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AN INVESTIGATION INTO THE MORTALITY OF IMPAIRED LIVES DURING THE PERIOD 1947–63

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INTRODUCTION

This report presents the results of an investigation into the mortality of impaired assured lives during the period 1947–63. A preliminary account, outlining the nature of the investigation, was given by the first author in his Presidential Address to the Assurance Medical Society in 1955, and a report on the results up to the end of 1958 was given in a paper by the second author, which was presented to both the Institute and the Faculty of Actuaries in 1961 (*J.I.A.* **87,** 196, and *T.F.A.* **27,** 20). Earlier this year the first author read a paper to the Assurance Medical Society which gave the statistical results up to the end of 1963. These same statistics form the basis of the present paper, but the text has been revised and expanded. Certain passages in the present paper, notably §§ 7, 8, 9 and 11 which describe the recording and tabulation of data, have been reproduced from Clarke's 1961 paper.

2. It will be apparent from the preceding paragraph that the conduct of the investigation has been a joint responsibility, being medico-actuarial in its nature and therefore only possible as a result of co-operation between the medical and actuarial professions. The classification of risks is essentially a matter for a medical officer, while the actuary's contribution lies in the analysis of statistical data. Co-operative enterprises of this kind have a long history in North America and it is to be hoped that they may become more frequent on this side of the Atlantic.

SOURCE OF THE DATA

3. The data for the investigation were drawn from holders of life assurance policies effected during the period 1947 to 1963 in the ordinary branch of an industrial-ordinary life office. Policies were included if the life assured exhibited one of the impairments listed in Appendix A. The terms of acceptance were not taken into account, so that the experience contains both lives who were surcharged and those who were accepted at standard rates. The investigation was designed to measure the mortality experienced within specified classes of impairment with a view to developing bases for assessing future ratings. Its purpose was not to test the underwriting decisions of the past—an objective which would have been difficult since underwriting policy is subject to modification from time to time and the consistency and homogeneity of the experience would be upset if a surcharge were made a criterion for inclusion in the data. The acceptance terms were, however, recorded on the basic cards, in case a subsidiary analysis should at any time be required for internal office purposes.

4. Both medically examined and non-medical lives were included without discrimination, although it will be obvious that for all the more serious impairments a medical examination will have been carried out. Thus it would have been impossible to code hypertensives without blood-pressure readings and these could only have been obtained as a result of medical examination. On the other hand, a family history of tuberculosis can be revealed on a non-medical proposal.

5. In general, lives exhibiting two or more *major* impairments were excluded. (For this purpose an impairment is regarded as 'major' if it would warrant a surcharge in its own right even if unaccompanied by other adverse features.) To this rule there are the following exceptions:

(i) Combination of hypertension and overweight.

(ii) Association of certain impairments in the tuberculosis group with underweight and with a family history of tuberculosis.

(iii) Association of glycosuria or diabetes mellitus with both overweight and underweight.

6. Another class inevitably excluded from the investigation is that of declined lives. This is a cause for regret, since an investigation into the experience of declined lives could yield useful information. It may well be that life offices are declining certain classes of lives who, if suitably surcharged, could in fact be regarded as insurable. However, as time goes on, it is likely that an increasing number of impairments now regarded as uninsurable will be brought within the ambit of life assurance—particularly as a result of the setting-up of reinsurance pools for some of the heavier risks.

RECORDING OF DATA

7. For every policy included in the investigation a special card was punched which was additional to the cards needed for ordinary office purposes. The work of the investigation was thus rendered independent of other routine processes. It was, of course, necessary to punch a special hole on the normal office 'in force' card to indicate that the policy was included in the impaired lives' investigation so that when the policy lapsed, matured or became a death claim, the information could be passed to the department handling the records of the investigation. The information recorded on the special cards was as follows:

1. Sex
2. Year and month of entry
3. Year of birth
4. Age next birthday at entry
5. Class of policy
6. Term (where appropriate)
7. Impairment code
8. Policy number
9. Sum assured
10. Acceptance terms
11. Year and month of exit
12. Mode of exit
13. Cause of death

Most of the items listed above are self-explanatory. Under item 10 the information recorded shows whether the policy was accepted at normal

rates, with a decreasing deduction, with an extra premium, or with a rating-up in age. The amount of the decreasing deduction, extra premium, or age rating, is also given. So far, however, none of this information has been used.

8. The cause of death codes employed are shown in Appendix B. One of the most interesting features of an investigation into the mortality of impaired lives is to discover which causes of death are particularly associated with specific impairments at entry. The code list may seem brief beside the far more elaborate analyses which are employed by demographers for population data, but the scale of the investigation did not justify a more elaborate classification. A careful scrutiny is maintained on 'other causes' and if any noteworthy features were being masked by inclusion in this residual category they would quickly be detected.

CODING SYSTEM

9. A list of the impairments covered by the investigation is given in Appendix A. A code of three digits is attached to each impairment. The first digit indicates the generic nature of the impairment, e.g. circulatory, digestive, respiratory, etc. Details of the particular condition are indicated by the second and third digits, the actual scheme employed varying according to the nature of the impairment. In addition to the three-digit code, a subsidiary letter code was adopted to indicate such subsidiary details as family history or duration since the observation of symptoms. So far the quantity of data has not justified analysis according to these subsidiary attributes, but it is possible that at a later date such an analysis may prove feasible for some of the larger groups.

10. There were originally five groups of impairments selected for study, viz:

1. Arteriosclerosis; hypertension; hypotension.
2. Peptic ulcer; dyspepsia; cholecystitis; amoebic dysentery.
3. Epilepsy; head injuries; psychoneuroses; migraine.
4. Tuberculosis.
5. Glycosuria and diabetes mellitus.

Subsequently four more groups were added, viz:

6. Underweight and overweight.
7. Hay fever; asthma; chronic bronchitis; emphysema.
8. Urinary disorders.
9. Neoplasms.

Further certain miscellaneous items were added to the main groups, viz.

Group 2. Herniae, varicose veins.
Group 3. Poliomyelitis; otitis media.
Group 5. Disorders of the thyroid gland.
Group 9. Osteomyelitis; anaemias.

For the various subdivisions of these classes of impairment, Appendix A should be consulted.

TABULATION OF DATA

11. Within each individual impairment group the following data were tabulated:

New business
Withdrawals
Deaths
Policies existing on 31 December 1963

For new business the ages employed in the tabulation were the ages next birthday at entry. For deaths and withdrawals the ages were derived by adding the mean duration (= year of exit minus year of entry) to the age next birthday at entry. For policies existing on 31 December 1963 the ages were the ages next birthday at entry plus the difference between 1963 and the year of entry. Thus E_x, the exposed-to-risk from age x to $(x+1)$, is obtained by the formula

$$E_x = E_{x-1} + \tfrac{1}{2}(n_x + n_{x+1}) - \tfrac{1}{2}(w_x + w_{x+1}) - e_x - \theta_x,$$

and the rate of mortality, q_x, is

$$q_x = \theta_{x+1}/E_x.$$

CONTROL EXPERIENCE FOR CALCULATING EXPECTED DEATHS

12. The most appropriate basis for measuring the extra mortality experienced by the various classes of impaired lives would be the experience of healthy—or unimpaired—assured lives of comparable duration over the same period of time. There are, however, no suitable data for unimpaired lives as such. Data are recorded for the Continuous Mortality Investigation for policies issued at standard rates of premium. These include cases which exhibit impairments not considered serious enough to warrant a surcharge and which may accordingly be included both in the 'standard' experience and in the impaired experience under investigation. However, the experience of lives accepted at standard rates is the only available source for constructing a control table and it has accordingly been used for this purpose.

13. As stated in the preceding paragraph, it is necessary that the control table should be based on policies of comparable duration and, in view of the steady improvement in mortality (at least at young and middle ages), that it should refer to the same period of time. The impaired lives' experience has been continually expanding since its inception in 1947 and the exposed to risk are accordingly more heavily weighted towards the end of the period 1947–63. The 'weighted mean point of time' for the investigation corresponds fairly well to the end of 1957 and accordingly it was initially decided to calculate expected deaths according to the mortality experienced by standard lives over the two years 1957–58.

14. A complication of some intricacy is presented by the variation of mortality with duration. If the investigation had been carrried out in select form (i.e. analysing each duration separately) no difficulty would have arisen. A fully select control table would have been constructed from the standard experience and applied to the data at each duration within each class of impaired lives. However, such detailed analysis was beyond the bounds of practicability and the investigation had to be conducted in aggregate form. This immediately raises two major difficulties:

(i) The impaired experience is more recent than the standard experience, hence it has a lower mean duration.

(ii) In most of the impairment groups the average age at entry is higher than among standard lives. Hence, even if the impaired experience had been running as long as the standard experience, the mean duration at particular ages would still be appreciably lower.

15. The experience for standard male assured lives for 1957–58 was available in two duration groups, namely '0-4' and '5 and over', and two tables of q_x were accordingly constructed from these data by the application of Spencer's 21-term summation formula. It was originally thought that by a judicious blending of these two tables, a suitable basis could be derived which would give due effect to the lighter mean durations of the impaired lives. However, experiments in this direction proved unsuccessful and it became apparent that up to quite a relatively high age even the 0–4 experience was too heavy to be a suitable control.

16. Any over-estimation of the normal level of mortality leads to an understatement of the extra mortality experienced by the impaired lives. In Clarke's 1961 paper he admitted that by using the 0–4 experience for standard lives in 1954–56 he had overstated the expected deaths by perhaps some 10%. As a result, he produced percentages of actual to expected deaths which were well below 100 in certain groups such as family history of tuberculosis or varicose veins. It is quite clear that although these mild impairments might well show a normal level of mortality, there is no reason why they should display an abnormally light mortality and it is, therefore, essential to construct a control table which makes proper allowance for the low mean duration of the impaired lives' experience. In the end it was decided to construct a table based on the 1954–56 table used in Clarke's paper (which, in fact, varied little from the 0–4 table for 1957–58), by applying a series of ratios to the values of q_x starting at 70% at ages up to 30, increasing to 100% at age 60 and to 115% at age 75. The 1954–56 table ceased at age 75 and thereafter the new table has been arbitrarily grafted on to the A1949–52 ultimate table so as to merge with it at age 85. As there is very little experience at ages over 75, the completion of the table at the higher ages is not, in fact, of any great importance.

17. On the basis of the control table so constructed, the percentage of actual to expected deaths was 101 for the major section of the family

history of tuberculosis group and 104 for the varicose veins group. These percentages would have been considerably less without the special adjustments to allow for the shortness of the mean duration at the younger ages and there can be no doubt that the adjustments have led to an altogether more satisfactory control basis.

18. The values of q_x in the control table will be found in Appendix C. Also reproduced are the two graduated tables derived from the 1957–58 experience (i.e. 0–4 and 5 and over), the original 1954–56 table used in Clarke's paper and the A1949–52 ultimate rates of mortality. All these tables relate to male lives. For female lives, the values of q_x in the male control table were multiplied by ratios of female to male rates derived from English Life Table No. 11.

ANALYSIS OF RESULTS

19. A comparison of actual and expected deaths is given in Table 1 (male lives) and Table 1A (female lives). These show, sometimes for individual codes and sometimes for groups of codes, the following data:

Number of policies entering the experience.
Number of years of exposure to risk.
Expected deaths.
Actual deaths.
Percentage of actual to expected deaths.
The function $\sigma = \dfrac{100\sqrt{\theta}}{qE}$ where θ = actual deaths
and qE = expected deaths.
The function $\bar{q}$ = Expected deaths ÷ Exposed to risk.

Owing to the presence in the data of duplicate policies on the same life the values of σ are not strictly valid estimates of the standard deviation of the percentage of actual to expected deaths. However, the additions that would be required to correct them are small in proportion to the extra mortality being measured. Moreover, the elimination of duplicates in an investigation of impaired lives' mortality has disadvantages. As an assured life grows older his health may change and later policies may be coded differently from earlier policies. To exclude these later policies could mean an important loss of data. For certain impairments, e.g. hypertension, the subdivision of data by age at entry has the effect of reducing the duplicate policies within individual codes.

20. The presentation of the results in the form of percentages of actual to expected deaths follows established actuarial practice and is no doubt the most readily comprehensible method of summarizing the experience of a specified group of lives by means of a single index. At the same time it has to be borne in mind that a given percentage extra mortality has a very different meaning at age 60 from what it has at age 30. An addition of two extra deaths per thousand at age 30 yields a percentage of actual to

Table 1. *Male lives: Comparison of actual and expected deaths*

Code	Description	Total number of policies entering	Exposed to risk	Expected deaths	Actual deaths	100 A/E	σ	$\bar{q}$
100–103	Arteriosclerosis or atheroma	477	3,326	49·74	51	103	14	·0150
100–101	As above—mild or moderate with normal B.P.	310	2,408	36·00	34	94	16	·0150
102–103	As above—severe or moderate with raised B.P.	167	918	13·74	17	119	30	·0150
110–118	Hypertension, entry age under 40, standard weight	3,288	21,183	25·13	64	255	32	·0012
120–128	Hypertension, entry age under 40, weight 20% + over standard	1,346	6,930	7·66	21	274	60	·0011
130–138	Hypertension, entry age 40–59, standard weight	5,173	34,633	251·11	480	191	9	·0074
130	As above—S.A.P. 155–170, D.A.P. < 95	1,550	11,322	90·41	159	176	14	·0080
132	As above—S.A.P. 155–170, D.A.P. 95–105	1,404	9,026	64·13	125	195	17	·0071
138	As above—S.A.P. < 155, D.A.P. 95 +	1,357	9,665	62·94	110	175	17	·0065
140–148	Hypertension, entry age 40–59, weight 20% + over standard	1,205	6,888	43·63	86	197	21	·0063
150–158	Hypertension, entry age 60 +, standard weight	1,260	7,843	217·22	264	122	7	·0277
150	As above—S.A.P. 160–175, D.A.P. 100	688	4,521	130·77	154	118	10	·0289
160–168	Hypertension, entry age 60 +, weight 20% + over standard	146	850	23·46	29	124	23	·0276
170	Hypotension	335	2,457	6·10	6	—	—	—
200–203	Peptic ulcer, short history, no operation	1,647	6,838	23·88	22	92	20	·0035
204–207	Peptic ulcer, short history, with operation	1,262	7,011	25·39	42	165	25	·0036
210	Peptic ulcer, long history, no complication, no operation	6,314	37,650	143·81	177	123	9	·0038
211–213	Peptic ulcer, long history, complication, no operation	707	4,149	21·81	30	138	25	·0053
214	Peptic ulcer, long history, no complication, operation	3,286	18,212	97·42	121	124	11	·0053
215–217	Peptic ulcer, long history, complications, operation	1,558	9,240	42·05	68	162	20	·0046
222	Dyspepsia, chronic, ulcer not suspected	1,886	11,573	39·15	40	102	16	·0034
223	Dyspepsia, suggestive of ulcer, but not proved	2,856	14,560	44·45	63	142	18	·0031
224	Dyspepsia, brief attack, no investigation	7,226	39,847	92·05	99	108	11	·0023
225	Dyspepsia, brief attack, investigation negative	3,254	15,987	43·64	49	112	16	·0027
230–233	Cholecystitis, all categories	1,049	6,324	45·99	60	130	17	·0073
233	Cholecystitis, with cholecystectomy	772	4,485	33·83	47	139	20	·0075
240–242	Amoebic dysentery	839	6,591	12·16	13	107	30	·0018
250–272	Hernia, all categories	29,783	179,998	680·02	740	109	4	·0038
280–287	Varicose veins, all categories	10,513	64,836	227·26	236	104	7	·0035
300	Epilepsy, petit mal	402	2,065	3·83	7	—	—	—
301	Epilepsy, grand mal	1,076	5,155	8·56	25	292	58	·0017
310–311	Cerebral concussion	3,547	18,041	37·30	44	118	18	·0021
312	Fracture of skull, no operation, no sequelae	1,607	8,659	16·94	26	153	30	·0020
313–314	Fracture of skull, no operation, sequelae	494	2,848	8·18	13	159	44	·0029
315–318	Fracture of skull, craniotomy	379	2,310	4·57	8	—	—	—
320	Psychoneurosis, mild	4,478	23,493	58·46	74	127	15	·0025
321	Psychoneurosis, moderate	3,653	19,446	45·71	64	140	17	·0024
322–323	Psychoneurosis, severe	964	4,157	11·57	16	138	34	·0028
330–331	Migraine	2,127	9,409	16·11	7	—	—	—
350	Poliomyelitis	1,244	6,203	9·37	11	117	35	·0015
360	Otitis media, no operation	9,415	41,076	73·10	83	114	12	·0018
361	Otitis media, mastoidectomy	6,228	30,693	51·98	51	98	14	·0019
400–409	Tuberculosis (non-pulmonary)	3,037	16,882	34·86	36	103	17	·0021
410	Tuberculosis of two or more organs	275	1,208	2·49	4	—	—	—
420–423	Fistula in ano	871	5,782	20·96	30	143	26	·0036
430–433	Pleurisy with effusion	1,962	10,767	19·75	16	81	20	·0018
434–437	Pleurisy, dry or indeterminate	4,963	33,622	110·39	129	117	10	·0033
438–439	Spontaneous pneumothorax	932	4,430	7·86	8			

Table 1. (cont.)

Code	Description	Total number of policies entering	Exposed to risk	Expected deaths	Actual deaths	100 A/E	σ	$\bar{q}$
440–443	Pulmonary tuberculosis, mild, sputum negative	2,399	10,897	19·33	27	140	27	·0018
444–447	Pulmonary tuberculosis, moderate or severe, not treated by special methods	5,561	14,007	33·32	47	141	20	·0024
450–453	Pulmonary tuberculosis, treated by artificial pneumothorax	1,389	7,912	13·73	25	182	36	·0017
454–457	Pulmonary tuberculosis, treated by major surgery	1,704	7,876	12·52	20	160	36	·0016
460	Family history of tuberculosis, entry age under 40 standard weight	13,669	80,364	75·95	85	112	12	·0009
461–462	Family history of tuberculosis, entry age under 40 underweight	2,452	15,648	16·52	11	67	20	·0011
463–465	Family history of tuberculosis, entry age 40 or over	6,494	50,182	285·47	287	101	6	·0059
500–508	Glycosuria (not proved diabetes mellitus), no B.S.T.T.	561	4,365	24·40	32	131	23	·0056
510–518	Glycosuria (not proved diabetes mellitus), B.S.T.T.	423	2,647	11·84	18	152	36	·0045
519	Proved renal glycosuria	305	1,987	5·96	8	—	—	—
520–522	Diabetes mellitus, entry age under 30	395	1,750	1·20	10	833	264	·0007
523–525	Diabetes mellitus, entry age 30–50	751	3,994	10·51	37	352	58	·0026
526–528	Diabetes mellitus, entry age over 50	213	1,177	13·78	24	174	36	·0117
540–544	Simple goitre, non-toxic adenoma and myxoedema	456	2,390	8·44	10	118	17	·0035
550–552	Toxic goitre	491	2,439	7·71	8	—	—	—
600–605	Underweight, entry age under 30	1,192	5,187	3·54	3	—	—	—
610–615	Underweight, entry age 30–50	3,822	22,301	67·53	77	114	13	·0029
620–625	Underweight, entry age over 50	1,067	6,861	86·87	92	106	11	·0127
650–652	Overweight, entry age under 30, 20%–30% over standard	8,683	39,421	27·08	42	155	24	·0007
653–658	Overweight, entry age under 30, 30%+ over standard	3,217	13,872	9·49	12	126	36	·0007
660–662	Overweight, entry age 30–50, 20%–30% over standard	11,284	70,576	149·39	229	153	10	·0021
663–665	Overweight, entry age 30–50, 30%–40% over standard	3,023	18,072	37·14	71	191	23	·0021
666–668	Overweight, entry age 30–50, 40%+ over standard	1,093	6,263	13·50	26	193	28	·0022
670–672	Overweight, entry age over 50, 20%–30% over standard	1,454	9,406	129·13	140	108	9	·0137
673–675	Overweight, entry age over 50, 30%–40% over standard	316	2,035	26·33	28	106	20	·0129
676–678	Overweight, entry age over 50, 40%+ over standard	121	736	9·34	16	171	43	·0127
700 710–720	Hay fever (all ages)	3,051	12,536	14·43	17	118	29	·0012
701	Bronchial asthma, entry age under 30	3,797	14,729	9·78	27	276	53	·0007
711	Bronchial asthma, entry age 30–49	2,448	11,651	19·51	39	200	32	·0017
721	Bronchial asthma, entry age 50 or over	214	1,093	11·04	17	154	38	·0101
712	Chronic bronchitis, no emphysema, entry age 30–49	643	3,223	6·95	14	201	53	·0022
713	Chronic bronchitis and emphysema, entry age 30–49	273	1,536	4·37	20	458	102	·0028
722	Chronic bronchitis, no emphysema, entry age 50 or over	211	1,090	12·21	28	229	43	·0112
723	Chronic bronchitis and emphysema, age 50 and over	166	880	10·63	18	169	40	·0121
724	Emphysema without bronchitis, entry age 50 or over	68	485	8·91	11	123	37	·0183
800–804	Renal calculus	2,638	12,348	39·69	35	88	15	·0032
820–831	Cystitis and pyelitis	1,944	8,477	19·93	12	60	17	·0024
840–842	Albuminuria	609	3,037	8·17	12	147	42	·0027
843	History of nephritis	813	3,826	8·00	10	125	40	·0021
852–854	Nephrectomy (miscellaneous)	479	2,031	4·72	10	212	67	·0023
903 912 933 952 962	Malignant tumours	186	695	3·23	11	341	103	·0046
901–961 ex. above	Non-malignant tumours	1,525	6,600	19·93	19	95	22	·0030
963	**Enlargement of prostate**	173	894	16·96	23	136	28	·0019

Table 1A. *Female lives: Comparison of actual and expected deaths*

Code	Description	Total number of policies entering	Exposed to risk	Expected deaths	Actual deaths	100 A/E	σ	q
130–148	Hypertension, entry age 40–59	1,136	7,922	36·46	50	137	19	·0046
130–138	As above, standard weight	873	6,199	29·02	41	158	35	·0047
140–148	As above, over standard weight	263	1,723	7·44	9	—	—	—
150–168	Hypertension, entry age 60 or over	381	2,176	35·75	40	112	18	·0164
150–158	As above, standard weight	330	1,880	31·57	35	114	27	·0168
160–168	As above, over standard weight	51	296	4·18	5	—	—	—
210–217	Peptic ulcer, long history	372	2,313	7·94	11	139	42	·0032
222–225	Dyspepsia	553	3,750	9·20	14	152	41	·0025
230–233	Cholecystitis	525	3,240	13·03	13	100	28	·0040
252	Hernia, unclassified, operation performed	598	3,872	8·60	11	128	39	·0022
280–287	Varicose veins	1,392	9,285	31·50	31	98	18	·0034
320–323	Psychoneuroses	1,221	7,356	14·47	18	124	29	·0020
460–465	Family history of tuberculosis	3,469	26,293	58·11	70	120	14	·0022
610–615	Underweight, entry age 30–50	3,002	22,979	45·89	56	122	16	·0020
620–625	Underweight, entry age over 50	904	6,247	38·70	39	101	16	·0062
660–668	Overweight, entry age 30–50	2,094	13,981	24·30	23	95	20	·0017
670–678	Overweight, entry age over 50	509	3,401	24·32	26	107	21	·0072
933	Malignant tumours of the breast	51	266	1·22	6	—	—	—
930–932, 934, 940–941, 943–944	Non-malignant tumours of the breast and genital organs	2,082	11,134	32·17	41	127	20	·0029

Note: $\sigma = \dfrac{100\sqrt{\text{Actual deaths}}}{\text{Expected deaths}}$ $\quad \tilde{q} = \dfrac{\text{Expected deaths}}{\text{Exposed to risk}}$

expected deaths of 400, i.e. an extra mortality of 300%. At age 60 the same addition yields a percentage of actual to expected deaths of 116, i.e. an extra mortality of 16%. This may seem a very obvious and elementary piece of simple arithmetic, but its implications must be fully appreciated when comparing percentages. It is, in fact, only to be expected that a young group of impaired lives will show a higher percentage excess mortality than an older group and where there is a difference in the age distribution of two groups, due allowance must be made for this feature before assuming that a higher percentage necessarily implies an inferior class of life. It is for this reason that the function $\bar{q}$, or the mean expected rate of mortality, has been shown in the final column of Tables and 1 and 1A. The reader can then readily assess the effect of the percentage extra mortality in absolute terms.

ANALYSIS OF DEATHS BY CAUSE

21. Examination of the results for particular codes or groups of codes can be considerably illuminated if information is available about the causes of death. Table 2 shows an analysis of deaths by cause for some of the larger groups (male lives only) where the data were sufficient to yield results of statistical significance. The full list of codes for causes of death is given in Appendix B. In Table 2 a certain amount of condensation has been adopted in order to avoid listing causes for which the numbers of deaths were too trivial to be significant. Before commenting on the results, however, it is necessary to describe the method of estimating the expected deaths within each cause category.

22. In studying causes of death among impaired assured lives, the ideal basis of comparison would be a set of statistics for deaths occurring among comparable first-class lives at similar durations since entry and over a corresponding period of time. However, information in this precise form was not available. At the beginning of 1964 the Institute and Faculty of Actuaries instituted an investigation into causes of death among standard lives, to which the office conducting the 1947–63 impaired lives' investigation contributed data. It has been possible to analyse the deaths returned by the office concerned during the first nine months of 1964 and in Appendix D will be found the resultant statistics showing the relative frequencies for sixteen causes of death separately for two age-groups, viz. 35–49 and 50–74. In most of the impaired groups there are few entrants under age 35 and to have taken the complete range of all ages up to 49 would have resulted in an overstatement of deaths from suicide and accident. However, in a few groups (such as family history of tuberculosis) where the age distribution corresponds closely to that of standard lives, deaths at ages under 35 have been added into the control group for the purpose of calculating the expected deaths from particular causes. Deaths at ages over 74 have been ignored throughout, because the impaired lives' experience is still quite young and the data at these higher ages are negligible.

Table 2. *Male lives: Analysis of expected and actual deaths by cause*

Cause of death	Ages under 50 E	Ages under 50 A	Ages 50 and over E	Ages 50 and over A	All ages E	All ages A
Codes 110–169 (Hypertension)						
Cancer	14·8	18	143·4	153	158·2	171
Vascular lesions	3·9	14	41·8	130	45·7	144
Coronary artery disease	19·5	52	182·0	270	201·5	322
Other circulatory disease	4·5	25	39·8	141	44·3	166
Pneumonia	·6	3	7·4	30	8·0	33
Nephritis	1·0	4	3·6	13	4·6	17
Accident and suicide	8·2	12	16·1	21	24·3	33
Others	8·3	12	73·3	46	81·6	58
Total	60·8	140	507·4	804	568·2	944
Codes 200–217 (Peptic ulcer)						
Cancer	20·6	36	76·1	102	96·7	138
Cardio-vascular diseases	38·9	41	140·0	144	178·9	185
Peptic ulcer	1·0	14	1·3	13	2·3	27
Accident	8·6	22	5·6	16	14·2	38
Suicide	2·8	11	3·0	4	5·8	15
Others	13·0	24	43·5	33	56·5	57
Total	84·9	148	269·5	312	354·4	460
Code 252 (Hernia, unclassified, operation performed)						
Cancer	30·9	39	67·1	85	98·0	124
Cardio-vascular diseases	58·2	43	123·4	162	181·6	205
Accident	12·9	17	4·9	9	17·8	26
Suicide	4·2	10	2·6	5	6·8	15
Others	20·7	25	39·5	35	60·2	60
Total	126·9	134	237·5	296	364·4	430
Codes 320–323 (Psychoneurosis)						
Accident	5·1	11	1·4	1	6·5	12
Suicide	1·6	17	·8	–	2·4	17
Others	42·5	49	64·4	76	106·9	125
Total	49·2	77	66·6	77	115·8	154
Codes 434–437 (Pleurisy, dry or indeterminate, not associated with pneumonia)						
Cancer of lung	2·1	8	9·1	11	11·2	19
Other cancer	6·1	10	12·6	16	18·7	26
Cardio-vascular diseases	15·4	11	39·9	36	55·3	47
Pneumonia	·3	2	1·1	4	1·4	6
Accident and suicide	4·5	8	2·4	1	6·9	9
Others	5·2	6	11·7	16	16·9	22
Total	33·6	45	76·8	84	110·4	129

Table 2. (*cont.*)

Cause of death	Ages under 50 E	Ages under 50 A	Ages 50 and over E	Ages 50 and over A	All ages E	All ages A
Codes 440–457 (Pulmonary tuberculosis)						
Tuberculosis	·1	9	·2	6	·3	15
Cancer of lung	1·9	1	4·5	3	6·4	4
Other cancer	7·1	12	6·3	8	13·4	20
Cardio-vascular diseases	14·2	19	19·9	27	34·1	46
Pneumonia	·4	5	·6	4	1·0	9
Accident	8·8	7	·8	—	9·6	7
Suicide	1·8	8	·4	2	2·2	10
Others	6·3	4	5·6	4	11·9	8
Total	40·6	65	38·3	54	78·9	119
Codes 500–519 (Glycosuria)						
Cancer	2·1	—	9·5	13	11·6	13
Diabetes	—	—	·2	2	·2	2
Cardio-vascular diseases	4·0	6	17·4	25	21·4	31
Accident and suicide	1·2	6	1·1	—	2·3	6
Others	1·4	1	5·3	5	6·7	6
Total	8·7	13	33·5	45	42·2	58
Codes 520–528 (Diabetes)						
Cancer	1·5	2	5·5	2	7·0	4
Diabetes	—	9	·2	9	·2	18
Cardio-vascular diseases	2·8	7	10·1	22	12·9	29
Accident	·6	6	·4	3	1·0	9
Others	1·2	7	3·2	4	4·4	11
Total	6·1	31	19·4	40	25·5	71
Codes 650–678 (Overweight)						
Cancer	34·2	38	70·0	81	104·2	119
Leukaemia	2·1	9	1·8	2	3·9	11
Cardio-vascular diseases	53·9	88	128·6	196	182·5	284
Accident	33·4	51	5·1	10	38·5	61
Suicide	6·8	15	2·8	11	9·6	26
Others	23·4	27	39·3	36	62·7	63
Total	153·8	228	247·6	336	401·4	564

23. Of the deaths included in the control group, 83% were attributable to three main categories, i.e. cancer, circulatory diseases and violent death. The actual percentages for each of these three categories are as follows:

	Ages 35–49	Ages 50–74
	%	%
Cancer (excluding leukaemia)	24·3	28·3
Circulatory diseases	45·9	51·9
Accident and suicide	13·5	3·2
	83·7	83·4

The full analysis is given in Appendix D.

24. In the sections which follow, the results for male lives, as set forth in Tables 1 and 2, are discussed for the main impairment groups.

Circulatory impairments

25. *Arteriosclerosis and atheroma.* Actual deaths were 51 compared with expected deaths of 49·74. A subdivision into the less and more severe cases suggested a small (but statistically non-significant) excess for the latter.

26. *Hypertension.* Significant excess mortality was observed in all groups. Inevitably (see § 19) the groups for young ages at entry show higher percentages than those for older entry ages. It is interesting that individual codes within the group 130–138 (entry ages 40–59) show little variation among themselves. For all three groups of entry ages the overweight lives show only a slight excess mortality over lives of standard weight and in no case is the excess statistically significant. Combining the overweight with the standard weight cases, the percentage of actual to expected deaths in the three groups of entry ages are as follows:

	%
Entry ages under 40	260
Entry ages 40–59	192
Entry ages 60 and over	122

27. Analysis of the experience in the hypertension class according to cause of death shows that the majority of the extra deaths were attributable to cardio-vascular causes. Deaths from vascular lesions were over three times expectation and deaths from coronary disease were about 1·6 times expectation. Deaths from other circulatory diseases were nearly four times expectation. There was also an excess of deaths from pneumonia and nephritis.

Impairments of the digestive system

28. *Peptic ulcer.* The two groups showing the highest mortality are 204–207 (short history with operation) with 165%; and 215–217 (long history with complications and with operation) with 162%. Cases of short history without operation showed no extra mortality. Uncomplicated cases with a long history showed 124% with no differentiation between operated

and non-operated cases. Analysis by cause naturally showed a heavy excess of deaths from peptic ulcer: 27 compared with an expectation of 2·3. There was some excess from cancer: 138 deaths compared with an expectation of 96·7. There was also a noteworthy excess from both accident and suicide.

29. *Dyspepsia.* The only group with significant extra mortality was code 223: dyspepsia suggestive of ulcer but not proved. For this code the percentage of actual to expected deaths (142%) was higher than for some of the peptic ulcer codes themselves.

30. *Cholecystitis.* For all categories combined the actual deaths were 130% of expectation. Cases with cholecystectomy showed 139%. Other cases showed normal mortality (13 deaths compared with expectation of 12·16).

31. *Amoebic dysentery.* This group showed no extra mortality, although with only 13 deaths the data have only limited value.

Hernia and varicose veins

32. *Hernia.* This is a large group (740 deaths) with a slight extra mortality (110%). Analysis of the largest code (code 252) by cause of death shows that the excess deaths were mainly due to cancer and to circulatory causes. There was also some excess from accident and suicide.

33. *Varicose veins.* There was no significant extra mortality in this group.

Impairments of the brain and nervous system

34. *Epilepsy.* Code 301 (grand mal) exhibited a heavy excess mortality, the actual deaths (25) being 292% of expectation. This is clearly an impairment which calls for caution in underwriting.

35. *Head injuries.* Actual deaths (39) among cases of fracture of skull without operation were 155% of expectation. There were only 8 deaths among cases with craniotomy, but these probably represent a more serious risk than the non-operated cases. Only when sufficient data have accumulated to permit analysis of the nine sub-groups into which head injuries are divided, will it be possible to draw significant conclusions.

36. *Psychoneurosis.* The differences between the mild, moderate and severe cases were not large enough to be statistically significant. The combined group experienced 133% of expected mortality. The analysis by cause of death showed 17 suicides as compared with an expectation of 2·4 and 12 accidents against an expectation of 6·5. Some of the accidents were possibly concealed suicides.

Otitis media

37. *Otitis media.* Cases without operation showed heavier mortality than operated cases (114% compared with 98%), but the difference is barely significant statistically. On these results it can be said that this impairment gives little cause for concern.

Tuberculosis

38. *Non-pulmonary tuberculosis.* For codes 400–409 combined (non-pulmonary tuberculosis) actual deaths (36) were close to expectation. This group of impairments thus appears so far to have presented no additional risk, but definite conclusions cannot be drawn until more material is available for analysis of the individual sub-groups.

39. *Fistula in ano.* Actual deaths (30) were 143% of expectation.

40. *Pleurisy and spontaneous pneumothorax.* Most of the data lie at codes 434–437 (pleurisy, dry or indeterminate), where actual deaths (129) were 117% of expectation. Analysis by cause of death shows excess both from lung cancer and from other cancer and also, not surprisingly, from pneumonia. The material accumulated here is appreciable and the low mortality is of considerable interest, especially in the case of pleurisy with effusion.

41. *Pulmonary tuberculosis.* The mortality rates are significantly raised in all groups. The figures suggest that although modern treatment has produced great improvement, pulmonary tuberculosis is still to be regarded by the underwriter as an impairment which must not be underrated. The results for the group treated by major surgery are of particular interest. The mortality shown by cases classified as 'mild' (codes 440–443) was 140% of expectation, compared with 141% shown by 'moderate or severe' cases (codes 444–447). This result suggests a degree of over-optimism in the allocation of cases to the 'mild' category.

42. Table 2 shows that the excess deaths in the pulmonary tuberculosis group were attributable to tuberculosis itself (15 deaths compared with an expectation of 0·3), cardio-vascular causes, pneumonia and suicide. There was no excess from lung cancer and none from accident.

43. *Family history of tuberculosis.* None of the various codes included in this group showed any significant extra mortality. A separate analysis of cases coded 'G' (contact within 2 years) showed no difference between these cases and those with no contact over this period.

Endocrine impairments

44. *Glycosuria.* Actual deaths (58) were 137% of expectation. The extra deaths were mainly due to cardio-vascular causes.

45. *Diabetes mellitus.* The experience has been very heavy. For entry ages under 30, there were 10 deaths against an expectation of 1·20, i.e. a percentage of 833. Too much importance should not be attached to this result as the number of deaths is so small, but at the same time it cannot be ignored. For entry ages 30–50 the actual deaths (37) were 352% of expectation and for entry ages over 50 the deaths (24) were 174% of expectation. The experience is much less favourable than that recorded by Steeds in his paper to the Institute in March 1965 (*J.I.A.* **91,** 68).

46. From Table 2 it can be seen that a substantial proportion of the extra deaths among diabetics were in fact attributed to diabetes (18 against an expectation of 0·2). Deaths from cardio-vascular causes were more than

double the expectation and there were 9 deaths from accident against an expectation of 1·0.

Underweight and overweight

47. *Underweight.* There was no significant extra mortality among underweight lives. It must be emphasized, however, that cases included in these codes were assumed to be otherwise unimpaired. Proposers who are grossly underweight, or who show recent loss of weight, should always be subject to investigation before acceptance.

48. *Overweight.* The extra mortality among overweight lives was substantial. In spite of some erratic results, it is broadly true that the heavier weight classes had also the heavier mortality. For entry ages 30–50, the mortality was 153% of expectation where the weight was 20%–30% above standard, and 192% of expectation where the weight was over 30% above standard.

49. As would be expected, a large proportion of the extra deaths among overweight lives was due to cardio-vascular causes. There was a significant excess of deaths from accident and also, surprisingly, from suicide—particularly at ages over 50, where there were 11 suicides against an expectation of 2·8. Another odd feature is the occurrence of 9 deaths from leukaemia at ages under 50 against an expectation of 2·1.

Respiratory impairments

50. *Bronchial asthma.* Mortality for this impairment has been fairly heavy, the percentages of actual to expected deaths in the three entry-age groups being as follows:

	%
Entry ages under 30	276
Entry ages 30–49	200
Entry ages 50 and over	154

51. *Chronic bronchitis.* The experience in this group has been heavy. At entry ages 30–49 the co-existence of emphysema more than doubled the mortality ratio. Paradoxically, however, for entry ages 50 and over the cases with emphysema had somewhat lighter mortality than those with no emphysema.

Urinary impairments

52. Two of the urinary impairments, viz. renal calculus and cystitis and pyelitis, show light mortality and would appear to involve no extra risk. It must be emphasized, however, that no case would have been accepted if there were active signs of cystitis or pyelitis at the time of entry. For albuminuria, actual deaths (12) were 147% of expectation. No conclusions can fairly be drawn without more detailed information, but the result suggests that a proposer with albuminuria cannot be accepted as a standard

risk until the condition has been fully investigated. For history of nephritis the actual deaths (10) were 125% of expectation; all cases in this category were free from albumen at the time of acceptance. The 10 deaths among cases with history of nephrectomy compare with an expectation of 4·72 and, in so far as conclusions can be drawn from such small figures, this would appear to be the heaviest of the urinary risks for which data have been obtained.

Tumours

53. The group of malignant tumours have so far yielded 11 deaths compared with an expectation of 3·23. More data must be obtained before the extra risk can be properly assessed, but it seems likely that with this type of impairment we are entering an exceptionally heavy risk area. Non-malignant tumours yield no extra mortality. For enlargement of the prostate the actual deaths (23) were 136% of expectation.

FEMALE LIVES

54. The experience among impaired female lives has been very favourable in comparison with the male experience, in spite of the exceptionally light rates of mortality employed for calculating the expected deaths. The results are contained in Table 1A and there are no special features calling for comment except, perhaps, to draw attention to the mortality among lives with a history of malignant tumour of the breast, where there were 6 deaths against an expectation of 1·22.

GENERAL OBSERVATIONS

55. In almost all the classes of sub-standard risk studied in this survey, the extra mortality observed has proved to be less severe than might have been expected when the investigation was launched in 1947. Of the risks most commonly encountered, hypertension and overweight have proved to be the most serious—a result which does not occasion any surprise. Psychoneurosis, which in Clarke's 1961 paper was found to have a mortality experience equal to expectation, now appears to present a definite extra risk. Of the less common risks, diabetes mellitus has appeared in an unfavourable light although, as stated in § 44, this finding is contrary to the results obtained by Steeds. It will be interesting to see whether the experience of the next few years shows any variation from the experience to date. Malignant tumours constitute another rare class of risk which calls for cautious treatment and for which further statistical data will be awaited with interest.

56. One result which may appear to call for comment is the occurrence in several impairment groups of an excess of deaths from suicide. In the psychoneurosis group this excess is not surprising. But excesses also occur in the peptic ulcer, hernia, pulmonary tuberculosis and overweight groups.

There may, of course, be a fortuitous understatement of suicides in the control group, which would lead to an artificial overstatement in the impaired lives. All the same, it does appear that certain forms of ill-health may be conducive to suicide although too much importance should not be attached to this deduction from an underwriting point of view, since the numbers of deaths involved are very small compared with the total deaths from all causes. Thus, in the peptic ulcer group, there were only 15 suicides out of a total of 460 deaths; and in the overweight group only 26 out of a total of 564.

57. In conclusion it may be affirmed that the results of the investigation fully justify the policy followed in recent years of a more liberal approach to underwriting. The statistics now obtained will help to provide a basis for assessing appropriate surcharges in the future or, in some cases, a justification for accepting the risk at standard rates of premium.

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APPENDIX A

IMPAIRMENT CODING SYSTEM

(1) *Circulatory impairments*

10– *Arteriosclerosis or atheroma*

100 Slight (palpable or thickened vessels) with normal blood pressure

101 Moderate (nodular or tortuous vessels) with normal blood pressure

102 Marked (hard or pipe-stem vessels)

103 Moderate or marked with raised blood pressure

11– to 16– *Essential (uncomplicated) hypertension (may include slight or moderate tachycardia or slight arteriosclerosis)*

Code	Age at entry	Weight	S.A.P.	D.A.P.
110	Under 40	Standard ± 19%	150–165	Under 95
111			Over 165	Under 95
112			150–165	95–105
113			Over 165	95–105
114			150–165	Over 105
115			Over 165	Over 105
116			150–165	Uncertain
117			Over 165	Uncertain
118			Below 150	95 or over
120	Under 40	Standard +20% or over	150–165	Under 95
121			Over 165	Under 95
122			150–165	95–105
123			Over 165	95–105
124			150–165	Over 105
125			Over 165	Over 105
126			150–165	Uncertain
127			Over 165	Uncertain
128			Below 150	95 or over
130	40–59	Standard ± 19%	155–170	Under 95
131			Over 170	Under 95
132			155–170	95–105
133			Over 170	95–105
134			155–170	Over 105
135			Over 170	Over 105
136			155–170	Uncertain
137			Over 170	Uncertain
138			Below 155	95 or over

Code	Age at entry	Weight	S.A.P.	D.A.P.
140	40–59	Standard + 20% or over	155–170	Under 95
141			Over 170	Under 95
142			155–170	95–105
143			Over 170	95–105
144			155–170	Over 105
145			Over 170	Over 105
146			155–170	Uncertain
147			Over 170	Uncertain
148			Below 155	95 or over
150	60 or over	Standard ± 19%	160–175	Under 100
151			Over 175	Under 100
152			160–175	100–110
153			Over 175	100–110
154			160–175	Over 110
155			Over 175	Over 110
156			160–175	Uncertain
157			Over 175	Uncertain
158			Below 160	100 or over
160	60 or over	Standard + 20% or over	160–175	Under 100
161			Over 175	Under 100
162			160–175	100–110
163			Over 175	100–110
164			160–175	Over 110
165			Over 175	Over 110
166			160–175	Uncertain
167			Over 175	Uncertain
168			Below 160	110 or over
170	[Uncomplicated hypotension (100 and below). Discontinued December 1961].			

Subsidiary codes for range 100–170

E Family history Good
F Family history Fair with two or more deaths from cardio-vascular disease*
G Family history Poor—general tendency to early death
H Family history Poor—with two or more deaths from cardio-vascular disease*
* Deaths at ages 70 and above to be disregarded

(2) *Stomach and intestines*

20– *Peptic ulcer (gastric and duodenal) short history (apparently acute)*

200 No operation: no complication
201 history of haematemesis
202 history of perforation
203 other complications
204 With operation: no complication
205 history of haematemesis or melaena
206 history of perforation
207 other complications

21– *Peptic ulcer (gastric and duodenal) long history (apparently chronic)*

210 No operation: no complication
211 history of haematemesis
212 history of perforation
213 other complications
214 With operation: no complication
215 history of haemtemesis or melaena
216 history of perforation
217 other complications

22– *Dyspepsia, gastritis*

220, 221 } Codes 220 and 221 were discarded at an early stage of the investigation
222 Dyspepsia: chronic or prolonged attacks; ulcer not suspected
223 suggestive of ulcer but not proven (duodenitis, etc.)
224 brief attack, apparently of no serious significance; no special investigations
225 brief attack, apparently of no serious significance, but investigations carried out with negative result

23– *Cholecystitis*

230 Without stones: no operation
231 With stones: no operation
232 cholecystotomy
233 cholecystectomy

24– *Amoebic dysentery*

240 One attack, uncomplicated
241 Two or more attacks, uncomplicated
242 With hepatitis, etc.

25– *Hernia (unclassified)—no medical evidence*

250 Hernia unclassified: no evidence of treatment
251 support worn
252 operation performed

26– *Hernia (inguinal or femoral)*

260 Hernia, inguinal or femoral: not efficiently treated
261 efficiently supported
262 cured by operation

27– *Hernia (ventral, umbilical, etc.)*

270 Hernia, ventral, umbilical, etc.: not efficiently treated
271 efficiently supported
272 cured by operation

28– *Varicose veins*
280 Varicose veins: slight, untreated
281 moderate or severe, untreated
282 sufficiently supported
283 efficiently treated by injection
284 efficiently treated by operation
285 complicated by phlebitis
286 other complications (dermatitis, ulcer, etc.)
287 no medical evidence

Subsidiary codes for range 200–287

A Symptoms within 2 years
B Symptoms 2–4 years ago
C Symptoms 4–6 years ago
D Symptoms over 6 years ago

(3) *Nervous disorders: Head and ear impairments*

30– *Epilepsy*
300 Petit mal
301 Grand mal (idiopathic)

Subsidiary codes for 300, 301

A Attacks within 2 years
B No attack for 2–5 years
C No attack for 5–10 years
D No attack for over 10 years

31– *Head injuries*
310 Cerebral concussion without fracture or operation: mild
311 severe
312 Fracture of skull, no operation: no sequelae
313 subsequent symptoms but no epilepsy
314 subsequent symptoms and epilepsy
315 Fracture of skull, craniotomy, no sequelae: no gap in skull
316 gap present in skull
317 Fracture of skull, craniotomy, sequelae: no gap in skull
318 gap present in skull

32– *Psychoneuroses*
320 Psychoneuroses: mild
321 moderate
322 severe
323 With features suggestive of psychosis

33– *Migraine*
330 Migraine: mild
331 severe

340 *Attacks of unconsciousness of uncertain origin*

350 *Poliomyelitis*

36– *Otitis media*

360 Chronic suppurative otitis media: without operation
361 with mastoidectomy
362 Perforation of drum without clear history of C.S.O.M. (trauma only)

Subsidiary codes for range 310–362

A Symptoms within 2 years
B Symptoms within 2–5 years
C Symptoms within 5–10 years
D No symptoms for at least 10 years

(4) *Tuberculosis*

40– *Tuberculosis, not pulmonary*

400 Tuberculosis of: spine
401 hip
402 other bones or joints
403 glands
404 intestines and peritoneum
405 skin (*lupus vulgaris*)
406 kidney (without operation)
407 kidney (with operation)
408 generative organs (testis, prostate, etc., fallopian tubes, ovaries) (without operation)
409 generative organs (with operation)

410 *Tuberculosis of other organs or of two or more organs*

For brevity the following classification is used in code definition in the 420–457 range:

Type I Weight standard or overstandard, no tuberculosis in family history
Type II Weight more than 10% below standard, no tuberculosis in family history
Type III Weight standard or over standard, one or more tuberculosis in family history
Type IV Weight more than 10% below standard, one or more tuberculosis in family history

42– *Fistula in ano*

420 Fistula in ano: Type I
421 Type II
422 Type III
423 Type IV

43– *Pleurisy and spontaneous pneumothorax*

430 Pleurisy with effusion (not including post pneumonic empyema): Type I
431 Type II
432 Type III
433 Type IV

434 Pleurisy dry or indeterminate (not associated with pneumonia): Type I
435 Type II
436 Type III
437 Type IV
438 Spontaneous pneumothorax: no definite history of trauma
439 definite trauma

44– *Pulmonary tuberculosis (not treated by special method of collapse)*

440 Pulmonary tuberculosis, mild cases (discovered by mass radiography, etc., never sputum positive): Type I
441 Type II
442 Type III
443 Type IV
444 Pulmonary tuberculosis, moderate or severe cases: Type I
445 Type II
446 Type III
447 Type IV

45– *Pulmonary tuberculosis (treated by special methods)*

450 Pulmonary tuberculosis treated by artificial pneumothorax: Type I
451 Type II
452 Type III
453 Type IV
454 Pulmonary tuberculosis treated by major surgical procedures: Type I
455 Type II
456 Type III
457 Type IV

Subsidiary codes for range 400–457

A Within 3 years
B 3–6 years ago
C 6–10 years ago
D Over 10 years ago

46– *Family history of tuberculosis (contact within two years)*

460 Age under 40, weight: standard or over standard
461 10%–20% below standard
462 more than 20% below standard
463 Age 40 or over, weight: standard or over standard
464 10%–20% below standard
465 more than 20% below standard

Subsidiary codes for 460–465

E [Obsolete from 31 December 1961]
F [Obsolete from 31 December 1961]
G Contact within 2 years (i.e. all cases from 1 January 1962)

(5) *Endocrine group*

(S = standard)

50– *Glycosuria (not proved to be diabetes mellitus); no B.S.T.T.*

500 One test only, weight: S ± 10%
501 S − 10%
502 S + 10%
503 Inconstant, two or more tests, weight: S ± 10%
504 S − 10%
505 S + 10%
506 Persistent, two or more tests, weight: S ± 10%
507 S − 10%
508 S + 10%

51– *Glycosuria (not proved to be diabetes mellitus); B.S.T.T.*

510 One test only, weight: S ± 10%
511 S − 10%
512 S + 10%
513 Inconstant, two or more tests, weight: S ± 10%
514 S − 10%
515 S + 10%
516 Persistent, two or more tests, weight: S ± 10%
517 S − 10%
518 S + 10%
519 Proved renal glycosuria

52– *Diabetes mellitus*

520 Age under 30, weight: S ± 10%
521 S − 10%
522 S + 10%
523 Age 30–50, weight: S ± 10%
524 S − 10%
525 S + 10%
526 Age over 50, weight: S ± 10%
527 S − 10%
528 S + 10%

Subsidiary codes for range 500–528

E Family history, no diabetes
F Family history, 1 or more diabetes

54– *Goitre (simple or unclassified)*

540 Goitre (simple or unclassified): no operation
541 operation
542 Thyroid adenoma, etc.: no operation
543 operation
544 Myxoedema

55– *Goitre (exophthalmic) (including toxic goitre, hyperthyroidism, Grave's disease, thyrotoxicosis)*

550 No special treatment
551 Surgical treatment
552 Other special treatment

Subsidiary codes for range 540–552

A Within 3 years
B 3–6 years ago
C 6–10 years ago
D Over 10 years ago

(6) *Underweight and overweight*

(S = standard, N.M.E. = Not Medically Examined)

600 Age under 30, weight 20%–30% under S: chest expansion satisfactory
601 chest expansion unsatisfactory
602 N.M.E.
603 Age under 30, weight more than 30% under S: chest expansion satisfactory
604 chest expansion unsatisfactory
605 N.M.E.
610 Age 30–50, weight 20%–30% under S: chest expansion satisfactory
611 chest expansion unsatisfactory
612 N.M.E.
613 Age 30–50, weight more than 30% under S: chest expansion satisfactory
614 chest expansion unsatisfactory
615 N.M.E.
620 Age over 50, weight 20%–30% under S: chest expansion satisfactory
621 chest expansion unsatisfactory
622 N.M.E.
623 Age over 50, weight more than 30% under S: chest expansion satisfactory
624 chest expansion unsatisfactory
625 N.M.E.
650 Age under 30, weight 20%–30% over S: girth satisfactory
651 girth unsatisfactory
652 N.M.E.
653 Age under 30, weight 30%–40% over S: girth satisfactory
654 girth unsatisfactory
655 N.M.E.
656 Age under 30, weight more than 40% over S: girth satisfactory
657 girth unsatisfactory
658 N.M.E.
660 Age 30–50, weight 20%–30% over S: girth satisfactory
661 girth unsatisfactory
662 N.M.E.
663 Age 30–50, weight 30%–40% over S: girth satisfactory
664 girth unsatisfactory
665 N.M.E.
666 Age 30–50, weight more than 40% over S: girth satisfactory
667 girth unsatisfactory
668 N.M.E.

670 Age over 50, weight 20%–30% over S: girth satisfactory
671 girth unsatisfactory
672 N.M.E.
673 Age over 50, weight 30%–40% over S: girth satisfactory
674 girth unsatisfactory
675 N.M.E.
676 Age over 50, weight more than 40% over S: girth satisfactory
677 girth unsatisfactory
678 N.M.E.

Subsidiary codes for range 600–678

E Family history good
F Family history indifferent
G Family history poor

(7) *Respiratory group (excluding tuberculosis)*

70– *Entry age under 30*

700 Hay fever, simple
701 Bronchial asthma
702 Chronic bronchitis without emphysema
703 Chronic bronchitis with emphysema
704 Emphysema without bronchitis

71– *Entry age 30–49*

710 Hay fever, simple
711 Bronchial asthma
712 Chronic bronchitis without emphysema
713 Chronic bronchitis with emphysema
714 Emphysema without bronchitis

72– *Entry age 50 or over*

720 Hay fever, simple
721 Bronchial asthma
722 Chronic bronchitis without emphysema
723 Chronic bronchitis with emphysema
724 Emphysema without bronchitis

Subsidiary codes for range 700–724

A Symptoms within 3 years
B Symptoms 3–6 years ago
C Symptoms 6–10 years ago
D Symptoms over 10 years ago

(8) *Urinary group*

80– *Urinary calculus (including both renal and vesical calculus)*

800 Urinary calculus: no operation
801 voided or removed per urethram

802 removed by nephrotomy
803 removed by nephrectomy
804 Renal colic (indefinite origin)

82– *Cystitis pyelitis*

820 Cystitis, without calculus
821 Pyelitis, without calculus

83– *Pyuria, haematuria*

830 Pyuria of obscure origin
831 Haematuria of obscure origin or unclassified

84– *Albuminuria*

840 Orthostatic albuminuria: age under 30
841 age 30 and over
842 Other forms of albuminuria
843 History of nephritis

85– *Other renal disorders*

850 Hydronephrosis, no operation
851 [Discarded 31 December 1961]
852 Nephrectomy for trauma of kidney
853 Nephrectomy for conditions other than trauma, tuberculosis, calculus or hydronephrosis or reason unknown
854 Hydronephrosis with nephrectomy
855 Hydronephrosis with operation other than nephrectomy

Subsidiary codes for range 800–855

A Symptoms within 3 years
B Symptoms 3–6 years ago
C Symptoms 6–10 years ago
D Symptoms more than 10 years ago

(9) *Tumours and miscellaneous*

90– *The skin and superficial tissue (including external genitalia)*

900 Rodent ulcer
901 Innocent tumours: confirmed
902 unconfirmed
903 Malignant tumours (other than rodent ulcer)

91– *Lips, mouth and salivary glands*

910 Innocent tumours: confirmed
911 unconfirmed
912 Malignant tumours
913 'Parotid' tumours

92– *Lymphatic system*

920 Enlarged lymphatic glands (other than tuberculosis)

93– *The breast*

930 Chronic mastitis: confirmed
931 unconfirmed
932 Non-malignant tumours: confirmed
933 Malignant tumours
934 Non-malignant tumours: unconfirmed

94– *Female genital organs (internal)*

940 Uterus, fibroids: confirmed
941 unconfirmed
942 Uterus, malignant tumours
943 Ovarian tumours, innocent: confirmed
944 unconfirmed
945 Miscellaneous: non-malignancy confirmed
946 non-malignancy not confirmed

95– *Male genital organs*

950 Testicle—innocent tumours: confirmed
951 unconfirmed
952 Testicle—malignant tumours

96– *Miscellaneous tumours (not previously classified)*

960 Innocent tumours: confirmed
961 unconfirmed
962 Malignant tumours
963 Enlargement of the prostate

Subsidiary codes for range 900–963

A Tumour present at time of proposal
B Tumour removed by operation, radiotherapy to within 5 years
C Tumour removed by operation, radiotherapy to within 5–10 years
D Tumour removed by operation, radiotherapy to within over 10 years

98– *Blood conditions*

980 Pernicious anaemia
981 Other forms of anaemia
982 Anaemia unclassified

990 *Osteomyelitis*

Subsidiary codes for range 980–990

A Within 3 years
B 3–6 years
C 6–10 years
D Over 10 years

APPENDIX B

CODING FOR CAUSE OF DEATH

1. Tuberculosis
2. Cancer of lung, bronchus, trachea
3. Other cancers
4. Leukaemia
5. Diabetes
6. Vascular lesions, cerebral haemorrhage, embolism
7. Coronary disease, angina
8. Hypertension, arteriosclerosis, other circulatory or heart disease
9. Influenza (merged with code 17 on account of small numbers)
10. Pneumonia
11. Bronchitis
12. Peptic ulcer
13. Nephritis
14. Motor accident
15. Other accident
16. Suicide
17. Other causes

APPENDIX C

VALUES OF q_x FOR MALE STANDARD LIVES

Age	Control table	1954–56 table, durations 0–4	1957–58 table, durations 0–4	1957–58 table, durations 5 and over	A1949–52 ultimate table
29 and under	·00066	·00095	·00080	·00090	·00111*
30	·00067	·00096	·00080	·00090	·00116
31	·00068	·00096	·00080	·00090	·00118
32	·00070	·00097	·00080	·00090	·00120
33	·00071	·00097	·00083	·00096	·00123
34	·00072	·00098	·00087	·00104	·00127
35	·00074	·00098	·00093	·00114	·00132
36	·00078	·00102	·00101	·00124	·00139
37	·00082	·00107	·00109	·00136	·00147
38	·00090	·00115	·00119	·00146	·00158
39	·00099	·00125	·00131	·00157	·00171
40	·00110	·00138	·00145	·00170	·00188
41	·00124	·00153	·00161	·00185	·00208
42	·00140	·00171	·00177	·00203	·00231
43	·00159	·00192	·00195	·00226	·00259
44	·00182	·00217	·00213	·00255	·00292
45	·00209	·00246	·00237	·00289	·00330

* Value for ages 22 and under.

Age	Control table	1954–56 table, durations 0–4	1957–58 table, durations 0–4	1957–58 table, durations 5 and over	A1949–52 ultimate table
46	·00239	·00278	·00267	·00328	·00372
47	·00274	·00315	·00303	·00374	·00420
48	·00313	·00356	·00350	·00425	·00474
49	·00358	·00402	·00404	·00480	·00534
50	·00410	·00456	·00465	·00539	·00599
51	·00469	·00515	·00527	·00602	·00671
52	·00532	·00578	·00589	·00669	·00750
53	·00600	·00645	·00654	·00745	·00837
54	·00672	·00715	·00726	·00833	·00931
55	·00746	·00785	·00807	·00937	·01035
56	·00827	·00861		·01062	·01148
57	·00915	·00943		·01206	·01272
58	·01013	·01034		·01366	·01408
59	·01119	·01130		·01536	·01557
60	·01236	·01236		·01715	·01720
61	·01366	·01352		·01906	·01899
62	·01510	·01480		·02109	·02096
63	·01669	·01620		·02318	·02312
64	·01845	·01774		·02543	·02549
65	·02041	·01944		·02760	·02810
66	·02262	·02134		·02994	·03095
67	·02508	·02344		·03240	·03409
68	·02779	·02573		·03506	·03753
69	·03078	·02824		·03808	·04130
70	·03410	·03100		·04156	·04543
71	·03775	·03401		·04561	·04995
72	·04200	·03750		·05024	·05489
73	·04690	·04150		·05557	·06028
74	·05244	·04600		·06164	·06616
75	·05865	·05100		·06841	·07257
76	·06534			·07582	·07953
77	·07279			·08383	·08709
78	·08109			·09239	·09528
79	·09033			·10151	·10414
80	·10063			·11140	·11369
81	·11210				·12397
82	·12488				·13500
83	·13912				·14681
84	·15498				·15942
85	·17282				·17282

Note: The 1957–58 tables were constructed with the aid of Spencer's 21-term summation formula. Consequently, reliable values of q could not be obtained in the 0–4 table beyond age 55.

APPENDIX D

DISTRIBUTION OF DEATHS BY CAUSE AMONG MALE STANDARD LIVES AGED 35–74

Code	No. of deaths		Percentage of total	
	Ages 35–49	Ages 50–74	Ages 35–49	Ages 50–74
1. Tuberculosis	2	11	·47	·61
2. Lung cancer	26	213	6·15	11·85
3. Other cancer	77	295	18·20	16·41
4. Leukaemia	4	13	·95	·72
5. Diabetes	—	12	—	·67
6. Vascular lesions	27	148	6·38	8·23
7. Coronary disease	136	645	32·15	35·87
8. Other heart disease	31	141	7·33	7·84
10. Pneumonia	4	26	·95	1·45
11. Bronchitis	3	89	·71	4·95
12. Peptic ulcer	5	9	1·18	·50
13. Nephritis	7	13	1·65	·72
14. Motor accidents	14	14	3·31	·78
15. Other accidents	29	23	6·86	1·28
16. Suicide	14	20	3·31	1·11
17. All other causes	44	126	10·40	7·01
All causes	423	1,798	100·00	100·00
Codes 2 and 3	103	508	24·35	28·26
Codes 6, 7 and 8	194	934	45·86	51·94
Codes 14, 15 and 16	57	57	13·48	3·17

Note: Code 9 was originally allocated to influenza, but deaths from this cause have proved so few that they have been merged with code 17.

ABSTRACT OF THE DISCUSSION

Dr T. W. Preston said that it was a very great honour to have the opportunity of introducing the paper. As indicated in the text, it was very much a combined operation between the actuary and the medical officer. The previous week, in Edinburgh, before the Faculty of Actuaries, his colleague had introduced the paper while he had himself replied to the discussion. Tonight the roles had been reversed as a symbol of their joint undertaking.

The first point he wished to make was that over the years a not inconsiderable amount of data had been accumulated, and he hoped that in some of the impaired groups the evidence was sufficiently consistent to be of rather more than academic interest, and that it might prove to be a guide to future underwriting policy.

Secondly, he emphasized the fact that the figures in the paper were entirely unselected. All the coding had been made strictly according to concrete facts as extracted from the proposals and from the medical reports, and was in no way biased by any personal opinions either of the authors or of any individual underwriter.

His third point was that Clarke, in presenting his paper in 1961, made the suggestion that with increasing experience the underwriter would find it necessary to decline fewer and fewer groups of impaired lives. The authors' results tended to confirm that suggestion. Looking at their tables, even selecting those groups of the more serious impairments in which the extra mortality was relatively high, in few, if any, could it be said, 'These cases should never have been accepted; they are quite unsuitable for assurance of any type.'

Ending on a personal note, Dr Preston said that it was to be his swan-song: he would be taking no active part in any further investigations which would take place. He was very glad to have had the opportunity of playing an active role in the investigation and hoped that, whatever its defects, the verdict would be that it had been a worthwhile effort and that the work should continue in the future.

Mr D. J. Bond, in opening the discussion, said that in all statistical investigations practical expediency dictated a departure from complete homogeneity within each group. The extent of the departure depended on the data available. In the present investigation the data were limited by the fact that the records from only one office had been used. It was undertaken as a trial run to see whether a more extensive study could be instituted to which all offices would contribute data. During the discussion on Clarke's paper in 1961, many speakers did not favour an all-offices investigation on the grounds that the data to be included could not possibly be assessed by one medical officer only. The idea of an all-offices investigation accordingly seemed to have been abandoned, but could not certain clearly defined impairments be examined in an all-offices investigation? Blood pressure was not the only obvious example. Operations such as partial gastrectomy could be included. It was, in fact, only such sub-divisions as mild, moderate and severe which would have to be excluded.

The list of impairments covered by the investigation was extremely detailed. That was, of course, no bad thing since it was easy to amalgamate groups at a later stage and difficult to sub-divide them. It would be interesting to amalgamate into broader groups some of the groups for which there were insufficient data to justify analysis according to subsidiary codes or attributes, and then to sub-divide by the subsidiary codes. For example, the extra mortality associated with overweight could be analysed not only by age but also by chest and girth measurements for all ages combined.

In assessing the adequacy of the control mortality table, the purpose of the comparison of actual to expected deaths had to be taken into account. If the purpose had been merely to ensure that extra premiums were adequate, the control table could have been the standard mortality table used in calculating premiums or valuation reserves.

The investigation, however, aimed to develop bases for assessing ratings on impaired lives. That did not require a control table of a precision necessary for medical statistical research but, to assess the significance of the percentages of actual to expected deaths, the reasons for its selection and the tests made to ensure its adequacy should be fully described. Obviously a great deal of thought had been given to the control table but it was not easy to see from the paper whether the table was reasonable or not. It seemed almost to have been built up to give the results the authors expected. In particular, why was the mortality rate of the 1954–56 experience reduced by 30% at young ages, and why did the reduction decrease to nil at age 60? That was important since, as the values of $\bar{q}$ showed, there was a considerable variation in the mean ages of the impairment groups.

Even if the control table were suitable for the investigation as a whole, was it suitable for each impairment? Some of the impaired lives had been on risk for over 15 years and yet the experience was assessed on a mortality table lighter than that relating to standard lives, durations 0–4. There could be a material difference in the average duration between different impairment groups. Hernia had not normally been a bar to acceptance for life assurance, and the average duration of that group could be higher than that for diabetes mellitus in respect of which only in recent years had life assurance been offered on any scale. Might not the excess deaths recorded for the hernia group be accounted for by that factor alone?

An alternative method was to build up a control experience of unimpaired lives matched as to dates of birth and entry with those included in the impaired lives' experience. Obviously, the greater the number of matched lives for each impaired life, the more reliable the results. Such a method was used to investigate the experience of those who suffered from coronary disease among members of a sickness insurance fund, as noted by Steeds in § 5.4.1 in his paper to the Institute in March 1965 (*J.I.A.* **91**, 231). Was that method considered? If the control table had been built up from the experience of matched lives, the effect of the overall improvement in the mortality rate during the period of the investigation would have been reduced, although, as was pointed out in the discussion following Clarke's paper in 1961, an overall improvement in the general level of mortality would not necessarily imply a similar rate of improvement in the mortality of impaired lives.

In the analysis of the results of the investigation, the authors had made clear the difference between an excess of deaths at younger ages, where the ratio of actual to expected deaths could fluctuate violently, and an excess of deaths at older ages. He was, however, uncertain what the authors meant when they stated in § 20 that it was to be expected that a young group of impaired lives would show a higher percentage excess mortality than an older group. Did they mean, for example, that for Code 701 (bronchial asthma, entry age under 30), because $\bar{q}$ was only ·0007, the actual to expected ratio of 276% and standard deviation 53 did not necessarily imply an inferior class of life to Code 711, entry ages 30–49, with a ratio of 200%, and Code 712, entry ages 50 and over, with a ratio of 154%? And, if the youngest group were not an inferior class of life, on what basis should the extra premium be calculated?

Similarly, as shown in § 26, the ratios of actual to expected mortality of the hypertensive groups decreased with advancing age at entry. But were not higher percentages

for the younger groups inevitable because hypertension at a young age was usually more serious than at an older age? If the young hypertensive group could be investigated separately throughout the duration of their assurances, he suspected that the ratio of actual to expected mortality would be greater than the corresponding ratios for the older hypertensive groups, throughout the whole period of investigation.

To compare the cause of death among impaired insured lives and comparable first-class lives, a control distribution of deaths by cause was calculated from lives with nothing in common either with the impaired lives or with the lives used to build up the control table of mortality rates, except that all held policies with the authors' office. The authors had not said whether only those deaths during the first nine months of 1964 with a low curtate duration were analysed or whether all deaths within that period were included. Since a control table based on the duration 0–4 rates of mortality was found to be too heavy, it would seem that, unless some attempt at selection were made, that analysis had to be interpreted with extreme caution. Also, the proportion of deaths arising from any one cause could vary according to the time of year. Had the authors any information on the difference which the inclusion of the final three months of 1964 might make?

There was no reference to multiple causes of deat and no information as to whether the data were classified by the underlying cause of death or by the direct cause. He had recently seen a death certificate where the cause of death was: 1(a) acute coronary occlusion, (b) coronary athero-sclerosis; 2, diabetes mellitus. How would that have been classified?

In Table 2, the causes of death for Codes 520–528 (diabetes) were shown separately for diabetes and for cardio-vascular diseases. If a death certificate for a known diabetic showed the cause of death to be coronary thrombosis only, would that be taken at its face value?

In the peptic ulcer group discussed in § 28, excess deaths were found, not unnaturally, from peptic ulcer. There were also excess deaths from cancer and that led to the thought that the correlation might be due in part to smoking habits. It was, in a way, a pity that the excess deaths of smokers could not have been included in the investigation, particularly in view of the statement in the *Annual Report of the Chief Medical Officer on the State of the Public Health* for the year 1964 that, broadly, the death rates, age for age, for male cigarette smokers under 65 were almost double those for non-smokers. Unlike most impairments, smoking could be varied at will; but it was worth considering whether the rating for an impaired but non-smoking life could be reduced or even eliminated.

If the probability of recurrence of pulmonary tuberculosis diminished with the time elapsed since the last attack, excess deaths from that impairment could be expected to reduce, particularly since the main cause of excess mortality in that group was tuberculosis itself. It was his office's practice and, he was sure, also the practice of many other offices to accept proposals at the normal rate where there had been a history of pulmonary tuberculosis but little chest damage and where the disease had been quiescent for five or more years. He was, therefore, disappointed that there was no analysis of the tuberculosis groups by duration since episode.

It was disconcerting that the results for the diabetes mellitus group were so much worse than those noted by Steeds in his paper in March 1965. Steeds himself attributed the difference to the fact that in his investigation diabetics with other minor but rateable impairments were not included in the statistics. While that might account for some of the difference between the results of the two investigations might not another factor be a

younger average age at onset of diabetes in the present investigation, since diabetes at a young age was far more serious than at an older age? If the onset of diabetes was after age 50, the extra risk could almost be regarded as trivial. Indeed, he believed that subdivision of diabetics by the age at onset would have been more useful than subdivision by entry age.

The small numbers made the results of the urinary impairments group of little value. The excess deaths among cases with a history of nephrectomy could possibly be attributable to the absence of a paired organ, thus throwing a heavy burden on the remaining kidney.

Malignant tumours showed a very heavy extra risk. It was encouraging, however, that, even in that group, on those results insurance on some terms could be offered.

The precision with which the authors' results were shown should not be taken to indicate that there was no more work to be done. Nevertheless, he believed that their conclusion, that the results justified a more liberal underwriting policy, could not be disputed.

Mr H. A. R. Barnett said that he shared the opener's misgivings over the control which was used. The authors stated that the standard lives data were available in durations 0–4 and 5 and over but he was sure that they were available for individual durations. Even if they were not available, he was also sure that if Clarke the author had spoken to Clarke the Secretary of the Joint Mortality Investigation Committee, the Bureau would have made them available. The authors would then have been able to use a control based on durations such as 0–1 and 0–2, and they could then have used q's which would have been based on a standard experience, and not on a standard experience adjusted by a series of percentages which, as the opener had said, happened to give the right answer.

His misgivings were due to the feeling that readers would get the impression that the impaired lives themselves had been used as a sort of control. But in making that criticism of just one small part of the paper, he did not want to give the impression that he did not appreciate the remainder of it, which was very good.

Mr R. H. Daw, in a written contribution which was read at the meeting, said that he did not think it was overstating the case to say that, to a very large extent, the results of the investigation stood or fell on the suitability of the control groups of first-class lives with which each impairment was compared. The difficulties involved in choosing appropriate mortality rates for first-class lives were considerable; as the authors explained, those rates should refer to the same period of time and be based on policies of the same duration as for the impaired lives. The facts that the impaired lives' experience had been expanding during the period of investigation, and that the average age at entry for most impairments was higher than among first-class lives, had to be taken into account, but the methods by which the authors had done so seemed to be rather arbitrary. The reason for deciding that the first-class mortality rates arrived at were suitable seemed to be that they gave percentages of actual to expected deaths of a little over 100% for two groups of impaired lives which were expected to show something like normal mortality—surely rather a prejudgment of the results of the investigation.

The same control rates of mortality were used to calculate the expected deaths for all impairments. But even if those rates of mortality made reasonable overall allowance for the effect of duration, it did not seem to him to follow that the same rates were appropriate for an impairment, such as arteriosclerosis, for which the average entry

age was high, and for an impairment with a low average entry age. In making that point, he mentioned that, for many of the impairments being considered, the additional mortality was comparatively small, so that small errors in the expected deaths could have a large effect on the apparent additional mortality.

In the discussion on Clarke's 1961 paper, Prof. Sir Austin Bradford Hill indicated a method of paired comparisons which would avoid the above difficulties and provide a control group which could properly be compared with the impaired lives. For each impaired life, a first-class life of the same age and type of policy entering at the same time was selected, and the experience of each group of impaired lives was then compared with the experience of the corresponding first-class lives. Thus a valid comparison of mortality and causes of death was obtained which was free from the present doubts regarding the control group and was subject only to the usual statistical variability. There did not seem to be any serious difficulty in choosing the first-class lives, but the method of paired comparisons would about double the routine work of the investigation, and in his reply to the discussion in 1961 Clarke said that that method had been considered but rejected because of shortage of manpower and punched card machinery. He did not know whether the same still applied, but if it were intended to continue the investigation he would make a strong plea that the method of paired comparisons should be adopted, at least for the future. Even if that meant curtailing the number of years covered by the experience, he felt that it was better to have a smaller volume of data and a reliable control group, than a larger volume with imperfect controls.

Mr W. Perks said that the mortality of sub-standard lives was a subject on which he had submitted a paper on a previous occasion* and one in which he had been interested for many years. He wished to make one or two points on the paper and then to say one or two things more generally on the financial significance of the mortality of impaired lives on the life fund.

Like other speakers, he too felt that the control table was suspect. It seemed to represent—at any rate at the early and middle ages—mortality for an average duration of little more than one year. That seemed to be a duration a good deal shorter than he would have expected to be suitable for data for policies issued over the period 1947–63. Clarke's 1961 paper covered the period 1947–58 and while it might have been right to have had some doubts about the control rates used at that time, that did not justify taking the same view for the present experience, which included five more years of experience so that the average duration of the years of exposure was inevitably much longer. He thought that the control table at the more significant ages of the experience was probably 10% or 15% too low.

Taking the varicose veins group (which represented part of the evidence on which the authors seemed to have based the control table), the ratio of actual to expected deaths was 104%, subject to a standard deviation of 7. It would not be unreasonable, therefore, to assume a set of control rates such that that group of medically examined lives, with varicose veins the only impairment, had an actual experience of, say, 90% of those control rates which would bring the actual experience within one and a half standard deviations. That would produce a set of control rates about 15% above those used by the authors.

The next point to which he wished to refer was the formula for the standard deviation given in § 19. That was the standard deviation of the ratio of actual to expected and the formula was 100 times the square root of actual deaths divided by expected deaths.

* *J.I.A.* **78,** 205.

He was not at all sure that that particular expression was suitable to test the first question that he would have expected the authors to be asking. It was suitable if the question that was being asked involved taking the ratio of the actual to expected deaths as the estimate of the mortality of a particular group. But for the relevant significance question—namely, 'Does this group experience extra mortality?'—which was the primary question to be asked, it was not appropriate. The appropriate standard deviation for this significance question was in the same form but with the square root of the expected deaths in the numerator instead of the square root of the actual deaths. That was a nice example of the importance of getting the question right when applying statistical tests.

Reference had been made to difficulties arising in the cause-of-death analysis that had been made by reference to a group of death claims in the authors' office. He assumed, with an earlier speaker, that the claims had been taken irrespective of duration, and that there had been no attempt to take a group of claims of short duration comparable with the duration assumptions in the control table. Like a previous speaker, he thought that that invalidated the cause-of-death investigation so far as the sub-standard lives were concerned. He was confirmed in that feeling by reference to the particular examples in Table 2, where in nearly every group of impairments the experience from accident and suicide was well above the expected. He did not believe that that could represent the true position. It could be that, for some impairments, there was an increased risk of death from accident or suicide but he did not think that that could extend over such a wide area as Table 2 would imply. However, those results were just what would be expected from taking the expected proportions of accident and suicide deaths from the claims in the office experience where the average duration was fairly long, and applying them to the deaths in an experience with a much shorter average duration, because the rate of death from accident and suicide was generally insensitive to duration. If, for example, the first-year mortality were 50% of the ultimate, it might be that the combined accident and suicide rate at the younger ages was as much as 70% of the first-year mortality. It would then be only 35% of the ultimate mortality. If 35% were used to compare the accident and suicide rate in the early durations, there would be obvious distortion. That also helped to confirm the suggestion that the control table was wrong.

Having indulged somewhat in pin-pricking, he wished to make it clear that he regarded the experience as a very valuable one. The results given should be very useful in underwriting—provided that appropriate adjustments were made for what was wrong with the control table and the cause of death analysis.

Turning to the financial aspect, his own feeling about underwriting sub-standard lives for the normal run of life assurance business was that the whole subject could become top-heavy with investigation and detailed underwriting. In a large office with which he was concerned, the sub-standard business had long been underwritten mainly on the diminishing lien system, with an occasional extra premium in lieu of the diminishing lien. For mortgage-protection policies and house-purchase policies they had charged an extra premium, for obvious reasons. Year in and year out it was found that the total of the diminishing liens deducted from the claims amounted to about 1% of the total death claim payments, or one per thousand of the premium income. The effect of that on the bonus rate was 2d. or 3d.%. Adding in the total of the extra premiums paid on the mortgage-protection policies and the house-purchase policies, those figures were just about doubled, so that what they were really operating upon was about 4d. or 5d. in the bonus rate.

The real underwriting issue of the day, he suggested, was how to exercise the greatest possible liberality for normal business while at the same time maintaining a sufficient

defence against anti-selection. That extended to mortgage-protection and family-income business, although the need to protect the office against anti-selection was greater in those cases. For those classes of business he did not think that either for the first-class lives or for the sub-standard lives the usual form of mortality investigation was likely to be very helpful. It was much more useful to build up a kind of risk-premium revenue account, taking in as income the premiums for those temporary assurances, and putting on the other side the claim payments, estimated expenses and an approximation of the reserves, leading to a balancing item of profit or loss for the year. That would give the actuary far more financial control of that kind of business than by attempting to do an elaborate mortality investigation. It would also be a good basis for investigating the monetary value of the underwriting experience of the large temporary assurances that were being written by some offices. It would be illuminating if such a revenue account basis could be provided and combined for a number of offices because no office was likely to have enough experience of large cases to form an average.

His own feeling was that the rates of premium and the underwriting being used for large temporary assurances (mostly reducing, in connexion with estate duty) were too generous. He did not understand why the market was so willing to take those loss lines off the backs of the few offices writing them.

Dr G. C. Pether (a visitor) made a plea for one small correction. Commonly, after an abdominal operation the abdominal wall went slack, and in consequence an applicant was adversely loaded because of the relative proportions of chest and abdominal circumference. That was something which should always be borne in mind; he mentioned it as he had recently been reminded of it on a visit to his tailor after having had his appendix out.

Mr W. T. L. Barnard said that he belonged to the Birmingham Actuarial Society on whose behalf Hayward and Lucena had earlier that year presented a paper to the Institute on the subject of the mortality of diabetics (*J.I.A.* **91**, 286). It was of great interest to him, therefore, to see the mortality of the diabetics in the authors' experience and to compare it with the Birmingham experience. It was evident that the authors' experience was very much heavier, but was the difference real or just apparent? It should be borne in mind that extra mortality from diabetes increased with the duration since diagnosis. Hayward and Lucena had produced mortality rates according to duration since diagnosis, but the authors' experience was naturally drawn from data commencing with the date of assurance and, because it was normal practice not to underwrite diabetics until, say, a year had passed since the diabetes was diagnosed, it might be that, in many cases, the diabetes had been in existence for several years before the assurance was effected. Thus, the 'exposed to risk' in the authors' investigation could be for people with already quite a long history of diabetes, and that, perhaps, accounted for the higher mortality.

Another factor was that extra mortality from diabetes decreased with increased age at diagnosis, and whereas less than one-fifth of the authors' exposed-to-risk was over the age of 50, 50 was the average age in the Birmingham experience.

As a control, the Birmingham investigation had used the West Midland Conurbation mortality, because their diabetics were drawn from the general population. He noted that the authors' control mortality was something like half that used in Birmingham, particularly because they had used a select table based on durations 0–4 and, since the average exposure was only six years, it indicated that a very high proportion of the authors' investigation fell within the select group.

Those three factors were, in his opinion, major contributors to the apparently very large difference in the mortality of the diabetics in the two experiences. There was the point, of course, that the number of deaths under age 30 in the authors' experience was very small, and perhaps that part of the table was not very significant. It was possible also that there was considerable adverse selection in connexion with life assurance which would be absent in the case of the general population, or perhaps the adverse selection applied to the smaller sums assured. Perhaps, too, the diabetics in the Birmingham investigation, because they were all regularly attending and under the surveillance of a clinic, might have a better prognosis than diabetics drawn from assured lives.

Mr H. C. Rutishauser (a visitor) said that, like Mr Perks, he was struck by the figure of expected deaths by accident and suicide. There seemed to be an excess of actual deaths in most of the groups and he had tried to get a sort of average rate of accidental death and found rates of between ·1 per thousand and about ·25 per thousand at ages up to 50, and around ·4 per thousand at ages over 50. He felt that to be most probably an under-statement. American life assurance statistics showed that the rate of accidental death under age 50 was somewhere between ·4 per thousand and ·7 per thousand, being higher at the younger ages. Rates at ages over 50 increased steadily with age from ·5 per thousand to 1·3 per thousand.

He had been very interested to read the results on the extra mortality amongst diabetics and thought it might be interesting for the meeting to hear the results of an investigation made in his office some time before. They also had the problem of the control population; perhaps even more so as the material was mostly from continental Europe. Some of the lives came from other parts of the world. In total, there were 880 policies and about 5,000 years of experience. There were altogether 80 deaths. For the control table they had used the mortality of their own portfolio, the lives in which came largely from the same areas as the diabetics. The results by age at entry were:

Issue age	Number of policies	Policy-years of experience	Actual deaths	Expected deaths based on normal mortality	Ratio of actual to expected deaths (%)
20–29	50	271·0	2	0·36	556
30–39	194	1,130·5	9	2·84	317
40–49	319	1,974·5	33	11·44	288
50–59	274	1,428·0	26	18·11	144
60–71	43	199·5	10	5·39	186
	880	5,003·5	80	38·14	210

As the investigation was done by policies, there was one death which involved four policies in the group 40–49, and the figure of 288% might therefore be expected to be an overstatement.

It seemed to him that at least the pattern of those results agreed very much with the pattern in the authors' investigation. The period was also similar. The investigation by his own office covered years of entry 1945 to 1962, and the observation period was from 1945 to 1963.

Another point of interest that came out of his office's investigation was that it confirmed one result which was found in the Birmingham study. For diabetics with overweight, the ratio of actual to expected deaths was 242%, whereas for diabetics with

underweight the ratio was 385%; in other words, the diabetics with underweight had a higher mortality than those with overweight.

He supported the opener in that he agreed that it would have been very useful to have had the investigation on diabetes by age at onset of the disease. Unfortunately, their own study was also by age at entry; but in underwriting they were tending to underwrite according to the age at onset.

Mr R. F. S. Hooker suggested that in any future investigation it would be very helpful if some reference could be made to selection. He appreciated the difficulties, but what he had in mind was not quite what was normally meant when selection was referred to. In the case of certain impairments, mortality could be expected to be partly a function of the time elapsed since some episode in the personal history of the proposer, such as a surgical operation. Turning to the data relating to peptic ulcer, and grouping together those cases not treated surgically, the ratio $100A \div E$ was 114 in the 1961 paper and 121 in the present paper—a small increase, but to all intents and purposes very much the same. The cases treated by surgery, however, showed an improvement in the ratio from 162 down to 140. In spite of what had been said about the control table, those comparisons were significant, and the fall from 162 to 140 for cases treated by surgery could well be a reflection of the natural increase in the average time elapsed since the date of the operation. He wondered whether it would be possible to classify the peptic ulcer experience in two broad subdivisions in future according to whether at the time of entry more or less than five years had elapsed since the operation or the disappearance of symptoms.

Mr Perks had referred to accident and suicide. The authors, in Table 2, had sometimes combined those causes of death and sometimes shown them separately. Why had they done this? It seemed to him that quite a number of deaths recorded as accident or misadventure were really suicide.

Prof. D. D. Reid (a visitor) thought it would be a great pity if the meeting were to close without some allusion to the medical as opposed to the actuarial interest of the paper. As one who had been concerned with the problem of disease causation and with the personal risk factors which were important in disease prevention, he had always envied the range and volume of the information accruing from the American investigation on the prognostic implications of defined physical disabilities. Without being chauvinistic he welcomed the authors' 'independent medical actuarial assessment'. It met a real need for a check on the applicability of American findings in the British context.

Recent epidemiological work done in his own department and elsewhere had strongly suggested that there were major differences in the frequency and character and natural history of disease in two countries, even when those diseases were given the same label. There were, in fact, three problems. The first was one of definition. Bronchitis, for example, was often dismissed by American clinicians as a mere nuisance, a relatively trivial disease. In Great Britain, in terms of death certification at least, it was a major health problem. The same question arose from emphysema and terms like that. British understanding of those terms and American usage were often very different, so that the first objective, in making comparisons between actuarial experience in the United States and Great Britain, was to get diagnostic standardization; and if that sort of work were to continue, it should be given high priority.

Secondly, it should be recognized that it was likely that the natural history of the evolution of the disease might be very different in the two countries, for quite good reasons, even though the disease bore the same name in each of them. Taking the whole

group known as chronic non-specific lung disease, the general indication of present studies was that it had a much more malignant course in the British urban environment than it did, for example, even in the major cities of the United States. Conversely, arteriosclerotic heart disease and conditions such as angina pectoris had a different outcome in Great Britain where they were probably less virulent than in the United States.

It had to be recognized that there was a different range of physical characteristics in the two countries. Some recent comparative studies showed that one of the most striking differences between men working as van drivers in London and New York was in their average weight—depending on age, about a stone. Those differences in national physique had to be taken into account when translating the American experience to the British context.

He had greatly enjoyed reading the paper and hoped that the actuaries and the medical people concerned would go on making those important contributions to medicine and not restrict themselves entirely to financial considerations.

Dr B. Benjamin, speaking in his Ministry of Health capacity, wanted to echo and emphasize what Prof. Reid had said. The paper did have an interest and a significance much greater than could be measured by its having been read to the Institute and to the Faculty.

There was no means of measuring the special mortality risks of groups of lives suffering from specified impairments or chronic diseases other than by using what could be obtained in the way illustrated. There was a National Cancer Register which was of varying completeness from region to region in the country, from which fairly good survival statistics could be obtained; and in relation to cancer, of course, many of the treatment centres had their own systems of following up cases, and some had produced classical reports on the mortality of different types of cancer. They had had for many years a fairly complete register of sufferers from tuberculosis, and that in the past had been an area where a great deal of information had been available about mortality. But apart from those two diseases, there were no such registers from which the trends of mortality could be obtained from time to time for any other major groups of chronic disease. He therefore greatly welcomed the invasion of that field of study by actuaries and hoped it would be extended much more in the future.

Since so many people had criticized the control mortality he wished to defend it in some respects. It was not especially relevant to the value of the paper to make quite so much of what defects there might be in the control mortality. Policy decisions were not made on the basis of ratios of actual to expected of 110%. It was rather larger differences that influenced policy, certainly in the health field, and he would have thought that, since people talked of a margin of 10%, it was not really a problem of great importance; and in any case, irrespective of the control mortality used, except in so far as it might have difficulties from a durational point of view, perfectly valid comparisons could still be made between the impairments.

Mr A. J. Steeds said that he was disappointed to be asked to close the discussion at six minutes past six. Had he risen to his feet at about 6.40 that would have been more in accordance with his own expectations and a better tribute to the authors. They were all very much in the authors' debt and yet the discussion had barely got off the ground. He was particularly disappointed in that there were sure to be many actuaries present who were underwriting from day to day and yet they did not feel they had anything to contribute to the discussion. What was required was the results of their work in practice,

as they were working along certain lines, and he hoped that on future occasions they would get up and say what those lines were.

The paper could indeed be regarded as an excellent tribute to medico-actuarial co-operation, and he felt that they would wish to pay a very affectionate farewell to Dr Preston, who had done so much for them in the past. A few months' retirement seemed to have stood him in excellent stead: he was looking better than ever.

His task was to draw together the threads of a rather sparse discussion. Most of his points had been met, and he felt that to be a tribute to the lucidity with which the facts had been presented. The present study had been given to them (as was said of Cromwell's portrait) 'warts and all', and the authors had laid bare everything they had done. He personally felt that it was an excellent job for which they should all be most grateful.

Thinking of the contrast with the paper presented by Clarke in 1961, at that time there was a hope of going on to something larger; that the pilot study should be enlarged into an inter-office study; but significant guns had been brought to bear on that particular hope and it had been sunk more or less without trace. The object had, on the present occasion, been defined as the measurement of mortality of specified classes, with a view to helping them in underwriting, and that was in itself a very worthy aim.

Many speakers had attacked the control, and there had been one defender. When reading the relevant section, his own feeling had been that the authors had concentrated on the 'warts' with perhaps too great care, but he felt a little guilty at all the stones which had been thrown at them. Earlier in the year he had himself produced some results and dismissed the matter of control within a very short space because it was too difficult a problem for him to solve, and nobody had thrown any stones at all.

Dr Preston and Mr Clarke had dealt with the subject fully. They had shown clearly what the difficulties were. In 1961 Clarke had told them of the difficulty he had in arriving at a control, and he had found a fairly simple solution. There were only one or two stones cast then—and the heaviest was cast by the author himself. But on the present occasion the authors had said how unsatisfactory they felt their methods were and had tried hard to improve them. Despite that, they had received quite a barrage of criticism.

The important implication was that the authors were up against the problem of too short a duration. The investigation started in 1947. He was sure that they all hoped that the authors would let it run on so that, despite all the difficulties which longer durations would bring, there might nevertheless be a longer duration. That was one of the aspects in which a study of that kind was deficient, and the Americans ran into the same problem. The average duration for the 1951 *Medical Impairment Study* was something like six years, with a vast mass of data. It was really open to question whether very much had been learned about the additional mortality to be expected from such impairments as hypertension and overweight.

He was very glad that the opener had made a plea for an all-offices investigation, but he felt that he would have to wait a little while. The idea had already been buried, and it could only be hoped that in a decade or two it would arise again like some phoenix.

Dr Pether suggested an analysis of overweight by chest and girth. He sympathized with that, but again it was rather typical of a fair amount of the comment made by speakers, a demand for more detail.

It struck him that the authors would now know how to make a perfect investigation. When they produced another paper there would be, of course, a perfect control table. There would be an analysis by duration since entry into assurance, since operation,

since first diagnosis, and since anything else one could think of—perhaps Dr Preston was glad he had retired after all!

To discuss diabetics briefly (not too much time should be spent on that question because they were a very small group), he was sure that his own results would look better, by which he meant that the extra mortality would look higher, if a different control had been used than the A1949–52 select table, because that was too heavy, in the light of what the authors had said. He could not, even so, explain the differences. They were subject to comment in 1961 and again at two recent meetings, and it was still a puzzle to him. They were again talking about very short durations and the fluctuations were bound to be considerable.

There was a plea to call cardio-vascular deaths among diabetics 'diabetic deaths' but that seemed to be a circular argument. If a diabetic died from coronary thrombosis he died from coronary thrombosis, and the fact that he was a diabetic was certainly not irrelevant but it was not the primary cause.

He had had Perks's paper in front of him but had not had time to read it again and to look at the discussion on it, otherwise he might have been better placed to comment on his contribution. Underwriting was continually being liberalized and they had all considered anti-selection to be one of the chief forces to watch when underwriting. He was a little surprised to learn that Mr Perks expected anti-selection in connexion with mortgage-protection policies and family-income benefits where the benefits were modest in amount. He was much more concerned with them where the large temporary assurances (which Mr Perks so much disliked) were concerned. As for the rates of premium on the large temporary assurances, it was not the right place to comment on them, but it might be said that 'a market is a market is a market', and that if it did not like the rates it ought to throw them out.

The underwriting on temporary assurances ought to take account of the mortality basis in the rates of premium, and there was not very much scope for liberal underwriting in straightforward term assurances.

The arguments about the control table were, he thought, a little out of proportion, and he regretted that the discussion had not contained more comment on the statistical results—whether or not they were significant. One surprising omission had been that of any comment on the fact that Table 1 showed overweight to have hardly any effect on hypertension. That was contrary to the indications of North American studies; underwriters had for years been advised to treat seriously the combination of hypertension with overweight. Perhaps they would have to reconsider their practice. It should, of course, be remembered that different results might well emerge for longer durations.

The President (Sir Herbert Tetley, K.B.E., C.B.) said that it was not the first occasion by any means on which Dr Preston and Mr R. D. Clarke had placed the profession under an obligation by producing a most valuable and interesting paper. The value of the paper was greatly enhanced by the fact that it formed part of a series dealing with substantially similar data and substantially similar experience. Two or three papers of such a type were worth far more than two or three times the value of one paper.

He was therefore rather depressed at first to hear Dr Preston say that it was to be his swan-song. He had been told on the best authority that dying swans did not sing—or, at least, that swans did not sing. He hoped that when the next paper in the series was produced in due course Dr Preston would come along and either listen to the discussion or join in, even though on that occasion he might not be one of the joint authors.

There was, of course, as the authors clearly appreciated, a danger in a series of papers

of that type, that the papers themselves, in so far as they threw light on excess mortality, might lead to changes in underwriting practice, so that the later papers might reflect lessons learned from the early ones, and those lessons would in themselves vitiate comparisons with earlier papers in the series.

The control experience had come in for a great deal of criticism but there were a number of advantages in using a standard table somewhat on the lines of that used by the authors. In the first place, they had to be quite clear exactly what they were trying to do. If they were investigating extra mortality, the question arose: excess to what? If they were trying to examine whether the extra premiums charged were adequate or more than adequate, there was a very strong argument for using for the expected deaths the table on which existing premiums were based; and, as Dr Benjamin had pointed out, if the object were to compare one type of impairment with another, the actual basis used for expected deaths was not very important provided they realized and emphasized (as the authors had) the dangers of ignoring such elements as selection or duration since onset of the impairment.

The obvious alternative—probably the ideal—was the paired experiment, in which every impaired life was matched with an identical life except for the single impairment being examined. He had only to put it in that way for it to be realized how difficult it was even to approximate to a truly paired experiment. If they tried to match such things as sex and age and other data such as weight, girth, blood pressure and so on (and, of course, selection was very important in the present context) it was extremely difficult to form the pairs in the first place. In hospital it could be done to some extent, but even there the same problem arose of the follow-up. The pairs got broken because one or other of the lives disappeared from the supervision; in life assurance experience lapses were very frequent, and the lapses, in the nature of things, tended to occur among the healthy more than among the impaired lives. The impaired lives hung on to the life cover because they appreciated its extreme value; the unimpaired tended to lapse more readily.

There was, moreover, the problem of paucity of numbers; it arose in extreme form when there were paired experiments, and there was a difficulty which had not been mentioned but which always arose in an acute form in practice. That was that they were comparing the impaired deaths with unimpaired deaths which themselves included very large random errors. Taking any experience except one on a national scale, the actual experience showed the widest fluctuations from one year to another or one duration to another, and they were therefore comparing impaired lives with widely fluctuating expected deaths. Thus, the expected deaths themselves had built-in fluctuations, on top of which a comparison was being made of excess mortality due to impairment. The only way to get over that was to do wholesale amalgamations, such as taking everyone irrespective of age or everyone irrespective of duration, and the results produced, while often valuable, were only of limited interest because the more important points that they wished to investigate, notably age, had had to be sacrificed in order to get sufficiently large numbers for the base to be reasonably reliable and to enable the variations in expected deaths to be brought within manageable proportions.

He was extremely grateful to Dr Pether for pointing out that, after major abdominal surgery, girth tended to grow and that there was little that could be done about it. He had been looking for an excuse like that for years!

The President then proposed a vote of thanks to the authors.

Mr R. D. Clarke, in reply, said that when he had opened the discussion at the Faculty

of Actuaries on the previous Monday he had made the point that the paper was a progress report on a continuing investigation, and that the authors were grateful for all comments because, as they went on to produce further reports, they were able to improve them in the light of the various comments and suggestions. He had also made the point at the Faculty that it was the authors' intention eventually, when they had enough data, to do a select investigation, and he had been interested in the number of speakers who had referred to the element of duration and to the interest which a select investigation would have. That was something with which he was in very full sympathy and there was a definite intention to achieve that objective in due course.

Referring to the causes of death, Mr Clarke said that the controls were based upon death claims at all durations over a period of nine months. That had been the only source of data available to them other than the Registrar-General's population figures, and they thought it was far better to use assured lives' experience rather than population figures for the purpose. Last time he had used a control which was inside the investigation itself, drawn from two of the groups which showed very light mortality. At that time it had been the best control available; but it was clearly not wholly satisfactory and had been criticized on grounds of bias. The control in the present report was intended to be an improvement on the former control, but he recognized that the use of all durations rather than durations 0–4, or some shorter number of durations, had probably led to distortion. He was grateful to Mr Perks for pointing out that that might be the answer to the apparent excess for suicide and accident among the impaired groups. In § 56 there was the statement, 'There may, of course, be a fortuitous understatement of suicides in the control group.' Perhaps the word 'fortuitous' should have been omitted, because the feature could be due to the use of all durations instead of only the early durations.

With regard to the criticism of the control table of mortality, Mr Daw had been kind enough to send him a copy of the contribution which had been read earlier in the meeting, so that he had been able to prepare a reply to it. In the course of that reply a number of other points that had been made by speakers during the discussion would also be answered. As he had said in 1961, he fully recognized that a 'paired' control was the ideal for an investigation of the present kind. But such a control was not practicable and an alternative had to be sought. He categorically rejected the suggestion that the control which had been used was so inferior as to undermine the value of the investigation.

When they were able to conduct an investigation on a select basis—and that depended on bringing the services of an electronic computer into play—they would virtually achieve the same as a paired investigation and compare like with like for each age and duration. What they had now was an aggregate investigation in which allowance had been made for the varying mean duration age by age. In 1961 he had made no such allowance for the age by age differences in mean duration between the 0–4 standard assured lives' experience and the impaired lives' experience. He recognized that after the report had been published and acknowledged it in the discussion. The clue to the failing had been the absurdly light experience of certain groups, such as lives with family history of tuberculosis. It was against all reason that a family history of tuberculosis should be an asset and lead to substantially lighter mortality. But it was quite wrong to suggest, as Mr Daw did, that the control used was based on its yielding a roughly normal mortality in those particular groups. The percentages applied to the 0–4 table were based upon statistics of new entrants year by year and age-group by age-group from which a kind of model office was built up so that an approximate relationship

between mean duration and age would be derived. The fact, recorded in § 17 of the paper, that the experience in the 'family history of tuberculosis' group was 101% of expectation, was fortuitous, and there was no element of pre-judgment.

The criticism that the same control was used for all groups was valid, but the calculation of a separate control for each code, or group of codes, was quite impracticable. But what was the scale of variation involved? At age 45, for example, the rate used of ·00209 approximated to duration 1·75. They knew that from other evidence of the relative percentages of mortality at individual short durations to durations 5 and over. What was the practical range of variation? It was from duration 1·5 to perhaps 2·5, in other words, from $q_x = ·00202$ to $q_x = ·00228$. That was a small range and the actual rate used was in the lower part of the range. If there was any error it was almost certainly on the side of understatement (that agreed with what Mr Perks said) and thus would lead to overstatement of the excess mortality. But the range of error there was small. He thought he should perhaps add at that point that, where they had impairments subdivided by age at entry, although the same basic control rates had been used, adjustments had been made within the different entry-age groups to allow for the durational variations.

Finally, on the general question of the extent to which the investigation was weakened by the lack of a perfect control, he reminded critics of the purpose for which the authors' piece of research was carried out. It was to aid the underwriter. Currently the medical officer was asked to state an answer to the question 'How much extra percentage mortality?' He used his judgment and might say 200% or 300% or he might say 250%. He rarely dealt in intervals other than 50%, and generally speaking he was making an *a priori* judgment without statistical data. The authors aimed to give some statistical basis for that judgment and the demand for a perfect control was to some extent a demand for over-refinement. If they were dealing with razor-fine distinctions he would be more inclined to accept Mr Daw's strictures. But he did not hesitate to say that the controls they had evolved were adequate to the purpose which the investigation was intended to serve.

Mr Clarke then dealt with some of the individual points made by speakers in the course of the discussion. The opener had asked why the authors had varied the percentage reduction with age in the 1954–56 experience. That was, of course, to allow for the variation in the mean duration from age to age as between the impaired experience and the standard experience. Mr Barnett's suggestion that they could have taken a control to duration where n had a value less than 4 would not solve that problem because it would not allow for the variation of n with age.

Then the opener had queried a statement in § 20 of the paper: 'It is, in fact, only to be expected that a young group of impaired lives will show a higher percentage excess mortality than an older group'. Too much importance appeared to have been attached there to what was intended to be a very simple statement of arithmetic, i.e. that if there were, say, 400% excess at an age where the expected mortality rate was only ·001, so that out of 1000 lives where only one death was expected there were in fact five, that was not nearly so important as with 400% at an older age, where out of 1000 lives they expected 20 and had 100. The actual quantity of mortality was so much more than at the younger age although the percentage was the same. That was all that was intended in that paragraph and he was sorry it had given rise to misunderstanding.

The causes of death were classified by the Registrar-General's rules and those rules were rather complex, but they were rigid and there was no element there of chance variation.

He had also been asked whether they could give separate data for smokers. The answer was that they had no data at all on the smoking habits of the assured lives concerned.

With regard to diabetics, he entirely agreed that an analysis according to the time elapsed since onset was more useful than one by age at entry; but that particular item of information was not available.

Mr Perks had questioned the formula used in calculating σ. He (the speaker) believed that they were there concerned with an estimation problem. If, for example, according to the control table there were, say, 100 expected deaths within a group which had recently had a surgical operation for cancer, and the actual deaths numbered 1000, he would have thought the sampling error was based on the square root of 1000 rather than 100. The authors were, in fact, not testing the significance of the variation from expectation, but estimating the sampling error of the observed level of mortality.

He was glad of Mr Hooker's point that the fall in percentage of actual to expected deaths in cases of peptic ulcer treated by surgery might be due to the lengthening age of the experience and hence to the increased time which on the average had elapsed since the date of operation. Mr Hooker had also asked why for some impairment groups in Table 2 causes of death were combined which in other groups were set out separately. The intention there was to set out the significant causes and to combine the others. Where numbers for individual causes were too small to make possible any sort of significant measurement, they had been combined in groups of causes.

He was very grateful to Prof. Reid and to Dr Benjamin for putting the discussion in the wider context of medical research as a whole, and he had been most interested in Prof. Reid's references to the differences between Great Britain and North America in the character and natural history of various diseases.

He was also grateful to Mr Steeds for his many kind comments and for dealing with some of the criticisms made by other speakers.