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THE NON-MORTALITY OF ANNUITANTS

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It seemed unfair that anyone should possess apparently perpetual youth as well as reputedly inexhaustible wealth.

1. ACKNOWLEDGMENTS

The praise of the praiseworthy is above all rewards.

1.1. It is traditional for acknowledgments to appear at the end of a paper. However, in this instance the main acknowledgments are due to those who, by their inspiration, made the conception of the paper possible, and cannot be separated from the underlying ideas and the aims and objects, which usually appear near the beginning. I therefore start with a grateful acknowledgment to F. M. Redington whose remark, made in private, that he would love to know the causes from which annuitants do not die, ignited the first spark without which this paper could not have been written; to R. D. Clarke who, when he was Secretary of the Continuous Mortality Investigation Committee, indicated the names of the two life offices who might be able to supply the required information; and to J. H. Gunlake and D. F. Gilley who, in the early stages, provided the necessary encouragement and stimulus to get the project off the ground.

Only a small part is played in great deeds by any hero.

1.2. Acknowledgments are also due to the two offices who have supplied the data, and to the actuaries and others who to a greater or lesser degree have been instrumental in preparing them, but as these offices have requested the usual anonymity accorded to them in these matters it follows that the actuaries, including the two who rendered valuable help at the preliminary stages, also have to remain anonymous; to the Office of Population Censuses and Surveys who have made available before official publication certain figures which will eventually appear in the *Registrar General's Annual Review for 1974*; and to the late J. R. R. Tolkien for the various quotations which appear, all of which are taken from his works.

2. HISTORICAL BACKGROUND

Few can foresee whither their road will lead them, till they come to its end.

2.1. In September 1971 the offices contributing data to the Continuous Mortality Investigation were asked whether it was their practice to obtain death certificates for deceased annuitants and pensioners and, if so, whether

they would be prepared to submit cause-of-death information. They were also asked for an estimate of the annual number of cases for which such information might be available. The thoughts underlying the preparation of the questionnaire, which developed after the C.M.I. Bureau had received two specific requests for information about the causes of death experienced by pensioners, were that advances in medical science reducing the rates of mortality from certain causes at the more advanced ages could have considerable implications for annuity and pension funds, the extent of which could not be assessed without a prior investigation into the mortality experience by cause for this class of life; and that an investigation of this type into the mortality of annuitants could throw some light on the detailed effects of self-selection.

All the Council sat with downcast eyes, as if in deep thought.

2.2. In August 1972 a further circular to the offices indicated that the replies to the 1971 circular showed insufficient support for the project, which was accordingly dropped. In fact thirteen offices were willing to supply cause-of-death information in respect of approximately 3,700 annuitants' deaths per annum, the corresponding numbers for pensioners being ten offices and approximately 1,200 deaths per annum; in the author's opinion the collection of such data over a period of, say, four or five years (if a continuous investigation was not considered feasible) would have yielded useful information large enough to be significant. On the other hand the Committee also had to consider that a new investigation into the mortality experienced under temporary assurances had been started only recently, and another new investigation into the mortality of female assured lives was just entering the pipeline, as was the large and complicated collection of sickness data under Permanent Health Insurance contracts. It is hoped the Committee will not regard as a breach of confidence the statement that the latter consideration weighed heavily with them and, indeed, the desire not to place too many additional burdens on the contributing offices was sufficient reason for not then proceeding with an annuitants' and pensioners' cause-of-death investigation. It is accordingly suggested, with all humility, that the Committee came to the right decision but that the main reason was not the one stated in the August 1972 circular. (In the event, about three-quarters of the offices are contributing female assured lives' data, and about three-fifths of them data for the temporary assurance investigation, but these may or may not include those offices who were willing to submit the additional cause-of-death data.)

3. CERTIFICATION OF DEATH

Tidings of death have many wings.

3.1. Again in all humility, it is perhaps permissible to question whether it is right for an office to record as deaths certain cases where certificates have not been produced. It is one thing to suspend a payment if no evidence of continued

existence has been produced for some time, but quite another to regard the case as a death, and it is submitted that such recording should only take place with the same scrupulous care as the life offices exercise when a death claim is made under an assurance contract. In the case of a man or woman in the public eye, it is conceded that there can seldom be any doubt that when death is reported it has in fact occurred. But in many other cases the mere failure to complete a certificate of existence is not evidence of death; if the office takes further steps to obtain information, how authoritative is such information without a death certificate? I offer three different instances from my own limited experience. First, I give notice to the office already paying me an annuity that it is not to cease without cast-iron evidence of my death (including production of a certificate); secondly, I have acted as an Executor eight times, and in the six instances where an annuity or pension had been payable to the deceased the death certificates were produced without question. Finally, a communication sent to the last known address of a club member who had, in fact, moved house prior to the demolition of his former abode was returned by the Post Office with the word 'deceased' on the envelope—the decease refering to the address rather than to the individual who had indeed 'gone away' but not that far! This story had a happy ending in the clearing up of the misunderstanding, but if the communication had been from an office paying an annuity it will be seen that even the word 'deceased' cannot be taken as conclusive evidence for discontinuance. It is not suggested that death certificates should be obtained merely to enable a cause of death investigation to be undertaken; what is suggested is that those offices who do not obtain certificates may be acting in a somewhat cavalier manner, particularly as in most cases the executors would be quite willing to produce them; it would merely be a corollary that adequate data would then become available for such an investigation.

4. DATA AND OBJECTS

I must consider this message and what it means under its fair cloak.

4.1. The object of the paper is to find out, from the limited data available, the causes of death which give rise to the generally light mortality of annuitants, and also to make what analysis is possible of the mortality of pensioners according to cause. Clearly the fact that we are restricted to data from one office for the annuitants, and from one other office for the pensioners, means that it is necessary to resort to broad groupings of the different causes, broader than the C.M.I. Bureau has been able to adopt in its analysis by cause of the mortality of male assured lives. Originally the idea was to compare the actual mortality experiences by cause with the mortality which would have been expected if the England and Wales population rates, also by cause, were applicable to the experiences being investigated. The population rates are obtainable separately for each calendar year from the *Registrar General's Statistical Review* by extracting the numbers of deaths and dividing them by the appropriate

Home Population shown in the *Registrar General's Annual Estimates of the Population*. To this extent the comparison is similar to that which is undertaken by the C.M.I. Bureau in respect of male lives assured by rather more offices. The exposed to risk are readily available from the returns to the Bureau of the particular offices and, as in the case of the assured lives' investigation, in order to find adjusted figures for the exposed to risk to which the population rates by cause may be applied, the exposed at each sex, age and duration group are reduced in the proportion which the number of deaths excluding those where the cause has not been ascertainable bears to the total number of deaths in the group; in other words, the cases where the cause of death remains unknown are deemed to be distributed amongst the different cause groups in the same proportions as the cases where the cause has been ascertained; this procedure is, of course, more liable to cause error in a small investigation than in a large one, and all that can be expected from examining the results is some hint of the position; we cannot expect conclusive evidence of anything.

[1]Many that live deserve death; and some die that deserve life.

4.2. The cause-of-death data for immediate annuitants were prepared by one office for the years 1972, 1973 and 1974, with sex, ages and durations recorded as in the main returns to the C.M.I. Bureau. However, the office suggested that the volume of information as to causes of death would be considerably increased if they also prepared cards for 'non-C.M.I.' cases (separately marked), indicating whether such cases occurred within a guaranteed period or a capital-protected period, whether they were lives in receipt of last-survivor annuities, and whether or not they were cases where an annuity had been issued in conjunction with an assurance; the information under each of these subdivisions proved too small for each to be summarized separately, the numbers under 'combined' schemes and the numbers within a guaranteed or a capital-protected period each being well under 5% of the total, and the vast majority being single life cases in 'non-combined' contracts outside any type of guarantee; however, as an additional conglomeration of data, they do provide further information as to the distribution of deaths by cause. It will be appreciated that in such cases a comparison of actual and expected deaths by cause cannot be made as the numbers exposed to risk are not known, but an absolute investigation into the distribution of the deaths (i.e. the proportions, age by age and also by sex, falling into each cause group) may give additional evidence as to those groups where the proportions of all deaths differ appreciably from those occurring either in the general population or in the assured lives' experience.

4.3. The office supplying pensioners' data had not completed its preparation at the time of writing this paper, but a report on the details of this experience will be added as Appendix 2.

The wise speak only of what they know.

4.4. In a report of this nature it is possible to publish a welter of figures;

in order to avoid this an attempt has been made to omit any tables which ultimately have no bearing on the conclusions; this applies in particular to the preliminary work described in the next section, but it has also, for example, been the thought underlying the decision not to show separately the results for each calendar year being investigated. Even after combining the years of investigation, the smallness of the data is such that only broad indications of the position can be arrived at rather than firm conclusions. All that can be done is to obtain as much information as possible, from the limited data available, as to the causes of death from which immediate annuitants tend not to die; and to judge whether the distribution of causes amongst pensioners is closest to that of the general population, of the body of assured lives, or of the immediate annuitants.

5. THE SELECTION OF ANNUITANTS

She was not yet weary of her days and thus she tasted the bitterness of the mortality that she had taken upon her.

5.1. At this stage it might be helpful to consider what is involved in the 'selection' exercised at the time an individual purchases an immediate annuity, since if it is accepted that immediate annuitants experience different mortality from that of the general population (and the evidence has always been that this is so) it implies that some process of weeding out (which is the complement of selection) occurs at the time when individuals become annuitants. If a person thinks that he or she is likely to die within a few years, then that person is unlikely to buy an annuity; this feeling could be due to the forces of heredity but, in view of the relatively advanced ages at which annuities are usually purchased, this seems unlikely to be the prime factor. If the usual ages of purchase were, say, between 50 and 55, it would be easy to imagine those whose parents and grandparents had died in their sixties arguing that their life expectation was probably less than average; but once the same prospective purchasers reach 65 to 70, which is more in accordance with the facts, it seems unlikely they would concern themselves with whether or not their parents or grandparents had reached the eighties. So the 'selection' must have some other explanation behind it, and I am forced to the assumption that those who buy annuities do not feel there is anything immediately wrong which would give rise to the belief that they are unlikely to have at least a normal expectation for their age. This, in turn, assumes that those who consider buying annuities but do not in fact do so feel that they may have some impairment, or feel that there may be something wrong even though they may not necessarily have taken medical advice. (And this, also in turn, seems to imply that if the ageing individual can feel that there is something wrong, the same person could well propose for life assurance before he or she consults the medical advisor who might, in due course, become the medical referee for life assurance purposes.) If it is conceivable that the individual may suspect that something is wrong, and this form of 'self-selection' determines who will or will not become an

immediate annuitant, then those impairments of which the person is vaguely aware should bear some relationship to the causes of death from which annuitants tend not to die, as compared with the general population.

At last he felt the approach of old age and knew that the span of his life-days were drawing to an end, long though it had been.

5.2. What, then, happens to the person who wishes to exchange a lump sum for an income for life, but who feels that his expectation is less than normal? Does he arrange for a guaranteed term, either of an arbitrary number of years, or until his purchase money will have been returned? It is suggested that such contracts are more for the financially cautious than for those with substandard faith in their survival prospects. Does he collaborate with his spouse and buy a last-survivor annuity? It is thought that this type of contract would generally be confined to partnerships where both (or all) are first-class lives. Does he combine the annuity with a life assurance contract? It seems more likely that the combined contract is attractive only as a device for obtaining life assurance rather than one for protecting the purchase money of an annuity. No, probably he would prefer to invest his money and hope that the combined ravages of depreciation, inflation and capital transfer tax will leave a reasonable amount of the original investment for his heirs and successors, at the same time drawing a modest return during the few years remaining to him.

5.3. A similar concept of selection does not arise in the case of the pensioners. To the extent that any 'selection' occurs this seems, from first principles, likely to be of the reverse variety. If, at a particular time or age, there is no option but to retire, then the question of selection is absent. On the other hand if there is any option, on the part either of the employer or of the employee, the implication seems to be that those who remain in employment would all be in good health, whereas those who retire would not necessarily be so.

6. PRELIMINARY WORK

Faithless is he that says farewell when the road darkens.

6.1. When the cause-of-death cards for immediate annuitants were first submitted, the population experience was only available up to and including the year 1973, and a preliminary investigation was made with a view to deciding which cause groups were worth keeping separate, bearing in mind that the data would not be sufficiently numerous to justify as many subdivisions by cause as are made by the C.M.I. Bureau in the assured lives' cause-of-death investigation. Initially eleven subdivisions were tried, apart from the 'cause unknown' cases. Amongst the neoplasms, malignant neoplasms of the digestive system and the leukaemia group were each kept separate in view of the fact that these two sub-groups appeared to yield a certain amount of information in the assured lives' investigation. Malignant neoplasms of the respiratory system were kept separate in view of the interest shown in this group in recent years. This left a

residual 'all other neoplasms' group. The preliminary work indicated that there could be some information derived from retaining these subdivisions although the numbers of deaths were comparatively small. The circulatory diseases were first subdivided into the coronary sub-group and all the others, but as these sub-groups indicated comparatively low ratios of actual to expected deaths (i.e. annuitants tend not to die from these causes) a further investigation was made to see whether either might be further subdivided; however the impression was that the experience of the coronary sub-group did not vary appreciably according to whether or not hypertension was mentioned, and similarly that five possible sub-divisions of the 'all other circulatory diseases' group would yield no additional useful information. The two groups of respiratory diseases and of digestive diseases both indicated the possibility of significant information, but the accident and violence group appeared to be too small to be worth keeping separate.

The mightiest man may be slain by one arrow.

6.2. Apart from 'all other causes' the only other sub-group kept separate for the preliminary work was 'ill-defined causes'; this included senility and it was thought that this cause alone might yield some interesting information. In the event, the indications were that where there might be anything interesting divulged by the 'ill-defined' group was in the 'younger' age groups (i.e. 65 to 84) rather than in the highest age-group where the senility cases occurred, and on balance there seemed little point in keeping the ill-defined causes separate. Accordingly when the detailed investigation was made, accident, violence, and ill-defined causes were all amalgamated with 'all other causes'. This left nine cause-groups, four under neoplasms, two under circulatory diseases, and one each under respiratory, digestive, and others. The same groupings were adopted for both males and females.

7. RESULTS—ANNUITANTS IN C.M.I. DATA

Peril comes in the night when least expected.

7.1. Tables 1 and 2 in Appendix 1 show the comparisons between the actual deaths, in cause groups, with those expected according to the population experience of England and Wales, for the years 1972–74 combined, for male and female immediate annuitants respectively. These are confined to those covered by the main returns to the C.M.I. Bureau; and there seems little point in showing the results for each calendar year separately; the figures are available for anyone who is interested. For ease of presentation the tables only show the I.C.D. codes in the headings, but in the paragraphs which follow the italicized headings also give the verbal description of the cause groups. The data were too small to justify keeping each of the first five years of duration separate, but duration 0 was separated from durations 1–4, whilst the ultimate data were divided between annuities purchased before or after the end of 1956.

7.2. *Malignant neoplasms, digestive (I.C.D. 150–159)*

In the male experience, although at duration 0, and also under age 70 at the higher durations, there were no deaths, the fractional expected deaths were so small as to cast doubt on the significance of the results. At the higher ages the act of having purchased annuities seems to have done nothing to eliminate deaths from these causes, and it may be recalled that in the assured lives' investigation this was one of the cause-groups where both initial and permanent selection were in evidence. So, for the males, self-selection seems to have ignored any predisposition to death from these causes whereas underwriting selection (both medical and non-medical) was effective. On the other hand, the female self-selection appears to have done some effective elimination, particularly in the long term as shown by the experience of annuities of durations 5 and over, both in the group where purchase took place after 1956 and in the group of earlier purchases; just why the effect of selection is not so clear at the lower durations cannot be explained, other than perhaps because of paucity of data. It will be appreciated that as the new investigation into the mortality of female assured lives has only recently started, no comparison is yet possible between the relative effects of female self-selection and underwriting selection.

7.3. *Malignant neoplasms, respiratory (I.C.D. 160–163)*

Again the fractional expected deaths for males were small, but in this case there were no deaths at all under age 80 as against nearly 10 expected, and this suggests that self-selection caused significant results which were, however, not evident in the two highest age groups. This contrasts with the assured lives' experience where the cause-of-death investigation indicated no clear duration effects after the first year. If the 'younger' annuitants are able to self-select themselves to the extent of excluding all deaths in their midst from this group of causes, does this not, perhaps, give just the merest hint that, despite the interest in lung cancer shown by life offices and others in recent years, proposers for life assurance are being successful in exercising their own selection against the offices?

Strangely, and in contrast with the experience for cause group 150–159, the female annuitants' experience shows no such evidence of self-selection in group 160–163.

7.4. *Neoplasms of lymphatic and haematopoietic tissue (I.C.D. 200–209)*

This is a cause group which has raised some interest in the assured lives' investigation because, after initial selection has worn off, the rates of mortality are as high as, or higher than, the population rates. So far as can be deduced from the limited data available, the annuitants' rates of mortality from these causes are also up to the national rates, without any reductions in the early durations as a result of self-selection. This comment applies to both males and females. What is it about this group, the major part of which is made up of the leukaemias, which causes the ultimate assured lives' rates of mortality, and

nearly all the annuitants' rates, to be up to or above the national rates? The Registrar General's published figures according to social class do not indicate any great differences in the neoplasm groups, although admittedly these figures do not separate I.C.D. 200–209 from the other neoplasms. Is what is being observed a feature of class differences? Or is leukaemia one of the causes which strikes fairly evenly over all sections of the population, one from which the effects of underwriting selection wear off completely after a few years, and one from which self-selection is quite ineffective? There may be much to be learned about this group, but it does not seem to be in any way responsible for the longevity of annuitants.

7.5. *Other neoplasms* (*I.C.D. 140–149, 170–199, 210–239*)

This is another group where the annuitants' rates of mortality, for both sexes, seem to be well above the population rates, and this cannot be explained away by the smallness of the expected deaths. It is a pity that more data are not available, as it could then be worth-while subdividing the group further. When this investigation was started, it was not anticipated that it would disclose certain groups where self-selection appears to be self-defeating. Perhaps this group, and the one immediately preceding, are causes to which certain of the affluent classes are prone, but this feature for some reason does not show up in the Registrar General's class figures; it may be masked through not applying equally through the whole of the social classes corresponding to the higher income groups.

7.6. *Ischaemic heart disease* (*I.C.D. 410–414*)

The figures indicate that, except at the highest age group, the actual male deaths are significantly lower than the expected, at all durations except for annuities purchased before 1957. Furthermore, the ratios which the actual bear to the expected below age 85 are considerably smaller than have been observed in the past in the assured lives' investigation. For the females too, the actual deaths tend to be below the expected, and this effect again reduces with age and duration until, after about age 80 and also at nearly all ages in the pre-1957 annuity group, it disappears; however, the ratio of actual to expected deaths is generally significantly higher than for the male annuitants.

Generally speaking, this is a group of causes from which annuitants tend not to die.

7.7. *Other circulatory diseases* (*I.C.D. 390–404, 420–458*)

When compared with the population experience, this group exhibits similar features to the immediately preceding group of ischaemic heart disease, although the progression with advancing age is not always so clear and the ratios of actual to expected tend to be higher than for the preceding group, particularly for males. When the male experience is compared with the latest available assured lives' experience (*C.M.I.R.* **1**, 49) however, it will be seen that, in general, the experiences are similar at ages from 75 upwards. Admittedly the

assured lives' experience related to an earlier period of investigation, but as broad indications rather than firm conclusions are being looked for it is permissible to make the comparison. Although this is another group from which annuitants tend not to die, this tendency appears to be no stronger than that exhibited by the assured lives.

7.8. *Respiratory diseases* (*I.C.D. 460–519*)

The male actual deaths are well below the expected deaths, at all age and duration groups where the expected deaths are appreciable, but the ratios of actual to expected are not as low as the assured lives' experience for earlier years, so here again the tendency of annuitants not to die is no longer evident when comparison is made with assured lives. In the female experience the ratios of actual to expected are much higher, particularly at the highest age and duration groups where the tendency not to die seems to have disappeared completely.

7.9. *Digestive diseases* (*I.C.D. 520–577*)

All the male deaths, and 10 out of the 14 female deaths, occurred in the age group 85 and over. In that age group the actual deaths were, in total, not very different from the expected; but at all other age groups the actual to expected ratios were very small and, in the male experience, considerably lower than shown in the assured lives' experience. The indication here, then, is that annuitants under age 85 tend not to die from this group of causes, and this could therefore be another example of individuals being aware of whether or not there may be a tendency to die. The data were not large enough to justify separating the group 571, 291 and 303, cirrhosis and/or alcoholism, which is a new group just being adopted for the assured lives where the greatest bulk of the group comes from cause 571 which, for the purpose of this annuitant investigation, falls within the cause group under discussion. It is, however, considered worthy of comment that during the years 1972–74, there were no deaths whatsoever reported as due to either cirrhosis or alcoholism, amongst the male and female annuitants (both included in the C.M.I. experience and not so included) of the one office who submitted data. This brings out the inevitable feeling that it is a great pity more data are not—or at any rate not yet—available.

7.10. *All other causes* (*I.C.D. 000–136, 240–389, 580–796, 800–999*)

This is a conglomeration of causes which, from the limited data available, do not appear to exhibit any interesting information either jointly or when subdivided; this is not necessarily to say that the tendency not to die is absent from all these causes (see § 7.9. *re* causes 291 and 303) and it cannot be said too often that, if a fuller investigation of larger data were possible, their analysis could yield useful results.

8. SUMMARY OF RESULTS—C.M.I. DATA

I have forgotten much that I thought I knew, and learned again much that I had forgotten.

8.1. The indications which may be gleaned from the experience of about 900 female deaths and about 250 male deaths are that the main groups of causes from which annuitants appear to have a tendency not to die are ischaemic heart disease (which, of course, includes coronary thrombosis), excluding females over age 80, and digestive diseases, excluding both sexes at ages 85 and above. To these may be added digestive malignant neoplasms in the case of females and respiratory malignant neoplasms in the case of males under age 80.

8.2. The previous paragraph omits mention of circulatory diseases other than ischaemic heart disease, and also of respiratory diseases in the male experience only, where the tendency not to die appears to a limited extent, but no greater than has already been exhibited by the experience of male assured lives.

9. DISTRIBUTION OF DEATHS—C.M.I. AND NON-C.M.I. DATA

It is a hard doom and a hopeless errand.

9.1. Table 3 shows, on a lives rather than a policies basis, the actual deaths compared with the deaths which would have been expected if the distribution by cause group had, for each of the years 1972–74, been precisely the same as the distribution exhibited by the population experience of England and Wales. This comparison is shown separately for the annuities in the C.M.I. experience and for the non-C.M.I. annuities, as well as showing the sexes separately. The results are considered in the following paragraphs.

9.2. *Malignant neoplasms, digestive* (*I.C.D. 150–159*)

The actual deaths for males are all greater than the expected, except for the non-C.M.I. cases at ages 80–4. The actual deaths for the females are all smaller than the expected (though not always significantly so) except for the non-C.M.I. cases at ages 85 and over.

9.3. *Malignant neoplasms, respiratory* (*I.C.D. 160–163*)

The actual deaths for males are less than the expected, except at age group 80–4, while for females they are generally greater than the expected.

9.4. *Neoplasms, lymphatic and haematopoietic* (*I.C.D. 200–209*)

Where there are any significant differences, the actual deaths for both sexes exceed the expected.

9.5. *Other neoplasms* (*I.C.D. 140–149, 170–199, 210–239*)

Where there are any significant differences, the actual deaths greatly exceed the expected.

9.6. *Ischaemic heart disease (I.C.D. 410–414)*

Although in about half the figures shown the actual deaths are slightly smaller than the expected, the rather surprising feature here is, generally, how close the actual are to the expected throughout both the C.M.I. and the non-C.M.I. data for both sexes.

9.7. *Other circulatory diseases (I.C.D. 390–404, 420–458)*

Here again the actual deaths never depart far from the level of the expected.

9.8. *Respiratory diseases (I.C.D. 460–519)*

The male actual deaths are generally smaller than the expected, and the same applies to the female non-C.M.I. data. In the female C.M.I. data the actual deaths exceed the expected at ages 80 and over.

9.9. *Digestive diseases (I.C.D. 520–577)*

The actual tend to be lower than the expected throughout, except at the highest age group.

9.10. *All other causes (I.C.D. 000–136, 240–389, 580–796, 800–999)*

The results are somewhat erratic in this residual group, which can scarcely be expected to yield much information when the data are not large enough to be subdivided into subgroups of similar causes.

9.11. *Summary*

The results of this part of the investigation tend to confirm the results summarized in § 8.1, apart from appearing to cast doubt on the validity of the conclusion—no, of the broad indication—suggested for ischaemic heart disease; but this appearance may be misleading, as all that the figures show is that in the C.M.I. data the non-mortality of annuitants from this cause (as compared with the population) is roughly proportionate to the non-mortality from all causes combined. Whether this further analysis, including non-C.M.I. data, has really achieved much is conjectural, but it does at least seem to have confirmed that annuitants tend not to die from digestive diseases. The results also indicate that the distribution of deaths by cause differs considerably from that exhibited by the population statistics and, in the case of males, from that exhibited by the assured lives.

10. CONCLUSIONS

Courage is found in unlikely places.

10.1. To enlarge upon the conclusions already hinted at, the following five considerations are put forward, both for the profession and for the life offices; perhaps also for the Continuous Mortality Investigation Committee, who are in no way responsible either for the production of the paper or for the opinions

and suggestions it contains, but who may possibly be interested. Some of these considerations (§10.2 to §10.6) may be thought conjectural, due to the paucity of data, but the paucity itself is one of the considerations; others are controversial.

10.2. The first such consideration is the general one, summarized in §8.1, that there appear to be certain causes of death from which annuitants show a tendency not to die.

10.3. The data investigated for the purpose of this paper are not large enough for the results to be regarded as in any way conclusive.

10.4. It should be possible for larger volumes of data to be made available without prohibitive effort; this could not be arranged overnight, but it should be feasible for all the preliminary procedures to be completed in time to start a full cause of death investigation for, say, the quadrennia 1979–82 and 1983–86; it could later be considered whether the investigations should then be made continuous into subsequent years.

10.5. Such an investigation could be of real benefit to the offices, not only in enabling them to estimate future improvements in longevity amongst certain classes of life, but perhaps also in helping them to be aware of those diseases in respect of which selection might be exercised against them by other classes of life.

10.6. In order that as many as possible different comparisons may be made, the cause of death investigation would need to be extended to female assured lives, to male and female immediate annuitants, and to male and female pensioners. It is hoped that the computerization of the C.M.I. work will in due course lighten the load involved in the offices' preparation of their main returns to the Bureau, while the new procedure for the submission of information for the male assured lives' cause of death investigation, under which death certificates are now copied photostatically and policy particulars written on the reverse of the photostats in positions indicated by a rubber stamp, should facilitate the submission of similar information for the other classes of life. It may be mentioned here that a number of offices who contribute data to the Bureau in respect of female assured lives have, without being asked, been submitting cause-of-death information in respect of them; regrettably it has not been possible to utilize this information, but its submission seems to indicate that some of the offices at least are able to prepare more data than has at present been requested by the C.M.I. Bureau. If the suggested information can be made available, then in due course it may be possible to say

All's well as ends better.

APPENDIX 1

Table 1. *Immediate annuitants, males; actual deaths* (A) *by cause experienced by one office in 1972–74 amongst its C.M.I. data compared with expected deaths* (E) *by cause according to the rates experienced by the population of England and Wales in the same three years*

Age group	International Cause of Death codes: 150–159		160–163		200–209		140–149, 170–199, 210–239		410–414		390–404, 420–458		460–519		520–577		000–136, 240–389, 580–796, 800–999		Total where cause known		Cause unknown
	A	*E*	*A*	*E*	*A*	*E*	*A*	*E*	*A*	*E*	*A*	*E*	*A*	*E*	*A*	*E*	*A*	*E*	*A*	*E*	*A*
Duration 0																					
All ages	0	·6	0	·9	0	·1	1	·2	2	2·8	0	2·6	1	1·7	0	·0	1	·7	5	9·6	0
Durations 1–4																					
–64	0	·2	0	·3	0	·0	0	·0	0	·7	0	·3	0	·3	0	·0	1	·0	1	1·8	0
65–69	0	·8	0	1·2	0	·1	1	·5	0	3·0	1	1·6	0	1·3	0	·3	0	·6	2	9·4	0
70–74	1	1·1	0	1·6	0	·3	0	·8	1	4·5	0	3·0	1	2·3	0	·3	0	·8	3	14·7	0
75–79	1	·7	0	·8	0	·0	0	·6	2	3·0	4	2·6	2	2·0	0	·3	1	·6	10	10·6	0
80–84	1	·5	2	·4	1	·0	0	·5	1	2·2	4	2·5	0	1·8	0	·3	1	·6	10	8·8	1
85–	1	·3	0	·2	0	·0	0	·3	2	1·7	0	2·5	1	1·7	0	·2	1	·6	5	7·5	0
All ages	4	3·6	2	4·5	1	·4	1	2·7	6	15·1	9	12·5	4	9·4	0	1·4	4	3·2	31	52·8	1

Durations 5 and over, purchases since 1956

–64	0	·0	0	·0	0	·0	0	·0	0	·1	0	·0	0	·0	0	·0	0	·0	0	·1	0
65–69	0	·3	0	·5	0	·0	0	·3	0	1·2	1	·6	1	·6	0	·0	0	·3	2	3·8	0
70–74	2	1·0	0	1·4	0	·2	1	·5	0	3·8	0	2·6	2	2·0	0	·3	1	·7	6	12·5	1
75–79	4	2·3	0	2·7	0	·3	2	1·8	7	9·8	3	8·3	4	6·5	0	·8	0	2·0	20	34·5	0
80–84	1	2·0	2	1·5	1	·3	1	1·6	3	8·3	4	9·2	4	6·7	0	·7	2	2·3	18	32·6	3
85–	3	2·7	2	1·4	0	·3	6	2·7	18	15·7	20	22·7	13	16·1	4	1·5	2	5·8	68	68·9	0
All ages	10	8·3	4	7·5	1	1·1	10	6·9	28	38·9	28	43·4	24	31·9	4	3·3	5	11·1	114	152·4	4

Durations 5 and over, purchases before 1957

65–69	0	·0	0	·0	0	·0	0	·0	0	·3	0	·1	0	·0	0	·0	0	·0	0	·4	0
70–74	0	·0	0	·1	1	·0	0	·0	0	·3	0	·3	0	·3	0	·0	0	·0	1	1·0	0
75–79	1	·0	0	·0	0	·0	0	·0	1	·4	1	·3	0	·3	0	·0	0	·0	3	1·0	0
80–84	1	·3	0	·1	0	·0	0	·1	1	1·0	0	1·1	0	·7	0	·1	1	·3	3	3·7	1
85–	1	·8	0	·4	0	·0	4	·8	4	4·4	11	6·3	2	4·4	0	·4	3	1·7	25	19·2	1
All ages	3	1·1	0	·6	1	·0	4	·9	6	6·4	12	8·1	2	5·7	0	·5	4	2·0	32	25·3	2

All ages and durations

	17	13·6	6	13·5	3	1·6	16	10·7	42	63·2	49	66·6	31	48·7	4	5·2	14	17·0	182	240·1	7

Note: all ages in this table are ages nearest birthday.

Table 2. *Immediate annuitants, females; actual deaths* (A) *by cause experienced by one office in 1972–74 amongst its C.M.I. data compared with expected deaths* (E) *by cause according to the rates experienced by the population of England and Wales in the same three years*

Age group	International Cause of Death codes 150–159		160–163		200–209		140–149 170–199 210–239		410–414		390–404 420–458		460–519		520–577		000–136 240–389 580–796 800–999		Total where cause known		Cause unknown
	A	*E*	*A*	*E*	*A*	*E*	*A*	*E*	*A*	*E*	*A*	*E*	*A*	*E*	*A*	*E*	*A*	*E*	*A*	*E*	*A*
Duration 0																					
All ages	1	1·2	0	·0	1	·0	0	1·4	2	4·2	3	6·0	2	2·4	0	·3	0	1·6	9	17·1	0
Durations 1–4																					
–64	0	·3	0	·3	0	·0	0	·6	0	·7	0	·7	0	·3	0	·0	0	·2	0	3·1	0
65–69	1	·8	0	·3	0	·2	5	1·2	1	2·1	0	2·0	0	·8	0	·3	0	·7	7	8·4	2
70–74	0	1·2	0	·5	0	·2	2	1·4	2	4·0	2	4·3	0	1·6	0	·5	1	1·2	7	14·9	1
75–79	4	1·6	2	·3	0	·3	3	1·4	3	5·6	3	7·3	1	2·6	1	·6	0	1·9	17	21·6	0
80–84	0	1·2	0	·3	0	·1	1	·9	5	5·0	5	7·7	1	3·0	0	·6	1	1·8	13	20·6	0
85–	1	·9	0	·1	0	·0	0	·7	5	5·4	3	10·4	0	4·4	0	·5	0	2·3	9	24·7	2
All ages	6	6·0	2	1·8	0	·8	11	6·2	16	22·8	13	32·4	2	12·7	1	2·5	2	8·1	53	93·3	5

Durations 5 and over, purchases since 1956

–64	0	·0	0	·0	0	·0	0	·3	0	·3	0	·3	0	·0	0	·0	0	·1	0	1·0	0
65–69	0	·5	0	·3	0	·0	1	·8	0	1·3	2	1·3	1	·5	0	·2	0	·5	4	5·4	1
70–74	1	2·0	0	·6	0	·3	3	2·2	4	6·4	5	7·0	1	2·6	0	·7	4	2·0	18	23·8	1
75–79	3	6·0	1	1·4	0	·8	8	5·3	16	21·3	20	27·3	2	10·2	0	2·2	4	7·0	54	81·5	3
80–84	3	8·2	2	1·4	1	1·0	6	6·8	28	35·2	51	54·0	16	20·6	3	3·8	17	12·4	127	143·4	14
85–	12	12·4	0	1·5	2	1·1	12	9·5	68	70·8	106	136·8	53	58·7	4	7·3	19	30·5	276	328·6	9
All ages	19	29·1	3	5·2	3	3·2	30	24·9	116	135·3	184	226·7	73	92·6	7	14·2	44	52·5	479	583·7	28

Durations 5 and over, purchases before 1957

65–69	0	·0	0	·0	0	·0	0	·0	0	·3	0	·3	1	·0	0	·0	0	·0	1	·6	0
70–74	1	·2	0	·0	0	·0	0	·2	0	·6	2	·6	0	·3	0	·0	0	·2	3	2·1	0
75–79	0	·5	0	·1	0	·0	1	·5	2	1·8	2	2·4	3	·9	0	·2	0	·6	8	7·0	1
80–84	1	1·7	0	·3	0	·2	0	1·4	9	6·9	7	10·7	7	4·1	0	·8	2	2·4	26	28·5	1
85–	1	6·1	3	·8	2	·6	5	4·7	31	34·9	71	67·5	37	28·8	6	3·6	20	14·9	176	161·9	9
All ages	3	8·5	3	1·2	2	·8	6	6·8	42	44·5	82	81·5	48	34·1	6	4·6	22	18·1	214	200·1	11

All ages and durations

	29	44·8	8	8·2	6	4·8	47	39·3	176	206·8	282	346·6	125	141·8	14	21·6	68	80·3	755	894·2	44

Note: all ages in this table are ages nearest birthday.

Table 3. *Immediate annuitants, males and females; actual deaths (excluding duplicates and cause unknown cases) (A′) experienced by one office in 1972–74 and subdivided by cause, compared with deaths which would have been expected (E′) if the distribution by cause had been in the same proportions as those experienced by the population of England and Wales.*

Age group	International Cause of Death codes 150–159		160–163		200–209		140–149 170–199 210–239		410–414		390–404 420–458		460–519		520–577		000–136 240–389 580–796 800–999		Total
	A′	*E′*	*A′*	*E′*	*A′*	*E′*	*A′*	*E′*	*A′*	*E′*	*A′*	*E′*	*A′*	*E′*	*A′*	*E′*	*A′*	*E′*	
Males, C.M.I. data																			
–79	7	3·4	0	4·2	1	·5	5	2·6	12	13·9	9	10·5	9	8·2	0	·9	4	2·8	47
80–84	3	1·6	4	1·2	1	·2	1	1·4	5	7·5	8	8·4	3	6·0	0	·7	4	2·0	29
85–	4	3·5	1	1·9	0	·4	8	3·4	23	20·1	29	29·0	14	20·4	3	1·8	6	7·5	88
All ages	14	8·5	5	7·3	2	1·1	14	7·4	40	41·5	46	47·9	26	34·6	3	3·4	14	12·3	164
Males, non-C.M.I. data																			
–79	19	14·4	16	18·6	1	1·9	9	10·0	63	59·4	52	42·6	20	33·4	1	4·4	15	11·3	196
80–84	3	5·0	4	4·0	0	·6	5	4·3	25	22·8	30	25·5	15	18·4	2	2·1	5	6·3	89
85–	8	7·1	2	3·8	2	·9	10	6·9	37	40·6	66	58·6	27	41·4	3	3·6	23	15·1	178
All ages	30	26·5	22	26·4	3	3·4	24	21·2	125	122·8	148	126·7	62	93·2	6	10·1	43	32·7	463
Females, C.M.I. data																			
–79	9	9·1	3	2·7	1	1·2	23	9·5	26	30·7	37	37·4	9	14·1	1	3·2	9	10·1	118
80–84	4	8·8	2	1·5	1	1·1	7	7·2	40	37·8	55	58·7	23	22·5	3	4·0	20	13·4	155
85–	14	16·8	3	2·1	4	1·6	15	12·9	98	95·3	176	183·5	85	78·1	9	9·9	37	40·8	441
All ages	27	34·7	8	6·3	6	3·9	45	29·6	164	163·8	268	279·6	117	114·7	13	17·1	66	64·3	714
Females, non-C.M.I. data																			
–79	12	12·6	5	4·0	1	1·8	20	13·9	47	40·9	40	47·8	16	18·1	4	4·3	12	13·6	157
80–84	9	9·4	1	1·7	5	1·1	10	7·8	35	40·4	64	62·3	19	23·8	5	4·3	17	14·2	165
85–	19	17·0	2	2·2	1	1·5	14	13·2	111	95·5	193	182·6	62	77·6	12	9·7	26	40·7	440
All ages	40	39·0	8	7·9	7	4·4	44	34·9	193	176·8	297	292·7	97	119·5	21	18·3	55	68·5	762

Note: all ages in this table are ages nearest birthday.

APPENDIX 2

The distribution of pensioner deaths by cause

The data received from one office of the causes of death amongst pensioners under insured pension schemes in 1973–74 were, at first sight, disappointing as the 'cause unknown' cases numbered 1,141 out of 1,541 males and 58 out of 89 females. The assumption made, in calculating the adjusted exposed to risk, that the 'cause unknown' cases were distributed between the various causes proportionately to the known cases must become progressively more unreliable the more numerous the unknown cases. Nevertheless, I am specially grateful to the office in question for having demonstrated that a considerable quantity of data can be assembled without making any unusual request to pension scheme trustees; if trustees were to be asked to forward death certificates or photostatic copies whenever possible, clearly a much larger volume of data would become available. Even with the limited data received for 1973–74 it is possible to detect some broad indications, although more than ever in the case of these pensioners it would be hazardous to draw firm conclusions.

2. In view of the size of the data sophisticated sub-divisions would be out of place. There was a space on the cards for indicating whether the pensioner had retired before, or at or after normal retiring age (a sub-division in the main C.M.I. pensioner investigation which may or may not be worth while); in the event the office ignored this space. On the other hand the office did supply information as to the duration between retirement and death, but it was not possible to use this as the exposed-to-risk were not available by duration. In order to keep the numbers in the sub-groups reasonably substantial the males, after calculating the expected deaths in quinary age-groups, were tabulated in four rather broader groups, the only quinary group worth keeping separate being 65–69; the females were combined into one all-ages group. The results are shown in Table 4.

3. In the four neoplasm groups (I.C.D. 140–239) the male actual deaths were broadly similar to those expected by the population experience, apart from lives under age 70 in the groups of digestive malignant neoplasms (I.C.D. 150–159) and respiratory malignant neoplasms (I.C.D. 160–163). This is not the pattern displayed by assured lives under which, even at the ultimate durations, mortality due to neoplasms has hitherto been observed as lower than the population mortality from these causes. Nor is the pattern similar to the male annuitants at ultimate durations, who seem to experience higher mortality than pensioners from digestive malignant neoplasms and lower from respiratory malignant neoplasms.

4. In the two groups of circulatory diseases (I.C.D. 390–458) the male pensioner mortality was generally lower than that of the population and, in some age-groups, lower than that of the ultimate annuitants. The experience was somewhat similar to that of the ultimate assured lives who, however, perhaps exhibit higher mortality from these causes at the highest ages.

5. Male pensioner mortality from respiratory diseases (I.C.D. 460–519) was similar to that of the ultimate annuitants, lower than that of the population,

Table 4. *Pensioners; actual deaths (A) by cause experienced by one office in 1973–74 amongst its C.M.I. data compared with expected deaths (E) by cause according to the rates experienced by the population of England and Wales in the same two years*

	International Cause of Death Order																				
Age	150–159		160–163		200–209		140–149 170–199 210–239		410–414		390–404 420–458		460–519		520–577		000–136 240–389 580–796 800–999		Total where cause known		Cause unknown
group	A	E	A	E	A	E	A	E	A	E	A	E	A	E	A	E	A	E	A	E	A
Males																					
–64	2	2·6	2	4·4	1	·5	3	1·5	5	10·6	1	4·4	4	3·0	0	·6	5	1·8	23	29·4	52
65–69	9	14·5	16	22·6	0	2·2	10	8·8	42	58·0	24	29·8	19	22·5	0	3·7	11	9·6	131	171·7	287
70–79	16	15·7	20	21·0	3	2·2	12	11·0	55	64·8	24	47·2	33	36·3	2	4·8	15	12·2	180	215·2	639
80–	3	4·4	4	3·6	2	·6	2	3·9	22	21·9	15	25·6	9	18·9	1	2·1	8	6·3	66	87·3	163
All ages	30	37·2	42	51·6	6	5·5	27	25·2	124	155·3	64	107·0	65	80·7	3	11·2	39	29·9	400	503·6	1141
Females																					
All ages	1	3·2	4	1·3	0	·6	3	4·1	5	10·1	10	12·6	6	4·9	0	1·0	2	3·5	31	41·3	58

Note: all ages in this table are ages nearest birthday.

but much higher than that of the ultimate assured lives, whilst male pensioner mortality from digestive diseases (I.C.D. 520–577) appeared to be lower than for any of the other classes of life.

6. As far as may be deduced from the scanty data, female pensioner mortality was generally lower than that of the population, with the exception of mortality from respiratory malignant neoplasms and from other respiratory diseases. It is interesting that the female annuitants also exhibited comparatively high mortality from these respiratory causes. The pensioner experience was by no means the same as that of the female annuitants, but any differences could be due to paucity of data.

7. In general, the distributions by cause of death amongst males appeared to be quite dissimilar from the annuitants, from the assured lives, and from the population, but it would not be safe to draw conclusions until a more substantial investigation has been made. For the females, the data were so small that it would be difficult even to claim any broad indications.

8. Nothing in this limited investigation into pensioner mortality modifies in any way the conclusions set out in the final section of the main paper. Consideration of the 'selection' which takes place before lives become pensioners would have led to the expectation that these are a quite different body of lives from the other classes investigated; the action of self-selection for purchase of an immediate annuity is a once-only operation; lives assured are initially selected by the office but the body of lives is subject to subsequent decrement by surrender or lapse and the implication must be that the worst lives would try to avoid such withdrawal; on the other hand pensioners were presumably selected for employment many years earlier, after which the body of lives may have been subject to various forms of decrement; those who chose to leave for different employment may have removed from membership of the scheme many first-class lives; dismissals would usually be for reasons unconnected with health; and some would have left through ill-health and received a lump-sum settlement, thus removing some of the worst lives. The latter cases would be likely to arise in insured schemes where the ill-health risk is not insured but recent legislation will result in more ill-health leavers taking immediate or deferred pensions. Deferred pensioners will eventually be classified as having retired at the normal age and perhaps a more useful classification, both for the main C.M.I. investigation and for the cause-of-death investigation, would be by duration since date of leaving employment rather than by duration since the pension started; the somewhat academic distinction between those who retired 'before' or 'at or after' normal retiring age could then be dropped.

9. It has probably always been realized that none of the standard tables for assured lives, annuitants or populations is strictly applicable to pensioners, although annuitants' tables have sometimes been employed for lack of a better yardstick. In the early 1950s the a(m) and a(f) tables were often close enough to employ; now pensioner mortality appears to be nearer to the a(55); but it may not always be sufficiently accurate to use for pensioners the tables applicable to annuitants some quarter of a century earlier.

ABSTRACT OF THE DISCUSSION

The author, in introducing his paper, began by saying that the case he had tried to make out was not proven. The data were scanty and he could not claim to have proved anything; he had merely tried, in a legal analogy, to have the case remitted to a higher court, the C.M.I. Committee, which would need more evidence.

He believed that the collection and analysis of data he had advocated in § 10 could add a new dimension to medico-actuarial science, and he hoped that the opportunity would not be allowed to slip. He was not aware of a similar investigation having been attempted in any other country; but it did not follow that it could not be done. It would have to be done sooner or later and in the words of Tolkien, through the mouth of Sam Gamgee, "It's the job that's never started as takes longest to finish".

If a further approach was made to the offices, the questionnaire would need to be somewhat different from that sent out in 1971. It was now known that most of the offices did not obtain death certificates for annuitants and pensioners. What should be asked was whether from the beginning of 1979 they would be prepared to do so. For annuitants it would mean instituting a simple new procedure. For pensioners the scheme managers could be warned in advance that a sight of certificates would be requested. That did not seem to be either outrageous or onerous.

It could be argued that annuitant mortality was low because the lives enjoyed a regular unearned income. Even if that were so, the profession would still need to be able to assess the effect of annuitant mortality of a postponement of future deaths through certain causes, as it would not be safe necessarily to assume that all required information was available in the Registrar General's publications. The evidence had been that both initial and class selection were present in annuitant mortality, and the type of investigation he was recommending should throw light on both elements. Initial selection did not necessarily mean the consciousness of certain immunities on the part of the person buying an annuity. It was more likely to arise from the fact that those who had considered buying annuities, but decided against it, might be aware of certain personal dangers or pre-dispositions, so that initial selection was in a way a negative element.

He had carried out some calculations on the a(55) table of the effect if all respiratory deaths—that was to say deaths from the group 460 to 519, together with the respiratory neoplasms—were to be postponed by five years as a result of advances in medical science. He had estimated the curtate expectation of life, which for females at age 70 was 13·44 on that table. If calculations were made on the basis of the proportions in the population dying from those causes, the 13·44 would be increased to 14·98. But if similar calculations were made on the basis of the proportions shown in the author's paper, the curtate expectation would be increased to 15·14, so that the first approach would not produce a large enough correction. On the other hand, for the males, it would over-correct: the curtate expectation was 10·61. If it were increased on the basis of the population proportions, it would become 11·53, whereas on the alternative basis it would be only 11·36. That was on the basis of the very scant data on which he had based his paper, so the last figure was subject to considerable statistical error. Those figures were given as an illustration of what could be the result of assuming blindly that the annuitants died from various causes in the same proportion as the general population.

Mr R. J. Sansom, opening the discussion, congratulated the author, and the late J. R. R. Tolkien, for combining so admirably in producing the paper. He wanted to classify his own remarks under four main headings: the available data; the practical usefulness of the research; factors other than medical which influenced annuitant mortality; and a study of the likely and unlikely causes of death for annuitants.

The author had already pre-empted the major part of the first heading by referring in his opening remarks to the scantiness of the data, a point also made several times in the paper. They were told that the C.M.I. Bureau deemed the support for their project to be 'insufficient'

when information on only 3,700 annuitant deaths per annum was available, though the author felt that four or five years' experience on that portfolio would have yielded information large enough to be significant. Yet, compared to some 16,000 annuitant deaths that would have resulted from such an investigation, the current paper was based on less than 1,000 deaths for the immediate annuitants. There was also a danger in being forced to rely upon information from only one office, where the composition of the portfolio resulting from the market that it reached could well affect the results.

He sympathized with the author in his search for statistics upon which to base the investigation since he had tried himself to obtain further corroborative data. Not only was he singularly unsuccessful in his enquiries—both at home and abroad—but he was continually met with the same question; why on earth would anybody require such information? It was perhaps worth while therefore asking themselves that very question.

At present, a company would base its immediate annuity rates on a(55) mortality, suitably adjusted with possibly some allowance for improvements in future mortality. Then, as further information became available from the C.M.I. reports, adjustments could be made in the mortality assumption. He assumed that the author's purpose in analysing annuitant deaths was to highlight the causes from which annuitants did and did not die, so that advances in medical knowledge might be reflected in annuity rate bases before the experience became available from the C.M.I. That point was borne out by the opening remarks and reference to the various figures made by the author. Mr Sansom did not feel that was possible because any medical advances which increased the expectation of life for sufferers of certain diseases would in turn affect their self-selection in the purchase of annuities.

Taking an extreme example of the action an annuity office would take if a cure for either neoplasms or ischaemic heart disease were to be found the next day, in each instance they would wish to adjust the annuity rates in advance of any experience data being available from the C.M.I. For neoplasms, where it was assumed that the proportion of deaths from that cause for annuitants was similar to the general population, a corresponding adjustment would be made to the mortality basis. For ischaemic heart disease much lower adjustment would be intended, since the proportion of annuitants dying from that cause was assumed to be less than in the general population.

However, with the elimination of ischaemic heart disease as a cause of death, sufferers would change their minds about effecting annuities, would select themselves for those contracts, and thereby remove the differentials shown on annuitant causes of death. A similar but less dramatic effect would be seen if mortality from those causes were to be reduced rather than eliminated. There was therefore a self-correcting effect for mortality improvements on those particular causes of death from which annuitants were less likely to die. To say that the effect was self-correcting might be too presumptuous without further detailed study; but he believed that it could be said, even with the information available, it would be impossible to assess the effects of changes in mortality from various diseases because it could never be established how much these changes would affect self-selection.

He was not convinced, therefore, that the effort necessary to produce a study of annuitant mortality by cause would be justified by the practical benefits. Certainly he agreed with the author that the C.M.I. Bureau at the time the matter was last considered had projects with much greater priority to consider, and he felt possibly that was still true.

Despite those comments, he admitted to being fascinated by any investigation which examined why people adopted certain courses of action. The purchase of an annuity was far more of a gamble from the policyholder's point of view than any form of life assurance. So why did people effect immediate annuities? Was the self-selection solely from a medical point of view, or did other factors come into it? One point to which the author referred both in his paper and in his opening remarks, was the effect of social class on annuitant mortality. That could perhaps be expanded to cover socio-economic conditions.

When the C.M.I. life assurance mortality results were analysed by cause of death, the comparison was made not with the full population data but with data standardized by social class. The influence of social classes IV and V was eliminated because it was considered that those

classes entered the assured lives experience to a much smaller extent than members of other social classes. Mr Sansom would therefore have liked to have seen the annuitant data compared throughout the paper with the C.M.I. data. Perhaps even better, annuitant data could be compared with the population statistics standardized for social class, but including only classes 1 and 2. Many people still did not know what an annuity was, and the purchase of an annuity required the outlay of a large amount of money. Both those factors pointed to the higher social classes as prospective buyers. More annuities might be effected by the middle classes as people began to take part cash from their pension funds, but at present annuity purchase was highly class selective.

It was difficult to divorce class from wealth and those two from geographical location, and each had its part to play in affecting mortality. A paper by Daw (*J.I.A.* **97**, 17) examined mortality and sickness by cause for the various geographical regions of the United Kingdom. For certain diseases the variations were enormous, and although one could see from causes such as bronchitis that some variations were climatic, there was certainly some social class differential built in. Daw quoted in his paper the standard mortality ratio for certain diseases classified by social class. Those figures were for all ages combined, and were population data. However, as an example, the S.M.R. on bronchitis for social classes I and II was 47 against 97 in classes III, 116 in class IV and 193 in class V.

The area where the higher social classes predominated was along the south coast, and it was just those areas which exhibited the lowest regional mortality for those causes of death which Daw examined. There were so many different factors interacting there that it would be impossible to isolate the effect of each. However, the receipt of a regular income must remove a great deal of worry from the life of an elderly person, and they could of course afford much more easily to maintain themselves in good health.

So income could in some way affect causes of death, but that was by no means the complete answer to the self-selection seemingly exhibited by annuitants. Why did some people effect annuities and others not? He had already suggested that certain classes of people effected annuities, and to eliminate any possible class effects from their analysis they needed not only to study the non-mortality of annuitants, they needed also to examine the non-mortality of non-annuitants—that was to say, the mortality of those who considered the purchase of annuities and elected not to do so. Although that was an impossible quest, it was the only way of proving conclusively that the self-selection idea was predominantly medically based.

Apart from that problem, which they might discard as being insoluble, there were two further difficulties. First, a person considering effecting an annuity would make his decision not on his current state of health or even his past history, but on what he considered his health was like and how he saw it developing in the future. People did not always act in a logical manner, especially the aged, and the decision could have nothing to do with their own state of health. For instance, Mr Sansom could well imagine those who had recently lost their spouse or even a close relative or friend being completely unprepared to consider the purchase of an annuity. There was nothing rational about this decision, and the individual might be in first-class health, but at that particular moment an annuity would not enter their minds. Of course some widows and widowers may have annuities bought for them, but it would be interesting to see how many who had been widowed for say less than five years, were in receipt of annuities.

The second difficulty in studying self-selection through examining causes of death was that the actual state of health of the annuitant at the time the contract was effected was completely unknown, let alone what the annuitant thought it was. There were two grades of self-selection of interest: first, whether a proposer could select himself for an annuity as well as an underwriter in possession of the necessary facts; and secondly, whether there were other peculiarly personal factors which enabled him to do better than that. Those two particular points could be examined by comparing them with population and assured life data.

The non-medical factors already referred to weighed more heavily in self-selection; but it was interesting to study the causes of death common among the aged, and attempt with the help of medical opinion a classification into likely and unlikely causes for annuitants. That was where Mr Sansom found himself in difficulties. It seemed every underwriter and doctor to whom

he spoke had a different idea. In all causes of death, there were exceptions to be considered; but he classified the sudden onset and relatively symptom-free diseases as likely causes for annuitants. Among those he included infectious diseases, accidents with the exception of suicide and all neoplasms. A difficulty arose in classifying myocardial infarctions and cerebrovascular accidents, since they both appeared to the layman to be sudden, but he understood that after age 65 both diseases tended to be of gradual onset, with perhaps more sudden cerebrovascular attacks than coronary attacks. There was therefore the warning upon which potential annuitants could act. The speaker therefore classified coronary thromboses—and probably cerebrovascular accidents as well—with all other heart diseases as unlikely, together with bronchitis, renal disease, and diabetes.

Relating those comments to the author's groupings, the speaker could find no strong reason for separating the various neoplasms and therefore would group those together. He was surprised that ischaemic heart disease exhibited different characteristics to the other circulatory diseases (§§ 7.6 and 7.7): he would have expected both of those to be unlikely causes, together with respiratory diseases under §§ 7.8 and 7.9, the digestive diseases, he found difficult: it included the various internal ulcers and liver diseases which could possibly be predicted; but it also included many other oddities such as appendicitis and hernia. If the author's findings could be supported by further statistics, the speaker could only assume that those were exactly the type of disease which generally made a person feel 'unwell' or 'rundown' without being too easy to diagnose. It might be those types of diseases where the prospective annuitant could select himself better than any doctor. It was worth stating that for deaths over 65, about 55% were circulatory and 20% were neoplasms, so those were the major areas for further research.

It was a tribute to the author that he had been able to stimulate interest in the idea of self-selection despite the lack of significant data. Much of Mr Sansom's comment had been necessarily subjective, and it would be nice to be able to prove or disprove those ideas with detailed statistics, but he feared that the profession had more pressing problems to solve.

Mr F. M. Redington, in a written contribution which was read to the meeting, said that when, all-unsuspecting, he had started to read the paper, the first paragraph came as a shock. It was as though he had been greeted by a complete stranger with the words 'Hello, father!' He therefore approached the paper with a measure of apprehension. In the end, however, he was happy to accept a charge of careless paternity since the offspring had had such a careful mother.

The thin data were attenuated by the fact that more than half the deaths were at ages over 85, where the sharper colours of earlier ages were beginning to merge into the uniform grey of extreme old age. In an attempt to achieve maximum illumination, he had combined all the data available in Table 3 and subdivided them into two groups only: 'under 85' and '85 and over'. Although the voice of the older group was fainter, the messages from the two groups were remarkably similar and that internal consistency encouraged a little tentative speculation.

The main message was clear: the notable success of self-selection by annuitants had its origin in a general intimation of well-being rather than a specific awareness of particular areas of safety. In only two out of the nine code-groupings did the superior mortality of annuitants differ significantly from the thesis that the superiority was uniform for all causes of death. If confirmed by a larger experience, that conclusion would be highly significant and all the more so because unexpected. When he had made his remark to the author, he was expecting annuitants to show superiority in most of the 'cause of death' sub-groups but *not* that the superiority would be uniform.

The success of medical selection of assured lives showed a far wider dispersion by cause of death. If the 1973 investigation of assured lives by cause of death was collected into the same 9 groupings used in the paper, no less than 7 out of the 9 groups would show a very significant difference from the average.

The possibility of basically different patterns for self-selection and medical selection opened up a fascinating prospect, but the data for annuitants was too frail to carry much superstructure. Nevertheless, he hoped that the tantalizing glimpse afforded will encourage other offices to give support to the public spirit of the office to whom they were indebted for those results.

He agreed with the author that further information could be of real benefit to the offices and he also felt that it could have wider consequences. The main difference between self-selection and medical selection lies in the individual's state of mind and that was a subject on which much more needed to be known, since it was both a cause and an effect of health, and something no instrument or doctor could measure.

Mr A. J. Steeds invited the meeting to rejoice that a paper on mortality had been presented to the Institute, interrupting a series on legislation, investment, solvency, inflation and what-not. There was a serious and a useful object to be gained from studying causes of death. Indeed, in his own paper on the selection of risks (*J.I.A.*, **91**, 231) Mr Steeds was taken to task by no less a person than Ed Lew for dismissing such an analysis too lightly, which provided for the link between the cause of death and an impairment existing at the date of an application. Mr Steeds believed that for a body of assured lives there was something to be gained, but he remained sceptical about the value for a body of annuitants.

In theory they could trace the secular trend in various causes of death but he believed that, after the differentiation required, their integration would be wholly suspect so that the practical value in any forecasting would be small. If that approach was valuable, then Mr Steeds thought it could be along the lines of Mr R. D. Clarke's analysis (*Proc. Cent. Ass.*, **2**, 12) between 'anticipated' and 'senescent' deaths.

Life assurance underwriting was necessary for several reasons of which selection by the proposer against the office was one of the most important; an individual could choose whether to assure his life or not and had wide discretion in practice about the sum assured and class of policy. What self-selection could be exercised by an annuitant? The size of the annuity was limited by the means of the proposer. That the effects were important was clear from published experience. Annuitants were expected to believe at the outset at least that their expectation of life was unimpaired; there would rarely be a serious overt disease or known feature such as substantial overweight or even hypertension.

He would expect annuitants characteristically to be a lean, abstemious, non-smoking lot. There were some impairments which the individual rarely suspected, notably malignant disease. Indeed, perhaps a kind of mirror effect should be expected when comparing the annuitants' experience with that of assured lives; neoplasms did appear in the scanty data as a more important than expected cause of death for annuitants, a less important cause for assured lives. Ischaemic heart disease was predictably the reverse.

The author had certainly done all he could with the data at his disposal. It would be interesting to known something about the social class, or even the region of the United Kingdom, from which the annuitants were drawn. Some light would be thrown on that and other aspects if an analysis of annuitant mortality and of causes of death could be undertaken by size of annuities. In life assurance, that was too difficult because of alterations, but the data for annuitants should be much more tractable. Alterations, lapses or surrenders were virtually unknown so that this was an ideal group in many ways with one mode of exit only.

Even so, he did not think that too much effort should be spent in that particular direction. More serious had been the failure of British actuaries in the United Kingdom to analyse assured lives' mortality by impairment. There was one honourable exception called Arthur Hunter, who was British and who led research in that field in North America. At a time when investment returns, inflation, tax and expenses were so much less predictable than mortality, whether of assured lives or annuitants, he said he would be surprised, though delighted, if that gap in their achievements was filled.

Mr R. D. Clarke, when he saw the title of the paper, was reminded of a conference which he had attended in Zurich in September 1971. The conference, 'A Forum on Human Ageing', was concerned with the researches of certain biologists and other scientists into ways of prolonging the human life span. Their approach was quite different from that of medical research workers who directed their efforts towards the treatment and cure of specific diseases.

The biologists of Zurich were aiming at slowing down the process of human ageing so that,

for example, youth might be prolonged to age 50, middle-age might extend from 50 to 100, and old-age from 100 to, say, 130. He felt considerable alarm at the prospect which was laid before them, not only because of the unmanageable strains which would be imposed upon annuity and pension funds if people started to live thirty years longer, but also because the moral and social consequences of discovering a means of controlling human ageing called for very serious reflection.

However, he was relieved to learn that the biologists were still a long way from achieving their objective. Moreover, even if they did discover a means of controlling ageing, it would affect only future generations. A sudden and dramatic fall in mortality rates was not therefore envisaged, but rather a long-term effect which would not become significant for some decades. Even so, he found it disturbing that such lines of research were being pursued and, if they ever bore fruit, some future Secretary of the Continuous Mortality Investigation Bureau might well be concerning himself or herself with the non-mortality of annuitants on a much bigger scale than had confronted Mr Barnett in his paper. For the 'biologists of Zurich', as the speaker had termed them, he could only recommend the quotation which the author had placed at the beginning of § 2 of his paper: "Few can foresee whither their road will lead them, till they come to its end." The end of that particular road would come long after all those present were dead.

There was nevertheless one lesson to be drawn from the venture into what many might regard as bordering upon fantasy. Actuaries had to project mortality rates into the future in order to safeguard the financial stability of annuity and pension funds. Such projections commonly assumed a gradual process of reduction year by year. In the real world, however, scientific advances, such as the discovery of antibiotics, could lead to sudden changes in mortality rates, as indeed occurred in 1942. But discontinuity could be due to other causes than medical science. In 1956, for instance, legislation was passed which introduced tax concessions for purchased life annuities. As a result, there was a change in the class of life entering the experience with what appeared to be an associated fall in mortality rates which could not be explained solely by secular trend.

But whatever may be the factors which had influenced the annuitants' experience over the years, the projections made when preparing the a(55) tables, and the series of generation tables based on those projections and printed at the end of the a(55) volume could not be said to have current validity. In deciding a mortality basis for immediate annuity rates, therefore, the life office actuary had to make such adjustments of the a(55) tables as he deemed appropriate to the experience of his fund and, in so doing, he would no doubt bear in mind the likelihood of further reductions in mortality rates in the future.

He was not surprised to learn from Tables 1 and 2 of the paper that the main cause of death group from which annuitants tended not to die was found to be the circulatory group diseases, for those were the impairments for which sufferers tended to get an early warning. People who had recovered from a heart attack or a stroke were unlikely to be eager to take out annuities. Similar arguments applied to the respiratory group, where the author had found a shortage of deaths in the male data, and also in the female data with the exception of the oldest age group.

Mr Clarke had looked at the published C.M.I. report on causes of death among assured lives for the period 1967–70, and if the medical experience were composed with the non-medical for durations under 5 and also for ages under 75 in the '5 and over' duration group, the medically examined lives showed appreciably lighter mortality from circulatory diseases than the non-medical lives. The same feature appeared, though not quite so prominently, within the respiratory group of diseases, and he tentatively inferred that there was probably a similarity between medical selection for life assurance and self-selection for immediate annuities. It would be an interesting exercise to compare the mortality rates of immediate annuitants and medically examined assured lives, for ages 60 and over, and for each individual duration from 0 to 4. Unfortunately that could not be extended to durations 5 and over because, in that ultimate section, the data for all ages at entry were merged.

He pleaded for the use of the C.M.I. annuitants' experience for studying mortality in extreme

old age. In many investigations—and that particularly applied to assured lives—the exposed-to-risk at high ages was liable to error because of the maintenance on the records of persons who were dead but whose deaths had not been notified. Consequently, the emerging rates of mortality in extreme old age were often subject to understatement.

Many years ago the C.M.I. Bureau decided to ask offices to group together ages 100 and over as a single entry in all their returns of data. He wanted to see the immediate annuitants' investigation returned to the earlier procedure of listing the data age by age right up to the oldest age. Apart from cases of actual fraud it should be impossible to include a dead annuitant as 'in force'. Consequently, a true 'order of dying out' table for a given year of birth could eventually be constructed to shed further light on mortality in extreme old age. Some years previously Mr G. T. Humphrey explored that method (*J.I.A.*, **96**, 105) using previously unpublished population data supplied to him by the Registrar General. It would be of great interest to conduct a similar investigation in respect of annuitants and to ascertain whether the differential mortality, or non-mortality, of annuitants in comparison with other groups of lives did or did not extend to the very highest ages.

Mr C. D. Sharp was reminded that a number of years ago he had been very much concerned with the mortality of annuitants and had wondered whether it would be practical for the insurance company to sort annuitants into the good lives and the bad lives. Just at that time he was in Hawaii and met an American lady (to whom he referred as Mrs G.) who was a graphologist. He was much impressed by her abilities and he was even more impressed when she told him that she could diagnose disease from handwriting. Half jestingly, he had asked if she could estimate longevity from handwriting, to which she had replied that she could. The speaker was so impressed by the lady that on returning to London he had arranged for a statistical test.

One hundred cases, all male lives who had effected annuities at age 65, were taken, 50 of whom had died and 50 of whom were still living. The lady was asked to examine their signatures and indicate whether the people were likely to be short-lived or long-lived. Mr Sharp quoted from the notes made at the time: "Reverting to the first experiment carried out in London, on the 100 cases where she was asked, among other things, to select those annuitants likely to live longest, it will be seen that there was only 1 death in 25 cases." She was remarkably accurate in the way she sorted out the short-lived and the long-lived. Obviously their data were small and perhaps there was some special reason, so they ran another test. Of the 35 cases where Mrs G. had indicated a short expectation, 29 were dead, and of the 25 where she indicated a long expectation only 1 was dead. In some cases she had been doubtful and those had been treated rigorously as errors. Mr Sharp did not think on the statistics he had given he could claim any great breakthrough, particularly as he was not altogether clear how he would use the results even if further experiment established the validity of the approach. Perhaps some young actuary who wanted to spend an entertaining few months of his professional life could be given some material to work on!

Mr L. V. Martin said that the author had for many years complained that actuaries had not paid sufficient attention to analysing deaths by cause. Largely as a result of his proddings, the C.M.I. investigation into cause of death for assured lives had been carried out and published, and the present paper now gave the results of a similar inquiry, on a small and somewhat fragmentary scale, into the causes of death for annuitants and life office pensioners.

This might be a suitable opportunity to consider some basic questions regarding 'cause of death' inquiries. First, and most important, what was 'cause of death'? The answer for C.M.I. inquiries has been to take the cause of death as it would be recorded in the Registrar General's statistical reviews. In turn, the Registrar General, like the C.M.I., based his statistics on death certificates. There were various rules to decide under which cause the death would be shown where there was more than one cause shown on the certificate.

Once said, the pitfalls of a cause of death investigation were obvious. Did death certificates always or even in the great majority of cases show the true cause of death? The evidence was inconclusive. Though for many deaths the true underlying cause was clear, such as an accident,

a neoplasm, or a stroke, his impression was that very frequently death, when it came, was not simply from one cause but from a variety of causes. Particularly at the old ages—the group with which they were largely concerned in the case of annuitants—a particular cause would kill only because other causes had weakened the patient's constitution.

A number of studies had shown very considerable differences between the cause of death recorded by a pathologist after a *post mortem* and the cause shown by the doctor who attended the death bed. It might be the difficult cases that came to a *post mortem* examination, but could they be sure that if every death were more closely investigated the recorded cause might not often be shown to be a mere symptom of a different underlying cause of death?

That area of uncertainty would not be so serious if there were a homogeneity in death certification; if, when actuaries compared two groups, they could be confident that all the various errors that could occur in certification were equally likely to occur in either group. He was far from confident that that homogeneity existed. It did not exist through time because fashions in certification certainly changed. It certainly did not exist between nations. The British, apparently, died of bronchitis in large numbers; but few Americans or Europeans did. Mr Martin felt sure that overstated the true difference. The French were apparently very liable to succumb to diseases of the liver, and there were other examples.

It might be thought that a common standard was far more likely when dealing with deaths in Britain. He thought that was true when one was dealing with comparisons between the general population of various regions of Great Britain. But was it true of comparisons between social classes or comparisons between annuitants and the general population? The accuracy of death certification would depend on the standard of medical attention: that enjoyed by either annuitants or assured lives was likely to be on average better than that of the general population.

It could well be that the apparent shortfall in deaths from ischaemic heart disease among annuitants and an apparent excess of 'other neoplasms' could be in part due to those differences. If there was no regular medical attendant, the rarer neoplasms could easily be missed and the death ascribed to the convenient umbrella of 'heart disease'. Similarly, cases which for the lower social classes were recorded as 'bronchitis' or influenza, or something similar, would often have been ascribed where there was a regular medical attendant to some underlying cause that had weakened the patient before the bronchitis or influenza struck.

That was not to argue that mortality by cause should not be studied. Past investigations had indeed produced valuable results and led to important advances in preventive medicine, but he entered a plea for the utmost care in interpreting results. In particular, he had the gravest doubts as to whether lessons of value could be learnt from a comparison by cause of death of annuitants or assured lives mortality with general population mortality. Caution should be reinforced where the data for the group were incomplete. Was there any reason to believe that the 'Cause not ascertainable' cases were not themselves highly selected? If those cases formed any sizeable proportion of the whole, it threw grave doubts on the validity of the results.

Mr R. E. Hayward believed annuitants to be people who had backed their chances of living to extreme old age (out of the survivors to a very good age to start with) in a population subject to stress and decay. It might be thought that most of the stress-prone had already died leaving only those who were liable to decay.

Before he could consider the figures in the paper, he needed an objective guide to show which of the author's causes of death groups were stress and which were decay. So he examined the Registrar-General's statistical reviews and tabulated, for each cause group shown, the number of deaths at all ages and the corresponding numbers at ages over 85 on the assumption that the former contained a good mixture of stress and decay subjects while the latter contained mostly decay. While his list did not coincide exactly with the headings of the tables in the paper, in general terms he had been able to allocate the first five columns (up to that headed 410–414) to stress, columns 6, 7 and 9 to decay and column 8 to stress. That grouping was somewhat like those arrived at by the opening speaker.

By adding up the actual deaths and expected deaths in his two divisions, and taking all ages and durations together, he obtained the following percentages of actual deaths to expected

deaths: for male annuitants, 81·6% for stress, 71·1% for decay, compared with an average of 75·8% for all causes, whilst for female annuitants it was 86·0% for stress and 83·5% for decay compared with 84·4% for all causes. For male pensioners it was 81·1% for stress and 79·4% for decay and for female pensioners, it was 64·0% for stress and 85·7% for decay.

With the exception of female pensioners, where the figures were not reliable anyway, he concluded that the lives concerned were more likely to die from stress and less likely to die from decay than the general population—in other words, they had a greater resistance to decay than the population as a whole. That was opposite from what he had expected.

The differences between pre-1957 and post-1956 entrants showed a similar pattern except that the level of the former was higher than the latter and the figures for females pre-1957 were the reverse of the trend. That showed that the C.M.I. committee was right to consider those two groups separately.

Mr J. A. N. Lockyer asked whether the information from the non-mortality of annuitants could be used to effect? He could not answer that positively. The effects of causes of death on annuitant mortality must surely be so complex that likely changes in prognosis of individual impairment could not be unravelled and put together again with much meaning. Even if it were possible, could that information be used for practical effect? Mr Barnett had referred in his opening remarks to the fact that if the deaths from neoplasms could be deferred five years, that would have a substantial effect on the annuity values. But at what point of time would the change be quantifiable? The speaker thought the effect would be just as readily apparent from their accepted methods of reviewing overall mortality just as quickly as if they could unravel all of the individual impairments and put them together again.

His other point had been touched upon by Mr Steeds when he had asked what place had mortality in days of high interest rates and other uncertainties. There was a tremendous disparity in the rate of interest assumed in any list of annuity rates, and he wondered even if Mr Barnett's ideas could be followed through and companies presented with prognoses of change in annuitant mortality, whether there would be a real interest?

Mr A. R. N. Ratcliff was surprised that several people had implied that mortality was very important in the case of lives insured but not important in the case of annuitants. His view was completely the reverse. If there were to be a sudden shift in the mortality of annuitants, it would almost certainly be a shift towards lighter mortality and would undoubtedly cause strains on the funds. A shift in mortality of lives assured caused little discomfort even if it deteriorated, and it was more likely to improve anyway. It would emerge as marginal change in rates of bonus. A cause of death investigation was worth more consideration than speakers had given it.

In the Centenary Assembly of the Institute, Mr R. D. Clarke presented a paper called, 'A Bio-Actuarial approach to forecasting rates of mortality' (*Proc. Cent. Ass.* **2**, 12). In that paper he said, "it seems not unreasonable to approach this task by analysing mortality according to cause of death and then to give individual attention to the probable trend in the death rate from each cause." That was twenty-five years previously.

In 1954 Prawitz, in his paper, 'Investigation of mortality from different causes of death as a basis for forecasting the future trend' (*Svenska Aktuarieforeningen*, **50** år) had shown how valuable such results were in forecasting future mortality rates taking the same approach as Clarke. Jung, in 1968 (*Trans. 18th Int. Cong. Act.*, **1**, 339) had pointed out that that forecast had been almost slavishly followed by the observed population mortality, although added a *caveat*—which related to the point made by Mr Martin—as to the effect of fashions in classification.

The author had identified some causes of non-mortality of annuitants and in speculating as to the reasons one was in danger, particularly as a medical ignoramus, of making ridiculous hypotheses. On the other hand, actuaries could bring to bear on the problem an appreciation of statistics and perhaps an ability to recognize true and false correlations, and it was with that thought that the speaker ventured the following observations.

In § 8.1 the author pointed out that the most significant feature of the investigation was the lower ischaemic heart disease death rates observed. A number of speakers had had trouble in coping with that fact. Deaths from ischaemic heart diseases, for example in the year 1970 males aged 55–64, varied from around ·2% in France, Yugoslavia and Japan to over ·8% in Scotland and Australia and over 1·0% in Finland, according to the international cause of death comparisons. In national terms it was the Japanese, French, Yugoslavs, Italians and Swiss who did not die of ischaemic heart disease. The Scots, Australians and the Finns did. The question was why? The correlation with population cholesterol levels was well established but that could not satisfactorily be explained away by environmental factors, diet, affluence or even smoking habits. Dr J. D. Matthews had examined the correlation between the relevant death rates of 19 Caucasian populations and the population frequencies of antigen H.L.A.-8 (*The Lancet*, 11 October 1975). He found correlations which were within the 1% significance level right across the board, for males in the age ranges 45-54, for the years 1962, 1966 and 1970 and a significant degree of correlation for females in 1966 and 1970. Dr Andrew Cudworth at Liverpool University had made a similar investigation into the presence of antigens and the incidence of juvenile-onset diabetes mellitus and he had found a similarly high degree of correlation.

Mr Ratcliff suggested that they were getting to a stage where there was conclusive evidence of a high correlation between genetic structure and susceptibility to a whole variety of illnesses. If there was that correlation, then somewhere on a particular chromosome there were one or more genes which conferred not an immunity but a susceptibility to a large area of diseases. Perhaps it was fanciful to think that a blood sample from each life assured or annuitant would be enough to put them in the right slot. Referring again to R. D. Clarke's paper, that writer had postulated that genetic factors governed senescent deaths and that the scope for any improvement of mortality lay in the field of causes of anticipated deaths. It now seemed clearly established that certain genes did determine the patterns of immune response and that could provide a physical method for identifying members of the population subject to those conditions. This process might facilitate a much greater degree of selection than they had been aware of heretofore.

R. E. Beard, in his paper 'Some observations on stochastic processes with particular reference to mortality studies' (*Trans. 17th Int. Cong. Act.*, **3**, 463) developed the assumption that since a group of births at a given time were genetically different, their reaction to their subsequent environment, even if that were identical, would be different, and their resulting mortality would in various ways reflect their different genetic constitutions.

Given the possibility of such selection and its possible extension to other major classes of death, actuaries had to revise their views on the subject of selection and return to an examination of the idea of an aggregate population comprising a number of homogeneous sub-populations, each subject to homogeneous risk factors, and the aggregate population mortality table comprising a family of discrete tables representing each risk category class combined together in appropriate proportions age by age. Thus Prawitz had grouped his causes of death according to those which were specific to certain sections of the population and those which operated generally. He then divided his heterogeneous population into those with the predisposition to each such cause and those without.

In the discussion on Barnett's 1968 paper (*J.I.A.*, **94**, 158), Beard had pointed out that the basic concept of actuarial mortality work had been that the group of lives could be regarded as similar but that a study according to different causes of death in the end involved expanding the model to allow for differences in the individuals. In his 17th Congress paper he had developed his approach by postulating "a characteristic which measures vitality or resistance to destruction, to assume that the survivors at any age can be classified according to his characteristic and to assume that the transition from one state of the characteristic to another occurs according to some probability process. It is assumed that death occurs when the characteristic reaches a prescribed value". The speaker agreed with Beard that if their mortality models were to be credible they had to retain their stochastic nature and not reduce to a deterministic form.

Mr Ratcliff suggested that the traditional approach to mortality had reached a dead end.

There were far too many loose ends which they had carefully swept underneath the carpet. There were loose ends particularly in relation to the select period and to deaths at extreme ages. Beard's paper was of inestimable importance as a new starting point and the tentative conclusions drawn by the author in the paper under discussion demonstrated that they were both on the same side. The adoption of that approach, coupled with an adequate investigation of annuitants' mortality by cause of death could yield important results to life offices in an area where mortality was still the overwhelming factor.

Mr G. B. Hey wanted to make a statistical point of general importance. The Institute was taking a lead in its attitude to non-life insurance which was based largely on statistics. The quality of the statistics which were presented to the public had to be improved. In the paper there were a considerable number of possible comparisons between 'Actual' and 'Expected'. If the differences were purely random and the usual 5% significance test was applied, somewhere between 10 and 35 were expected to be significant at that level. He was not accusing the author of trying to prove anything, because the author had wisely said it was not proven, but he would have been glad if when the author said the differences were significant, he had explained and expanded on the problems of taking a vast mass of data where there were several hundred or thousands of possible comparisons, and of deciding how the ones that looked significant at ordinary levels could be assumed to reflect real differences.

It was a pity that significance was used in two senses. He hoped that the author would explain what sort of tests should be applied, in looking at data of that nature, in order to detect differences which were genuine and not merely 'statistically significant'.

Mr P. J. Turvey joined in the discussion on § 7.6 of the paper and the question as to whether or not annuitants had significantly lower mortality from ischaemic heart disease. As Mr Sansom said, to do the comparison properly it was necessary to know the non-mortality of non-annuitants. There was no proper experience of the people who did not take out annuities. However, there were two things that he had been able to find, where they were able to compare two comparable sets of people.

One was the comparison made from the C.M.I. studies published three years previously, looking at the relative proportions of death from various causes at select durations and at ultimate durations. Deaths from circulatory disease at ultimate durations had become the much higher proportion. That backed up the idea that one could select against circulatory diseases. The other was a study by Dr Kreis (*Annals of Life Insurance Medicine*, 4) who compared two portfolios, one of policies issued at standard rates and another of policies issued at sub-standard rates with extra premiums. In that study he found that a much higher proportion of the sub-standard lives died from circulatory diseases.

Mr Turvey supported Mr Steeds' suggestion that a study of sub-standard mortality should be made, a study which had been left for far too long, and he believed that cause of death studies on sub-standard lives should also be pursued.

Mr E. B. O. Sherlock, in closing the discussion, said that the discussion had ranged well beyond the confines of the paper. Mr Steeds, for example was more interested in what Mr Sherlock could only describe as the non-subject of the paper; namely, assured lives. Mr Clarke was interested in middle-aged men of 100. Mr Sharp took them into an unfamiliar world, Mr Hayward described a rather unusual view of death, and Mr Ratcliff told them about genes. He proposed briefly to talk about the paper from the point of view of the Continuous Mortality Investigation Committee, as he was a member of that Committee, although not in any sense appointed as an official spokesman.

The Committee had a duty to the profession and also to the contributing offices. So far as he was aware those two duties were seldom if ever in conflict. There was the implication that any research activities which the Committee undertook should hold out a reasonable prospect of benefit both to the offices and to the profession.

He had been wondering what the author was up to in presenting the paper. One way of

expressing it was that, in the nicest possible way, he was giving the Committee a second chance to consider recommending an investigation into cause of death among annuitants and pensioners, and enabling them to hear some expression of views from members of the profession. That gave the author less credit than he deserved. He was a man of great enthusiasm, thoughtfulness and inventiveness on the subject of mortality, all qualities from which the Committee and profession benefited, but he also had the quality of determination to which Mr Martin had drawn attention. In some ways the paper might be regarded as round one of a new battle.

He wanted to refer to some detail in the paper. One comment related to certificates of death. He found without too much difficulty one office of some antiquity which operated in relation to certificates of death in a way of which the author would approve. Unfortunately, Mr Sherlock was not so sure that he was pleased because he found that in order to get the certificates of death of pensioners and annuitants some of the lengths to which the office went were of doubtful economic value. In many cases the fact of death was not in dispute, and possibly a request to provide photo-copies of death certificates would cause offices to review their current practice, whatever that might be.

Mr Sherlock was concerned, as was Mr Martin, regarding matters related to certificates of death. First there was the possibility that there was bias in the distinction between those who did and those who did not provide certificates, or for whom certificates of death could not be obtained. Obviously they could not know, but he had a nasty suspicion about that. He was also concerned as was Mr Martin with comments from doctors regarding the validity of causes of death, particularly at extreme old ages. It might have been helpful if the author had brought some of his more general comments relating to selection from later in the paper and from Appendix 2, into § 5. There were, as he made clear in various places, a number of types of selection at work in relation to annuitants, pensioners and assured lives; various speakers had referred to that. In all cases there was class selection, there was initial selection and what the author had called continuous selection applied, for example, to assured lives deciding to maintain policies. When actual and expected deaths were compared using population mortality, all those factors were brought together, and it was difficult to disentangle what they were actually looking at. It was self-selection and to some extent office selection in the case of assured lives, both of which depended on someone's conscious assessment of the state of health, that they were really trying to study.

His view was that there was at least some reason to believe that annuitants and assured lives came from the same section of the population—that was, the groups with which life assurance companies were in contact. That was a theme the opening speaker had developed. However, that did not really take them very far and he thought they had to go into the general discussion rather than statistical analysis on the slender data available to them.

The opener's approach was useful in looking at the matter more generally. Mr Hayward also adopted that approach, but from a rather special viewpoint. Basically it was to consider what an annuitant might be able to decide about himself and those points had been well covered in the discussion. The conclusion must be that certain causes of death would not be expected to be influenced by self-selection, but only class selection, and others where both influences would be expected to be at work.

The amalgam of the two forms of selection, as in the paper, meant that it was not practical to deduce from the available data what was happening except that in the case of heart disease there was the feature to which special attention was drawn. Nevertheless, given more data, it would be established with reasonable certainty that there were certain causes of death from which annuitants in general did not die.

The next question was to consider where they went next. On that argument which he had used earlier, that the Committee should only indulge in applied research where there was a reasonable prospect of benefit to those to whom they were responsible, they should consider as part of that discussion how they would use information of that nature. To the speaker, the fact that there was a cause from which annuitants did not die was not in itself particularly valuable, though, if Mr Redington found it interesting, he felt he should do likewise. The Committee's concern was surely to give the profession the best advice it could about the allow-

ance that should be made for present and future trends in mortality rates. It would therefore be important to note and make allowance for some major medical advance affecting causes from which annuitants died. Clearly, the only changes which would be worth taking note of would be those which affected major causes of death, changes of such tremendous importance to the community as a whole that they would be well publicized.

Mr. Sherlock suggested that a cure for diabetes would not be of very great significance because the treatment of diabetes was well established and the presence of the disease did not have a significant effect on life expectancy. On the other hand, that would not be true of a breakthrough in the treatment of cancer. He had already said enough to indicate his own doubts about the benefit that would be derived by the profession or the offices from the proposed investigation. The opener of the discussion indicated that a self-correcting effect might operate. If that was so doubt was thrown on the use of the data for that purpose, as the author suggested it might be used in his opening remarks. Many speakers had indicated similar and other doubts, some of which could be resolved if a more adequate body of data was available. A number of people had put forward alternative lines of thought, with, in their view, a more practical relevance for the Committee. Mr Steeds and Mr Turvey had referred to the need for an impaired lives investigation. Mr Clarke was interested in extreme old ages, defined for that purpose as those over age 100. Mr Sherlock was pleased that Mr Ratcliff brought back the importance of the subject so strongly when he stressed the financial importance of making adequate projections of annuitants' mortality.

From the discussion those were the questions which the Committee would have to consider and in that sense the author had won round one. The mortality committee met in Edinburgh in March; being a good secretary, the author had included 'any other business' on the agenda. Mr Sherlock suspected that the secretary had already chalked up one item on his copy of the agenda.

The President (Mr Gordon V. Bayley), in proposing a vote of thanks to Mr Barnett, said that he had made many notable contributions to the discussions and to the *Journal* over the years, including three previous papers presented to sessional meetings and a large number of other articles. Apart from that, he had been working continuously with the C.M.I. Bureau for the past twenty years and had been its secretary since 1972. All were grateful that he had written another paper for them and one moreover written in such attractive and readable style. He had produced an active and digressing discussion, certainly it had been uninhibited by the paucity of data which started it all. There were moments when those attending the meeting would have observed with Tolkien that "all the council sat with downcast eyes as if in deep thought"! It was gratifying to think that three of them were contemplating not only their own experiences of annuitants' longevity, but their contributions to the discussion as well.

Mr H. A. R. Barnett, replying to the discussion, thanked the meeting for the way it had received his paper. He had kept a note of the number of speakers who appeared to want some firmer information on causes of death among annuitants—and he said 'annuitants' and not 'annuitants and pensioners' because, until Mr Sherlock, nobody had mentioned pensioners although he could not think why—and of the eleven speakers six wanted more information, four did not want more information, and three of these four came from offices which did not subscribe data to the Bureau. Mr Sherlock spoke both for and against; perhaps that was a deliberate neutral position in his capacity as Chairman of the Committee.

The author was grateful that Mr Ratcliff had answered the point made by Mr Steeds. It seemed that in times of improving mortality one could almost ignore mortality for assured lives but one could not for annuitants or pensioners. The author was also particularly pleased to hear what else Mr Ratcliff had to say. There were present at the meeting four members who were members of the Committee when the decision was taken in 1972. Two of them were still on the Committee but did not speak; the other two did speak and Mr Ratcliff had been a convert because for maybe a different reason he had previously been against obtaining further data. Mr Barnett was grateful to welcome him on his side.

He had prepared some comments regarding Mr Redington's contribution, which he had seen in advance. The figures Mr Redington had produced had indeed combined the C.M.I. annuities with the non-C.M.I. annuities and they had also combined males with females. So there could be a certain amount of compensation and cancelling-out of significant results. The author was not going to be drawn by Mr Hey in going into questions of what was significant and what was not because on the size of the figures he had produced nothing was really significant. Nevertheless, taking Mr Redington's two groups where he perceived significance, the one group where annuitants had more deaths than they ought to have was not really significant, as it was the 'dustbin' group of neoplasms, and those were cases where the Registrar General, whose statistics were regarded as the control, obtained additional information and a lot of the neoplasms of unknown sites were by him re-allocated to other sites. So on Mr Redington's figures, the one significant group was the respiratory diseases. He might have found if he separated the males from the females possible significance in other groups.

He was sorry that Mr Redington was not able to deliver his contribution in person because, if he had been, Mr Barnett could have quoted from Tolkien and said, "strange accents do not mar fair speech".

Mr Barnett believed they would learn a lot if they were able to undertake the investigation he had been suggesting. He also believed that, proportionately, there would be as few cause-unknown cases as there were for assured lives. Those were mostly cases where the office had lost the certificate before it had forwarded the information, or cases where the certificate was prepared in a foreign country, or by a consul where the cause of death was not recorded. That non-recording had nothing to do with the actual cause of death. He believed their whole panorama of mortality could be compared with the mirror of Galadriel: "Many things I can command the Mirror to reveal, and to some I can show what they desire to see. But the Mirror will also show things unbidden and those are often stranger and more profitable than things which we wish to behold. What you will see if you leave the Mirror free to work I cannot tell for it shows things that were and things that are and things that yet may be; but which it is that he sees even the wisest cannot always tell".

WRITTEN CONTRIBUTIONS

Mr J. Hamilton-Jones subsequently wrote as follows: In the report on the mortality of assured lives investigation for 1967-70, the purposes of the investigation were described. Those which may be relevant to the present paper were briefly: (i) to indicate the causes of death in which lie the main differences between assured lives mortality and population mortality; (ii) to indicate for which causes of death initial selection is effective; and (iii) to give a continuous record to which reference could be made if medical science were successful in eliminating, or appreciably postponing, deaths from any one particular cause, in order to estimate the possible effect.

Selection was well covered in the discussion of the present paper. I believe, however, that the main justification for collecting statistics is the search for important causes of death (or causes for which mortality is very light) amongst annuitants and pensioners.

Although the present investigation is based on scanty information, it may be worth considering available methods of investigation. If results are obtained for two separate periods, one can take a population of 1,000 lives at exact age x and divide them according to whether they died from causes 1, 2 . . . n, or survived from 'cause 0', before attaining exact age $(x+1)$ in each period. What is the relationship between the two distributions? Another question we might ask is how the distribution at time t_1 for age x compares with that for time t_2 for age $(x+t_2-t_1)$ (i.e. for the same generation at a later date).

If we knew the answers to these questions, that might suggest new ways in which groups of causes might be combined. Obviously one must group causes; but the groups in the International Classification were not necessarily put together to help us. It would be interesting to know which main users of the I.C.D. are best served by the abbreviated classification. Besides helping us with the way groups are combined, an idea of the changes in the distribution over time could

indicate the probable effects of the elimination or drastic reduction of a hitherto important disease.

Anyone interested in this approach may refer to a French actuarial paper by Paul Damiani published in 1973 (*Bull. Trim. de l'Institut des Actuaries Français*, **84**, 35). He took 1952–56 and 1960–64 as the two periods, ten groups of causes (nine principal causes and a miscellaneous group) and the French population between ages 45 and 64 at each period. He based his technique on a Markov chain approach, which is equivalent to the hypothesis that the rate of mortality from cause K in the later period is a linear function of the rates of mortality from causes '0' to 10 in the earlier period. It remained to calculate the coefficients, which was done by a least squares method applied to the data from the separate Départments of France.

It appears to me that as one approaches the highest age-groups, causes of death become far less significant: Redington's 'uniform greyness' casts its shadow. With a model such as the one just described, this effect too could be allowed for.

Clearly one cannot conduct satisfactory experiments with limited data. I join the author in the hope that offices will consider submitting further data to the Investigation.

Mr A. R. N. Ratcliff: Whilst I was happy to stand up, and to be counted, I am not sure that Mr Barnett can claim me as a convert. Although the results of the cause of death investigation published in 1971 marked a new starting point in mortality investigation in the U.K. by breaking down, for the first time, the death rates of assured lives by reference to medical factors, offices generally were reluctant to see this investigation extended to annuitants for understandable reasons. In the first place there was the serious difficulty of certification, which was automatic in the case of assured lives, and in the second place there was no general inclination to attach any practical value to the results of such an investigation. Against this background I do not think that it would then have been practicable for the Committee to embark on an annuitants' investigation and what was needed was a wider debate on the merits and problems of such an investigation, which this paper admirably provided.

But a close examination of cause of death statistics in my opinion inevitably leads us into asking more fundamental questions. Our commentaries on mortality tables, and our textbooks, inherently assume homogeneity in the 'population' and are strewn with attempts to explain, manipulate and generally dispose of the phenomenon of 'selection', all, to my way of thinking, less than satisfying. In the official textbook, Benjamin and Haycocks content themselves with the conclusion that after a relatively short period the practical effect of selection is negligible. "The actuary is concerned only with the practical consequences of selection and is not interested in attempting to estimate precisely how long a duration effect actually persists which could be extremely difficult as well as unprofitable." Later on, however, they put us on the right road by reminding us that "In actuarial practice, the term (selection) has become wrongly applied to the operation of factors which influence mortality rather than to the classification of data with different characteristics."

Whilst present-day approaches to rating rightly minimize the significance of such selection in relation to mortality of lives assured, we should not ignore its significance in relation to the immortality of annuitants. The present treatment of mortality at extreme ages is also unsatisfying. The approach I supported in the discussion deals adequately with selection and with mortality at advanced ages and provides a rational basis for the insurance of impaired lives. There is a close analogy between such an approach to mortality risk and the consideration of a heterogeneous motor insurance portfolio.

The analysis in the paper 'Entmischung von Absterbeordnungen' by Sachs, Staniszewski and Roper in the memorial publication *100 Jahre Victoria* published in 1953 is, I suggest, theoretically acceptable and the practical application thereof to the insurance of impaired lives was the subject of a further paper 'vom Wesen der Auslese' by the same authors (*Mitteilungen Schweizerischer Versicherungs mathematiker* **54**, No. 1). These two papers, together with Clarke's paper and particularly Beard's 17th Congress paper, 'Some observations on stochastic processes with particular reference to mortality studies', to which I made reference, could, I suggest, well form the basis for such fundamental reconsideration.

The author subsequently wrote as follows: It is particularly gratifying that the majority of speakers in the discussion appeared to share my desire for additional information to be made available on the causes of death of immediate annuitants, and these included most of the speakers from those life offices which contribute data to the C.M.I. Bureau; if some speakers are not mentioned by name as their remarks call for no reply, I am none the less grateful for their support; even amongst the four against, although Mr Steeds apparently does not want the additional data collected he does want it to be on an 'amounts' basis.

Mr Sansom referred to the 3,700 annuitant deaths per annum which the replies to the 1971 circular indicated had cause-of-death information available; but this was only the number the offices could produce without really trying. If the offices were prepared to try—and I believe many of them are—a much larger volume of information could be produced, both for the annuitants and for the pensioners. Since the discussion, my attention has been drawn to the difficulty arising in those cases where the office is informed of the annuitant's death by the bank to which the payments have been remitted; whilst taking the point, I doubt the wisdom of taking a bank's word for anything in these computerized days when errors are by no means unknown and when a remittance is not infrequently credited to a wrong account; presumably the office would acknowledge the communication from the bank and could at the same time ask for the name and address of the executor or administrator, to whom application could then be made for a sight of the death certificate or a photostatic copy. Nor do I accept the suggestion made by one or two speakers that there might be a bias towards certain causes of death in cases where no certificate is available; from my experience of the assured lives' investigation I can say that most of the 'cause unknown' cases are those with foreign or consular certificates on which there is no place for indicating cause of death; the majority of the remainder are cases where the office has seen the certificate but has omitted to record the cause before parting with it.

Mr Sansom mentioned the transatlantic lack of interest in the type of project I have suggested, but it might be considered an added incentive to do something our American friends have not tried; and if when the first report is ready it is, like Concorde, unpopularly noisy would it matter?

I do not completely accept Mr Sansom's theory that a reduction or postponement of deaths from some cause would be counterbalanced by changes in self-selection; surely the effect of a medical breakthrough on any cause must be that annuitants would tend to live longer; and if, as I believe, the main factor in initial selection is the self-exclusion of would-be annuitants who feel there may be something wrong, this would probably remain unchanged.

Some of the causes to which Mr Sansom referred, such as infectious diseases and diabetes, are in fact quite rare causes of death amongst both assured lives and annuitants, but I agree with his remarks about digestive diseases.

I would not wish to put too much reliance on the Registrar General's information about social class and occupational mortality by cause, quite apart from the fact that by the time the appropriate volume is published it is usually somewhat out of date; some of the cause groupings in these publications are rather broad, and the standardization factors given in *C.M.I.R.*, **1**, 64, indicate surprisingly little difference between all social classes except 4 and 5 and all classes combined.

Mr Redington's analysis of the figures in Table 3 is interesting. However, even if there were only one cause-group for which the annuitants exhibited superiority significantly different from the average, it would be useful and instructive to be able to break that group down and find out whether the difference was due to one or two of the several dozen causes making up the group. Had Mr Redington taken the figures for males only under age 85 he would have compared 3 actual deaths from digestive diseases with 8·1 expected; if the standard deviation is approximately the square root of the expected deaths this result is not quite significant at the 5% probability level but larger data could well show a significant difference.

It will not have passed unnoticed that three mortality 'giants' in the persons of Messrs Redington, R. D. Clarke and Ratcliff have supported my call for a full investigation, and this is not vitiated by the fact that Mr Redington and Mr Clarke arrived at somewhat different

conclusions; rather does it accentuate the need for more statistics. References were made to Mr Clarke's earlier work on 'anticipated' and 'senescent' deaths which Mr Hayward redefined as due to 'stress' and 'decay', but the practical difficulty in such an approach is that the largest cause of all, coronary thrombosis, contains a mixture of the two ingredients in unknown proportions.

I was surprised, as was Mr Ratcliff, that Mr Steeds dismissed as unimportant the measurement of the mortality of annuitants; I would have thought that in times of lowering of mortality rates the greater longevity of annuitants and pensioners would be of far greater financial consequence than the mortality of assured lives.

To the comments that offices have something better to do than to investigate the mortality of annuitants by cause I would reply, first, that this is a philistine outlook which I cannot support and secondly, that there are not a few offices who already submit cause-of-death data (unasked) in respect of classes for which no such investigation has yet been instituted, and this scarcely indicates any great difficulty in production.

I take Mr Martin's point that in some cases the death certificates may not show the true cause; but I would estimate that these would amount to less than 10% of the total. And in any case it is still valid to compare experience with experience so long as the coding has been consistent between the different experiences. His mention of the differences between countries of the incidence of bronchitis and of liver diseases can probably be explained by the former being a hazard of a maritime climate and the latter being positively correlated with alcoholic consumption (even if not so stated on the death certificate).

Mr Lockyer referred to the illustrative figures I gave when I introduced the paper; they were in fact based on all respiratory diseases combined and not, as Mr Lockyer had stated, on deaths from neoplasms.

Mr Hey, who by implication seems to range himself on the side of those who wish for more information, asked particularly about significance. I am not at this stage prepared to be drawn, as with data as scant as those on which the paper was based there is scarcely anything which can be identified as definitely significant; that is why I stressed that the figures gave no more than broad indications. And as Mr Redington has pointed out, in an investigation of this nature we are not so much interested in whether annuitant mortality from a certain cause is lower than population mortality—we know annuitant mortality is low—as whether the lightness of mortality from a certain cause is appreciably (I will not say significantly) different from the average.

Mr Turvey's suggestion of a study of sub-standard lives has been flogged for decades, and when the Life Underwriters' Club approached the C.M.I. Committee the latter expressed their willingness if the L.U.C.'s members could produce data; that was in 1973, since when nothing.

I am grateful to all the participants in the discussion both for their stimulating contributions and for their kind remarks; but it was disappointing that pensioners' mortality was only once mentioned. The profession ought to be particularly interested in the effect of light mortality on pension schemes, and there should be no difficulty in obtaining cause-of-death information if pension scheme managers are approached in advance of the inception of an investigation.