6.9	7.5	—	—	—	—	5.5
40-59	5	3.7	2.4	2.1	2.0	2.8	1.1	3.0	1.9	2.1	2.1	2.3	1.0
	10	5.8	3.6	3.8	3.7	—	1.9	4.5	3.4	3.3	3.5	—	1.7
	15	7.1	5.0	5.2	—	—	2.9	6.0	4.4	4.6	—	—	2.6
	20	8.8	6.7	—	—	—	4.5	7.4	5.2	—	—	—	3.7
	25	10.8	—	—	—	—	8.4	9.0	—	—	—	—	6.3
60-79	5	9.1	5.7	5.6	5.3	5.1	2.6	5.9	5.0	3.7	4.4	4.0	2.0
	10	14.2	10.3	8.9	8.7	—	4.8	8.7	6.8	6.0	6.3	—	3.2
	15	19.0	15.0	13.6	—	—	8.5	10.9	9.1	8.2	—	—	5.1
	20	19.7	22.9	—	—	—	14.9	10.8	11.8	—	—	—	8.0
	25	37.9	—	—	—	—	48.6	17.3	—	—	—	—	20.6
All Ages (crude)	5	2.6	1.5	1.9	1.7	1.8	0.8	2.3	1.9	1.8	2.0	1.8	0.9
	10	4.0	2.4	3.0	2.8	—	1.4	3.3	2.8	2.7	2.9	—	1.4
	15	4.9	3.2	4.0	—	—	2.0	4.2	3.4	3.5	—	—	1.9
	20	5.8	4.1	—	—	—	2.9	4.9	4.1	—	—	—	2.7
	25	6.8	—	—	—	—	4.8	5.8	—	—	—	—	4.1

Downloaded from http://diabetesjournals.org/diabetes/article-pdf/16/12/875/335915/16-12-875.pdf by guest on 26 November 2022