OXFORD JOURNALS
OXFORD UNIVERSITY PRESS

Biometrika Trust

A Note on the Age Distribution of Deaths from Diabetes Mellitus

Author(s): G. D. Maynard

Source: *Biometrika*, Vol. 8, No. 1/2 (Jul., 1911), pp. 225-231

Published by: Oxford University Press on behalf of Biometrika Trust

Stable URL: <http://www.jstor.org/stable/2331446>

Accessed: 27-06-2016 03:56 UTC

Your use of the JSTOR archive indicates your acceptance of the Terms & Conditions of Use, available at
<http://about.jstor.org/terms>

JSTOR is a not-for-profit service that helps scholars, researchers, and students discover, use, and build upon a wide range of content in a trusted digital archive. We use information technology and tools to increase productivity and facilitate new forms of scholarship. For more information about JSTOR, please contact support@jstor.org.

Biometrika Trust, Oxford University Press are collaborating with JSTOR to digitize, preserve and extend access to *Biometrika*

MISCELLANEA.

I. A Note on the Age Distribution of Deaths from Diabetes Mellitus.

By G. D. MAYNARD.

In a paper entitled "A Statistical Study in Cancer Death-rates," published in *Biometrika*, Vol. VII. Part 3, brief mention was made of the fact that the Diabetes death-rates at age periods could not be fitted satisfactorily by any single frequency curve. The form of the curve obtained seemed to indicate that the population dealt with under the term Diabetes Mellitus was not homogeneous.

I have attempted therefore to resolve the complex distribution into its components. After some considerable labour, on the principle of trial and error, three curves have been found that give a very close fit to the original observations. For the sake of convenience I have termed the first sub-curve the Growth Curve, as its range is from birth to about 20 years; this curve is symmetrical having its mean at 10 years, and being platykurtic belongs therefore to Type II. The second or Reproductive Curve approximately corresponds to the period of reproduction, that is from 15 to 50; this curve is also symmetrical and platykurtic, except in the case of the U.S.A. data where it was best fitted by the normal curve. The third or Old-age Curve is skew and of Type I.

Finding, as might be expected, that the irregularities due to random sampling were of considerable inconvenience when dealing with only one year's returns, the figures dealt with in the paper above referred to were abandoned in favour of five-yearly returns for the period 1900—1904. Three tables were available, England and Wales Male, England and Wales Female, and U.S.A. Male and Female; separate tables for males and females in the case of U.S.A. were not obtainable for a five-yearly period. These data were then reduced to rates per million at each five-yearly age period. The higher rates observed in the U.S.A. table are largely due to the fact that the returns used are obtained chiefly from urban areas, whereas the English figures are compiled from the whole country.

It will be seen that the various sub-curves agree very closely with each other, both as to range and position of the mean, but the final test as to the suitability of the resolution rests in the result of the application of the test for 'Goodness of Fit.' A total theoretical distribution was then constructed, by adding together the areas of the various components standing on the same five-yearly bases. The value of χ^2 was then found and P , the probability of goodness of fit, obtained from the table in *Biometrika*, Vol. I. In both the English distributions the values of P could hardly be improved. In the U.S.A. figures the result is not quite so satisfactory when all the groups are taken into consideration. The number of cases of diabetes from which the rates were calculated is very small after the 80—85 age period and considerable variation may be expected; in the 95—100 group only 3 cases were recorded in the 5 years. The effect therefore of a single case, or the misstatement of age in one case, will very materially alter the rate. I have therefore calculated χ^2 for the first 19 and also 17 groups. The exclusion of the 20th group increases the value of P from .6726 to .9968, and if only the first 17 groups are taken $P = .9994$, which is I think a very satisfactory value.

Medically this analysis is of some interest. Diabetes Mellitus has presented considerable difficulties and different types are well known. For instance, it has long been recognised that diabetes in the young adult is a much more serious disease than it is when it occurs in a person of advanced life. Then, again, pathologically there is the form associated with pancreatic disease, and a type in which hepatic disturbances are found. It is conceivable that the Growth Type may be associated with some pathological condition of an organ mainly of importance during development. The statistical analysis indicates that a different group of cause factors is

concerned in the production of the three types; what these are can only be discovered by the clinician and pathologist. Each type has its peculiar age period and one can say that, except in very rare instances, any case occurring in a child under 10 years of age will belong to the Growth Type, if the disease is present in a young adult between 20 and 30 most probably to the Reproductive Type, and in persons over 55 to the Old-age Type.

Diabetes Mellitus.

Constants of Curves.

	U. S. A. ♂ and ♀	England and Wales ♂, 1900—1904	England and Wales ♀
Total Observations			
ν_2	10·707757	8·4462	9·2298
ν_3	— 39·898144	— 35·6000	— 37·6492
ν_4	582·482889	363·5801	422·0587
σ	3·272271	2·9062	3·0381
β_1	1·296611	2·1034	1·8027
β_2	5·080271	5·0966	4·9544
κ_1	·270709	— 2·1170	— 1·4993
Mean	71·793190	66·0115	65·6125
Mode	81·108435	88·0993	81·9805
Old-Age Curve, III			
ν_2	6·523346	4·427590	4·433679
ν_3	— 5·344153	— 6·656844	— 5·300318
ν_4	117·214998	65·102404	60·322009
σ	2·554084	2·104184	2·105630
β_1	·102884	·510546	·322338
β_2	2·754497	3·320949	3·068650
κ_1	— ·799658	— ·889740	— ·829714
b	19·601235	18·655191	17·836714
y_0	913·3	775·55	561·583
Mean	73·5556	69·370275	68·875840
Mode	76·3920	74·601783	72·989120
Reproductive Curve, II			
ν_2	2·9319	3·4115	3·0853
ν_4	24·7888	25·1364	22·0005
σ	1·6878	1·8470	1·7565
β_2	2·8778	2·1598	2·3112
a	—	4·1880	4·5502
y_0	51·53	51·81	48·14
Mean	30·9175	30·8450	30·3960
Growth Curve, I			
ν_2	1·0444	·7400	·7100
ν_4	2·0699	1·3640	1·2210
σ	1·0219	·8602	·8426
β_2	1·8976	2·4909	2·4221
a	1·8962	2·7804	2·4395
y_0	23·80	8·268	11·31
Mean	10·375	9·5000	10·1925

$$\begin{aligned}
 &\left. \begin{array}{l} \text{Diagram (i)} \\ \text{U.S.A.} \\ \text{\text{♂ and ♀}} \end{array} \right\} \begin{array}{ll} \text{Total} & y = 939.6e^{-.5368x} \left(1 - \frac{x}{3.8844}\right)^{2.0850} \\ \text{III} & y = 913.3 \left(1 + \frac{x}{13.3157}\right)^{7.0598} \left(1 - \frac{x}{6.2856}\right)^{3.3326} \\ \text{II} & y = 51.53e^{-x^{2/5.6972}} \\ \text{I} & y = 23.80 \left(1 - \frac{x^2}{3.5955}\right)^{0.2213} \end{array} \\
 &\left. \begin{array}{l} \text{Diagram (ii)} \\ \text{England and Wales} \\ \text{\text{♂}} \end{array} \right\} \begin{array}{ll} \text{Total} & y = 1246.3 \left(1 + \frac{x}{23.4829}\right)^{3.8931} \left(-1 + \frac{x}{1.4718}\right)^{-.2440} \\ \text{III} & y = 775.55 \left(1 + \frac{x}{15.7145}\right)^{8.5993} \left(1 - \frac{x}{2.9407}\right)^{1.6092} \\ \text{II} & y = 51.81 \left(1 - \frac{x^2}{17.5390}\right)^{1.0706} \\ \text{I} & y = 8.268 \left(1 - \frac{x^2}{7.7305}\right)^{3.3928} \end{array} \\
 &\left. \begin{array}{l} \text{Diagram (iii)} \\ \text{England and Wales} \\ \text{\text{♀}} \end{array} \right\} \begin{array}{ll} \text{Total} & y = 713.1 \left(1 + \frac{x}{28.4401}\right)^{6.5528} \left(1 - \frac{x}{0.2517}\right)^{-.0580} \\ \text{III} & y = 561.583 \left(1 + \frac{x}{14.1129}\right)^{8.4094} \left(1 - \frac{x}{3.7238}\right)^{2.2189} \\ \text{II} & y = 48.14 \left(1 - \frac{x^2}{20.7048}\right)^{1.8554} \\ \text{I} & y = 9.824 \left(1 - \frac{x^2}{5.2500}\right)^{2.0000} \end{array}
 \end{aligned}$$

Diabetes Death-Rates. U. S. A., 1900—1904.

Male and Female.

Age	Observations	Calculated Curves			Totals
		I	II	III	
2.5	15	15	—	—	15
7.5	21	23	1	—	24
12.5	32	24	5	—	29
17.5	32	18	15	—	33
22.5	33	—	31	1	32
27.5	46	—	47	2	49
32.5	58	—	50	8	58
37.5	67	—	38	28	66
42.5	94	—	20	70	90
47.5	149	—	8	146	154
52.5	266	—	2	263	265
57.5	418	—	—	417	417
62.5	604	—	—	593	593
67.5	768	—	—	760	760
72.5	894	—	—	877	877
77.5	924	—	—	904	904
82.5	805	—	—	822	822
87.5	663	—	—	633	633
92.5	400	—	—	385	385
97.5	200	—	—	160	160
102.5	—	—	—	29	29

$$\begin{aligned}
 \chi^2 \text{ to } 82.5 &= 3.461, & P &= .9994, \\
 \chi &\text{ to } 92.5 &= 5.765, & P &= .9968, \\
 \chi^3 \text{ to } 97.5 &= 15.765, & P &= .6726.
 \end{aligned}$$

Diabetes Death-Rates. England and Wales, 1900—1904.

Male.						Female.				
Age	Observations	Calculated Curves			Totals	Observations	Calculated Curves			Totals
		I	II	III			I	II	III	
2·5	3	3	—	—	3	3	3	—	—	3
7·5	8	8	—	—	8	9	10	—	—	10
12·5	18	7	11	—	18	19	10	8	—	18
17·5	32	2	30	—	32	26	3	23	—	26
22·5	44	—	43	1	44	34	—	38	—	38
27·5	55	—	50	3	53	48	—	47	1	48
32·5	61	—	51	9	60	54	—	47	6	53
37·5	68	—	46	24	70	60	—	40	17	57
42·5	90	—	35	55	90	66	—	26	41	67
47·5	129	—	18	110	128	98	—	10	88	98
52·5	199	—	1	198	199	158	—	—	163	163
57·5	323	—	—	325	325	285	—	—	268	268
62·5	479	—	—	484	484	385	—	—	395	395
67·5	651	—	—	648	648	496	—	—	504	504
72·5	761	—	—	761	761	562	—	—	560	560
77·5	747	—	—	742	742	521	—	—	512	512
82·5	517	—	—	511	511	331	—	—	334	334
87·5	90	—	—	98	98	90	—	—	94	94

$\chi^2=0\cdot992.$
 $P=1.$

$\chi^2=2\cdot781.$
 $P= \cdot9999945.$

[NOTE. The application of the theory of frequency curves to *rates* as distinguished from total frequencies is possibly open to criticisms, which might touch also the applicability of the χ^2 test for goodness of fit. That test essentially concerns total numbers dealt with, and is not necessarily a test of good graduation formulae. The groups given by Dr Maynard, however, seem of much interest and suggestiveness. EDITOR.]

DIAGRAM (i). Age Polygon of Diabetes Death-Rates, ♂ and ♀.
U.S.A., 5 years, 1900—1904.

$$\begin{cases}
 \text{III} & y = 913.3 \left(1 + \frac{x}{13.8157}\right)^{7.0598} \left(1 - \frac{x}{6.2856}\right)^{3.3326} \\
 \text{II} & y = 51.53 e^{-x^2/5.6072} \\
 \text{I} & y = 23.80 \left(1 - \frac{x^2}{3.5955}\right)^{0.2213}
 \end{cases}$$

$$\text{Total} \quad y = 939.6 e^{+0.6368x} \left(1 - \frac{x}{3.8844}\right)^{2.0860}$$

DIAGRAM (ii). Age Polygon of Diabetes Death-Rates, ϵ , England and Wales, 1900-1904.
Continuous rectangles rates given. Dotted rectangles rates used in calculations.

$$\begin{cases}
 \text{III} & y = 775.55 \left(1 + \frac{x}{15.7145}\right)^{8.5993} \left(1 - \frac{x}{2.9407}\right)^{1.6092} \\
 \text{II} & y = 51.81 \left(1 - \frac{x^2}{17.5390}\right)^{1.0706} \\
 \text{I} & y = 8.268 \left(1 - \frac{x^2}{7.7305}\right)^{3.3928}
 \end{cases}$$

$$\text{Total } y = 1246.3 \left(1 + \frac{x}{23.4829}\right)^{3.3928} \left(-1 + \frac{x}{1.4718}\right)^{-2.440}$$

DIAGRAM (iii). Age Polygon of Diabetes Death-Rates, % .
England and Wales, 1900—1904.

$$\begin{cases}
 \text{III} & y = 561.58 \left(1 + \frac{x}{14.1129}\right)^{8.4094} \left(1 - \frac{x}{3.7238}\right)^{2.2189} \\
 \text{II} & y = 48.14 \left(1 - \frac{x^2}{20.7048}\right)^{1.8554} \\
 \text{I} & y = 9.824 \left(1 - \frac{x^2}{5.2500}\right)^{2.0000}
 \end{cases}$$

$$\text{Total} \quad y = 713.1 \left(1 + \frac{x}{28.4401}\right)^{6.5528} \left(1 - \frac{x}{0.2517}\right)^{0.0580}$$