

Classification of Multiple Causes of Death

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Introduction.

Statistics of causes of death are probably the most important single item in any vital statistics system for the planning and administration of health services necessarily depend on them and on statistics of morbidity. Nearly all civilised countries have developed statistics of causes of death during the past century, but although morbidity statistics are closely associated with mortality statistics, few countries at present publish comprehensive statistics of illnesses. Much still remains to be done to improve the quality of statistics of causes of death in many countries, and to ensure that they are internationally comparable. For the improvement of these statistics and for the formulation of proposals in regard to the preparation and analysis of morbidity statistics, a study of multiple causes of death is essential.

It is well known that official statistics of causes of death are based on the principle that each death is to be assigned to one cause only. It is well known, also, that in a large number of cases two or more causes are entered on a single medical certificate. The compiling authority is at once faced with the problem: how is the selection of the cause of death for tabulation to be made in such cases? This problem has by no means been solved completely. Different methods of selection have been used in different countries, and sometimes even in the same country the method of selection has been changed over the years. These differences cause difficulties when international comparison of death rates from different diseases are made, and the same difficulties arise when comparisons in time for one country are made. The World Health Organisation has tried to obtain international comparability in the selection of the cause of death for tabulation, and in 1948 the international form of medical certificate was adopted by most of the member countries of the World Health Organisation. At the same time these countries adopted a list of rules for the selection of the cause of death for tabulation. It will probably, however, be many years before cause of death statistics are fully comparable at the international level.

With the international form of medical certificate now in use, the responsibility of selecting the cause for tabulation is placed on the medical practitioner who attended the deceased during his last illness. Medical certification is not an exact science, and the cause of death returned for tabulation in the official statistics must depend sometimes on the opinion of the doctor concerned. When it is remembered that the certificates currently being completed in any country are filled in by doctors who have been trained in different medical schools

over the past fifty years, it is seen that the possibility of different opinions arising with regard to the cause of death in certain cases is quite considerable. It is for this reason that tabulation of all the causes of death on certificates may be of the utmost importance. A study of multiple causes of death may lead to the conclusion that the rules for the selection of the cause of death for tabulation in official statistics are not being interpreted in the same manner everywhere. It may then be possible to clarify the international rules. It is obvious, also, that knowledge of the most frequent combinations of illnesses is of fundamental significance. The course of a morbid process is often the combination of several causes. If the choice of the main cause of death among these several causes is liable to be incorrect, the danger of incorrect interpretation of the resulting statistics is lessened if other causes are also tabulated to furnish a more complete picture of the morbid process.

The preparation of statistics of multiple causes of death is somewhat tedious and such tabulations are not at present prepared for publication in official reports. Indeed the best method of presenting such statistics requires careful consideration, and the World Health Organisation has not yet issued any concrete proposals in the matter. The investigation, the results of which are presented in this paper, is, therefore, of an experimental nature, and for that reason is confined to only a sample of the deaths which occurred in 1952. Since this subject is completely new to many of the listeners, it is desirable, in order that the tabulations presented later may be understood, to give a short historical review of the statistical classification of causes of death.

Historical Review.

The quantitative study of any phenomenon entails classification of data, for the statistician is interested in groups of cases, not in the individual cases recorded by individual medical practitioners. It is by the collection, classification and analysis of the data supplied by the individual doctor that the statistician is able to draw inferences about the state of public health in a country. In the study of causes of death, therefore, a statistical classification of diseases and injuries is essential. A statistical classification must not be confused here with a nomenclature. As you know, a medical nomenclature is a list of terms for describing clinical and pathological observations. It must be so extensive that any pathological condition can be accurately recorded. On the other hand, a statistical classification must be confined to a limited number of categories into one of which must fit each term in the nomenclature. In choosing the categories for a statistical classification, regard must be had to the use to be made of the statistics compiled. The anatomist is principally interested in the part of the body affected, the pathologist in the nature of the disease process, and the clinician is further interested in etiology. Whatever the basis for the construction of a statistical classification, every defined disease must have a definite place in one of the categories in the classification. Some ill-defined diseases, which cannot be allocated to specific headings, will occur in residual items in the classification, but the number of these residual items must be as small as possible.

It is then up to the medical practitioner to ensure by accurate certification that the number of deaths assigned to these items is very small.

Names associated with the first attempts to classify diseases systematically are Francois Bossier de Lacroix (1706-1777), better known as Sauvages, and Linnaeus (1707-1778). These two pioneers published treatises under the names of *Nosologia Methodica* and *Genera Morborum* respectively. From these works William Cullen, a professor in the University of Edinburgh, published a classification under the title of *Synopsis Nosologiae Methodicae*. This was the classification in use in the public services when William Farr came to work in the Registrar-General's Office, London. It was not deemed by him to be satisfactory, and he revised and improved it. Medical statistics owe much to the work of Farr in this respect. He laboured unceasingly to secure better classifications and international uniformity in their use. At the first International Statistical Congress held in Brussels in 1853, Farr and Dr. Marc d'Espine of Geneva were requested to prepare a uniform statistical classification of causes of death suitable for all countries. In 1855 the lists were presented, but neither was accepted. At a later date the Congress adopted the classification in use in the City of Paris, and this list was revised in 1864, 1874, 1880 and 1886. It came to be based more on Farr's idea of classifying diseases by anatomical site, and this idea has survived as the basis of the international list of causes of death to the present day. This list, however, did not find favour generally, and no two countries employed precisely the same form and methods for the statistical classification of mortality.

The International Statistical Institute which succeeded to the International Statistical Congress in 1891 appointed a committee with the task of preparing a classification of causes of death. The classification prepared by this Committee was adopted in 1893 and became known as the "International List of Causes of Death." The list was revised in 1900, 1909, 1920, 1929, 1938 and 1948. The list adopted in 1948 is the list used for the compilation of statistics in this country since 1950.

So far we have been dealing with classification of disease solely in relation to mortality statistics. Since Farr's time, however, it has been recognised that it is desirable to extend classification of diseases to include those which, though not necessarily fatal, cause illness in the population. Classifications of diseases for morbidity statistics were prepared at the Decennial Revision Conferences of the Cause of Death Classification, but these did not receive general acceptance. It was left to a United States Committee on Joint Causes of Death, formed in 1945, to put forward the view that classification of sickness and injury is closely linked with classification of cause of death, and at the Sixth Decennial Revision Conference in 1948 an extended version of the International List of Causes of Death was adopted. The present classification represents an expansion of the disease rubrics of the previous International Lists in order to provide specific categories for a number of non-fatal diseases and injuries.

The person who registers the death must bring this certificate to the Registrar (if not already sent).

S.R.D.....
District.....
Entry No.....

BIRTHS AND DEATHS REGISTRATION ACT (IRELAND), 1880.

MEDICAL CERTIFICATE OF THE CAUSE OF DEATH.

(To be signed and given by the Medical Attendant to some person by the Act required to give information concerning the Death to the Registrar of the District in which the Death occurred, and to no other person.)

I HEREBY CERTIFY that I attended.....
whose age was stated to be.....; that I last saw h..... on the.....day of.....19.....; that he died*..... on the.....day of.....19.....; at†.....; and that to the best of my knowledge and belief the cause of death and duration of illness were as hereunder written.

CAUSE OF DEATH		Approximate interval between onset and death
I.	I.	
Disease or condition (a) directly leading to death.‡	due to (or as a consequence of)
Antecedent causes (b)	due to (or as a consequence of)
Morbid conditions, if any, giving rise to the above cause, stating the underlying condition last.(c)
II.	II.	
Other significant conditions contributing to the death, but not related to the disease or condition causing it.

*Should the Medical Attendant not feel justified in taking upon himself the responsibility of certifying the fact of death, he may here insert the words "as I am informed."

†In case the death occurred in a Public Institution, the person filling in the certificate is required to state also the particulars as under.

‡This does not mean the mode of dying, e.g., heart failure, asthenia. It means the disease, injury or complication which caused death.

†Former Residence of deceased <hr/>

Witness my hand, this.....day of
.....19.....

Signature
Registered Qualification
Residence

The second large problem that has occupied the attention of Decennial Revision Conferences is the attainment of uniformity between countries in the method of selection of a single cause of death for tabulation when more than one is stated on a death certificate. It is evident that international comparability of mortality for specified diseases was seriously affected by the rules obtaining in different countries with regard to the selection of the cause for tabulation. It is true to say that mortality from such well-known diseases as bronchitis and myocarditis, to take typical examples, could not be readily compared in such countries as Ireland, the U.S.A. and Great Britain. Repeated efforts were made to secure uniformity, but they met with no success until 1948 when a form of death certificate, which had been used in Great Britain since 1926, was approved by the World Health Assembly, and most of the countries in the World Health Organisation now use this certificate.

A copy of the certificate adopted in 1948 is shown on page 162. It is divided into two main parts. In Part I is reported the cause leading immediately to death (on line (a)), while antecedent conditions which gave rise to the cause on line (a) are shown on lines (b) and (c). Thus any disease on line (b) must have existed before or as long as the disease on line (a) and must have caused the disease on line (a). Similarly any cause on line (c) must have given rise to the cause on line (b). In Part II are entered any other significant conditions which unfavourably influenced the morbid process, but which were not related to the disease or conditions directly causing death.

Selection of Underlying Cause for Tabulation.

It is obvious that the coding of death certificates is relatively easy when there is only one cause on a certificate. It may, of course, be very difficult for the certifying physician to select the one cause, and perhaps that is one reason why many certificates have two, three or more causes. Let us, however, consider a simple case with three causes on a certificate. Suppose a man has cancer of the stomach for which he has to undergo an operation. After the operation, assume that he contracted pneumonia from which he died. In this case, what is the cause of death? Here one can choose any one of three causes to the point of view selected. You may say if the patient had not contracted pneumonia, the operation would have been successful and that, therefore, pneumonia is the cause of death. On the other hand, you may say that if he had not undergone the operation, he would still be alive, at least for some time, and that, therefore, the operation is the cause of death. You may argue further, however, that it was cancer which necessitated the operation, and that if the patient did not suffer from cancer, the subsequent operation which resulted in contracting pneumonia would not have been necessary, and that, therefore, cancer is the cause of death. In this example, pneumonia is actually the *immediate* cause of death and cancer of the stomach the *underlying* cause of death, that is, the cause which initiated the train of events leading to death. It is this underlying cause which the World Health Organisation has decided it is best to tabulate when only one cause is to be tabulated. The death certificate in this case is correctly filled in as follows :—

- I. (a) Post-operative pneumonia.
- (b) Cancer of the stomach.

II.

Unfortunately, not all physicians read the instructions issued with books of medical certificates, and it sometimes happens that certificates are completed in the reverse or otherwise incorrect order. In the example considered, it is manifestly impossible for cancer of the stomach to be due to post-operative pneumonia and, of course, when a certificate which is completed incorrectly is received in the Statistics Office, the coders rightly assume that the physician has incorrectly filled in the cause of death and code cancer of the stomach as the underlying cause of death. The example just given is deliberately simple in order that it should be clearly understood. Not all sequences are so clearly apparent, and medical opinion sometimes differs as to the possibility of occurrence of some of the sequences stated on medical certificates.

We will now consider Part II of the certificate. In this part the medical practitioner is requested to mention causes which contributed to the fatal outcome, but which are not directly related to the underlying cause of death. In the example just considered, if the patient had suffered from a heart disease, this disease might have contributed to the death by lowering the resistance of the patient to pneumonia. In such a case the heart disease should be entered in Part II of the certificate. This completes the simple illustration I wanted to make, and from it you will see that there are three types of causes that may occur on a certificate. These are (1) the underlying cause of death which is that normally tabulated, (2) one or more complications related to the underlying cause, (3) contributory conditions not related to the underlying cause but contributing to the death. In a correctly completed certificate the underlying cause is the last-mentioned cause in Part I. The complications are the other causes in Part I, listed in correct sequence, and the contributory conditions are shown in Part II. In official statistics only the underlying cause of death is coded according to the International List of Diseases, Injuries and Causes of Death. The classification of cause of death in the annual reports of an tArd Chláraitheoir is based, therefore, on the underlying cause only.

The International List of Causes of Death.

The present international list of causes of death comprises about 600 different causes, grouped into 17 different major categories. The selection of some of these categories is based on type of disease, e.g. Group I, Infective and Parasitic Diseases, but most of them are based on collecting together diseases of the same anatomical site, e.g. Group IX, Diseases of the Digestive System. Most of the causes in the international list refer only to one disease which, however, may have many synonyms for its description. To a limited extent, the international list makes provision for the recording of certain combinations of diseases, even when only the underlying cause of death is tabulated, for some of these combinations are assigned definite numbers in the list. For example, myocarditis is number 422, and hypertension is number 444. However, if these two causes occur together in the same certificate, the death is assigned to number 443.

In this particular case the code number for the combination is different from either of the code numbers for the individual diseases. In other cases this is not so. Cerebral haemorrhage is number 331, and arteriosclerosis is number 450, but the combination of these two diseases is still coded as number 331. These examples lead naturally to the consideration of rules for coding and tabulating causes of death when more than one disease is stated.

Multiple Causes.

The first problem to consider is: in cases where the international list makes provision under one code number for combinations of causes, should either or both of these causes be coded as a complication? For instance, if myocarditis and hypertension appear together on a certificate, then the code number of the underlying cause of death is 443, and we have to consider whether one or both of the separate components, myocarditis (422) and hypertension (444), should be coded as complications. The title of number 443, "other and unspecified hypertensive heart disease" throws some light on the problem. The title gives the information that hypertension and heart disease were both present, but does not disclose the nature of the heart disease. Number 443, does, in fact, include other heart diseases as well as myocarditis. If, therefore, we code 443 as underlying cause and 422 as a complication we have coded all the information on the certificate, some of which is lacking if 443 is coded as underlying cause of death and no complication is coded. It might be observed here that 443 also includes the term "hypertensive heart disease," and the absence of any complication would signify that the underlying cause was described in this manner. The solution, therefore, appears to be that when a combination term is coded as underlying cause of death, the term in the combination not disclosed by the title of the combination should be repeated as a complication. This is only one of the difficulties to be encountered in the coding of multiple causes, and before deciding on the rules for coding I consulted the World Health Organisation, as a result of which I adopted the following rules for coding which have been used in Canada:

1. Code the underlying cause of death according to the existing rules.
2. Code other conditions in Part I as complications, in the order line (c), line (b), line (a). Code conditions in Part II as contributory, in the order in which they are listed—that is from above down.
3. Where the underlying cause is a combination of conditions, repeat as complications those components of the combination whose existence is not disclosed by the title of the combination term.
4. When the components which are to be repeated in accordance with rule 3 form in themselves a combination term, code this combination term as a complication. If this latter combination does not disclose the existence of its components, code its components as individual complications.

5. Where a condition in Part II is brought up to combine with one or more conditions in Part I as underlying cause, repeat as a complication the conditions brought up subject to rules 3 and 4.
6. Do not repeat any classification number.

These are by no means the only rules which can be adopted for coding multiple causes. For instance, under the above rules, combination terms can be coded as complications. It might be considered preferable to take no account of combination terms in coding complications which means that each complication would be coded separately as if no combination term existed. A tabulation on these lines has been prepared by Corbett.¹

Each cause on the certificates was coded according to the detailed international list, 3-digit categories only being taken as causes. No account was taken of sub-division of certain causes by the fourth digit.

Two matters require mention at this stage. As will be seen later, cardiac failure and respiratory failure account for a very large number of causes coded as complications or contributory conditions. Consideration was given to the question whether or not such causes should be coded. These causes are only modes of dying and add no useful information to those cases where a well-defined cause of death is to be taken as underlying cause. For this first investigation, however, it seemed preferable to code every cause on each certificate in order to obtain a complete picture of all the causes appearing on the certificates.

Deaths caused by accidents or other external causes can be coded in two different ways according to the international list. The first method is to code them according to the external cause of the accident, and the second method is to code them according to the nature of the injury sustained. For multiple cause coding, I decided in those cases where an accident was the underlying cause to code the external cause as the underlying cause, and to code the injuries as complications or contributory conditions. Where external causes appeared on certificates, otherwise than as underlying cause, the injuries are coded as contributory conditions. There are, of course, other methods of dealing with deaths from external causes.

All the deaths registered in Dublin County Borough in 1952, which were returned on the new international form of medical certificate were included in the investigation. A small number of deaths returned on coroners' certificates and on the old type of medical certificate were excluded. Each cause of death was coded according to the above rules, and in order to extract some additional interesting information, the following information was coded: (a) sex, (b) age at death, (c) whether death occurred in a hospital or other institution or at home, (d) total number of causes of death, (e) total number of complications, (f) total number of contributing conditions. The number of deaths coded was 5,510.

Table I shows these deaths classified by sex and by number of causes of death on the certificate, distinguishing the deaths which occurred in hospitals and other institutions and those which occurred elsewhere. Table 1A shows the percentage distribution of the deaths by number of causes.

¹ *Multiple-Cause Tabulation of Causes of Death*, by H. G. Corbett, WHO/HS/Nat. Com./45, dated 16 July, 1954.

TABLE 1.

Deaths classified by sex, place of death and by number of causes of death on the certificate.

Place of Death	Number of Causes					Total
	1	2	3	4	5 and over	
Persons						
Hospitals, etc. ...	946	1,463	865	325	108	3,707
Elsewhere	362	804	471	134	32	1,803
TOTAL	1,308	2,267	1,336	459	140	5,510
Males						
Hospitals, etc. ...	549	737	452	167	51	1,956
Elsewhere	203	356	214	52	18	843
TOTAL	752	1,093	666	219	69	2,799
Females						
Hospitals, etc. ...	397	726	413	158	57	1,751
Elsewhere	159	448	257	82	14	960
TOTAL	556	1,174	670	240	71	2,711

TABLE 1A.

*Percentage distribution of deaths according to number of causes with separate particulars for each sex and for each place of death.
(Calculated from Table 1).*

Place of Death	Number of Causes					Total
	1	2	3	4	5 and over	
Persons						
Hospitals, etc. ...	% 25·5	% 39·5	% 23·3	% 8·8	% 2·9	% 100·0
Elsewhere	20·1	44·6	26·1	7·4	1·8	100·0
TOTAL	23·7	41·1	24·3	8·3	2·5	100·0
Males						
Hospitals, etc. ...	28·1	37·7	23·1	8·5	2·6	100·0
Elsewhere	24·1	42·2	25·4	6·2	2·1	100·0
TOTAL	26·9	39·0	23·8	7·8	2·5	100·0
Females						
Hospitals, etc. ...	22·7	41·5	23·6	9·0	3·3	100·0
Elsewhere	16·6	46·7	26·8	8·5	1·5	100·0
TOTAL	20·5	43·3	24·7	8·9	2·6	100·0

The number of deaths for which only one cause was returned on the certificate was 1,308 or 24% of all the deaths. Two causes were stated on 2,267, or 41% of the death certificates, and three causes were stated on 1,336, or 24% of the certificates. Certificates having 4 or more causes numbered only 599, or 11% of the total. The proportion of males with only one cause of death was considerably higher than the corresponding proportion of females (27% as against 21%), but the proportion of males with two causes was lower than the corresponding proportion of females (39% as against 43%). There was little difference between the sexes in the proportions having 3, 4, 5 or more causes on the certificate.

Contrary to what might be expected, entry of a single cause of death is more frequent in hospitals than in the case of deaths which occurred elsewhere, the proportion of these certificates being 26% and 20% respectively. On the other hand, certificates with 2 or 3 causes form 63% of all hospital deaths, and 71% of the other deaths, while those with 4 or more causes form 12% of hospital deaths and 9% of the others.

Since the age distribution of deaths in hospitals is different from that of the other deaths, it is possible that the differences observed may be due to these different age distributions. To investigate this it is necessary to classify the deaths by age group and number of causes, distinguishing those in hospital and those elsewhere. The figures are shown in Table 2 and the corresponding percentage distributions are shown in Table 2A.

TABLE 2.

Deaths classified by place of death, age-group and by number of causes of death on the certificate.

Age Group (years)	Number of Causes					Total
	1	2	3	4	5 and over	
Hospitals						
0	196	288	75	8	3	570
1-14	65	55	26	15	4	165
15-44	120	156	104	49	17	446
45-64	216	329	266	107	31	949
65+	349	635	394	146	53	1,577
TOTAL	946	1,463	865	325	108	3,707
Elsewhere						
0	13	20	11	1	—	45
1-14	5	11	4	2	1	23
15-44	33	39	25	6	—	103
45-64	114	200	126	39	7	486
65+	197	534	305	86	24	1,146
TOTAL	362	804	471	134	32	1,803

TABLE 2A.

Percentage distribution of deaths according to number of causes with separate particulars for each age-group and place of death.
(Calculated from Table 2)

Age Group (years)	Number of Causes					
	1	2	3	4	5 and over	Total
	Hospitals					
	%	%	%	%	%	%
0	34.4	50.5	13.2	1.4	0.5	100.0
1-14	39.4	33.3	15.8	9.1	2.4	100.0
15-44	26.9	35.0	23.3	11.0	3.8	100.0
45-64	22.8	34.7	28.0	11.3	3.3	100.0
65+	22.1	40.3	25.0	9.3	3.4	100.0
TOTAL:						
Crude	25.5	39.5	23.3	8.8	2.9	100.0
Standardized	24.7	39.2	24.0	9.1	3.1	100.0
	Elsewhere					
0	28.9	44.4	24.4	2.2	—	100.0
1-14	21.7	47.8	17.4	8.7	4.3	100.0
15-44	32.0	37.9	24.3	5.8	—	100.0
45-64	23.5	41.2	25.9	8.0	1.4	100.0
65+	17.2	46.6	26.6	7.5	2.1	100.0
TOTAL:						
Crude	20.1	44.6	26.1	7.4	1.8	100.0
Standardized	21.8	44.1	25.6	6.9	1.6	100.0

The last column in Table 2 shows that the age distribution of the deaths in hospitals is quite different from that of the other deaths. For instance about 15% of the hospital deaths are those of infants under 1 year, while less than 3% of the other deaths occurred at these ages. Table 2A shows that at the younger ages the proportion of deaths with either one or two causes was greater than at ages over 15 years. In order to eliminate the effect of age at death on the percentage distributions of deaths by cause, the standardised percentages shown in Table 2A were compiled by multiplying the percentages for the individual age-groups in Table 2A by the total numbers of deaths in the corresponding age-groups and summing the resulting products. This sum was then divided by 5,510, the total number of deaths, and the result was expressed as a percentage. These percentages are the standardised percentages shown in the table. The standardised percentages are not markedly different from the crude percentages, and the differences between the deaths in hospitals and elsewhere, already observed in the crude percentages, are still evident in the standardised percentages.

It is interesting to observe that the distribution of all the deaths by number of causes is much the same as that found by Stocks¹

¹ "Study of medical certification of cause of death by means of the international form of medical certificate with reference to the entry of multiple causes and of interval between onset of illness and death," by Dr. Percy Stocks. WHO/HS/Nat. Com./40, dated 11 January, 1954.

from a sample of 4,000 deaths which occurred in England and Wales in 1950. The following table shows the comparison :—

TABLE 3.

Percentage distribution of deaths according to number of causes in Dublin County Borough and in the sample taken in England and Wales.

Area	Number of Causes					Total
	1	2	3	4	5 and over	
	%	%	%	%	%	%
Dublin County ...	23.7	41.1	24.3	8.3	2.5	100.0
Borough ...	27.5	40.3	24.9	6.1	1.2	100.0

Multiple causes classified by cause of death.

In the manual of the International Statistical Classification of Diseases, Injuries and Causes of Death, 1948, a form of multiple-cause tabulation is suggested (Volume I, p. 368). The draft table shows for each cause the total number of times that it was stated as underlying cause, as complication and as other contributory condition, classified by age-group of deceased. The list of causes suggested for tabulation is either the Intermediate or Detailed International List. For a preliminary investigation it did not seem important to classify the deaths by age, and since the sample discussed in the paper comprises only about 5,000 deaths, the Intermediate List would appear to be unnecessarily lengthy to be used for a tabulation of these deaths. It was, therefore, decided to base the list on the seventeen major categories in the International List subdivided further to show important diseases or diseases which have large numbers of deaths. A total of 37 causes shown in Table 4 was selected, and the underlying causes, complications and contributory conditions are classified separately according to that list.

On the 5,510 death certificates there were mentioned in all, 12,419 causes of death, and of these, 5,116 were complications and 1,793 were contributory conditions. The table shows that the distributions by cause of the complications and contributory conditions are quite different from these of the underlying causes. Certain causes which figure prominently among the underlying causes are negligible among the complications and contributory conditions. For example, tuberculosis accounts for 5.4% of underlying causes, compared with only 0.5% of complications and 1.2% of contributory conditions, and arteriosclerotic heart disease, including coronary disease, accounts for 8.6% of underlying causes, compared with only 0.6% and 0.5% of complications and contributory conditions, respectively. On the other hand, certain diseases such as hypertension and arteriosclerosis occur as complications rather than as underlying cause of death. Other diseases such as myocardial degeneration, other heart diseases, diseases of the respiratory system, diseases of the digestive system etc., occur frequently in each of the three categories. The last column in the table shows the number of underlying causes as a percentage

of the total causes in each group. While underlying causes are 44% of the total causes, the percentage varies considerably among the different causes, from 92% for arteriosclerotic heart disease to 14% for arteriosclerosis, if the group of ill-defined diseases is omitted.

It should, of course, be observed that certain diseases occur in Table 4 more frequently as complications than as underlying causes, as a result of the international rules for coding the underlying cause of death, and the rules adopted in this paper for coding combination categories. For example, when arteriosclerosis and cerebral haemorrhage appeared on a certificate, arteriosclerosis (No. 450) was coded in this paper as a complication since, according to the international rules, cerebral haemorrhage (No. 331) had to be coded as underlying cause, and according to the rules for multiple coding adopted, the cause not disclosed by the title of the combination category, was repeated as a complication. Similarly, coronary disease appears rarely as a complication, because it combines with nearly all the conditions it complicates and the combination is coded as coronary disease.

One-third of the complications and over one-fifth of the contributory conditions are merely described as cardiac failure or respiratory failure, these two causes together accounting for over 2,000 of the total 12,419 causes. These causes add no useful information to certificates on which a well-defined cause of death is stated, and it would be far preferable to omit them altogether from such certificates. It would also be desirable to omit them from any future multiple cause tabulations, particularly in order that valid international comparisons can be made, as differences between countries in the frequency of entry on certificates of these modes of dying seriously affect the international comparisons of even the simple figures shown in Table 1. International comparison of the statistics in Table 4 may throw some light on why there are large differences between countries in the death rates from broad groups of diseases even when the death rates from all causes are much the same. One would expect that for those diseases which occur rarely as complications or contributory conditions (e.g. tuberculosis, arteriosclerotic heart disease) international comparisons of death rates would be valid, but that difficulties would arise in comparing death rates from diseases which often occur as complications or contributory conditions (e.g. arteriosclerosis, bronchitis).

For the further analysis of multiple causes, it was considered desirable to condense the list of 37 causes shown in Table 4, and Table 5 shows, for a condensed list of 23 causes, the underlying causes of deaths classified by number of causes on the certificate.

About one in four death certificates have only one cause stated but in the case of tuberculosis deaths nearly one-half have only one cause and more than one-third of the deaths from malignant neoplasms, etc., and from certain diseases of early infancy have only one cause stated.

About one in nine death certificates have four or more causes of death, but the proportion exceeds one in five for certificates which have diseases of the digestive symptom or of the genito-urinary system coded as underlying cause. Over half of the certificates with external causes as underlying cause have four or more causes. The proportions shown in Table 5 are affected markedly by the frequency of mention of ill-defined conditions as complications or contributory

TABLE 4.

Deaths classified by Cause distinguishing Underlying Causes, Complications and Contributory Conditions.

International List Nos.	Cause	Number of Causes				Underlying percentage of all Causes
		Underlying	Complication	Contributory	All Causes	
001-008 ...	Tuberculosis of respiratory system	206	5	16	227	90.7
010-019 ...	Tuberculosis, other forms ...	93	18	5	116	80.2
Rem.-138	Other infective and parasitic diseases	77	5	20	102	75.5
140-199 ...	Malignant neoplasms ...	887	171	50	1,108	80.1
200-205 ...	Neoplasms of lymphatic and haematopoietic tissues ...	48	3	4	55	87.3
210-239 ...	Benign and unspecified ...	54	1	6	61	88.5
260 ...	Diabetes mellitus ...	34	—	29	63	54.0
Rem.-289	Other endocrine metabolic and blood diseases ...	68	21	24	113	60.2
290-299 ...	Diseases of the blood and blood forming organs ...	52	29	34	115	45.2
300-326 ...	Mental, psychoneurotic and personality disorders ...	16	5	44	65	24.6
331	Cerebral haemorrhage ...	213	24	6	243	87.7
330, 332-334	Other vascular lesions ...	340	76	19	435	78.2
Rem.-398	Other diseases of nervous system and sense organs ...	136	74	48	258	52.7
420 ...	Arteriosclerotic heart disease, incl. coronary disease ...	474	33	9	516	91.9
421 ...	Chronic endocarditis not specified as rheumatic ...	54	34	12	100	54.0
422 ...	Other myocardial degeneration ...	648	340	47	1,035	62.6
Rem.-434	Other diseases of heart ...	256	405	56	717	35.7
440-443 ...	Hypertension with heart disease ...	160	38	4	202	79.2
444-447 ...	Hypertension without mention of heart ...	150	350	14	514	29.2
450 ...	General arteriosclerosis ...	78	457	35	570	13.7
Rem.-468	Other diseases of the circulatory system ...	39	68	28	135	28.9
480-488 ...	Influenza ...	9	—	3	12	75.0
490-493 ...	Pneumonia ...	184	105	28	317	58.0
500-502 ...	Bronchitis ...	214	38	105	357	59.9
Rem.-527	Other diseases of the respiratory system ...	59	195	71	325	18.2
530-537 ...	Diseases of the digestive system ...	190	160	88	438	43.4
590-637 ...	Diseases of the genito-urinary system ...	139	43	66	248	56.0
640-689 ...	Deliveries and complications of pregnancy, childbirth and the puerperium ...	16	8	8	32	50.0
690-716 ...	Diseases of the skin and cellular tissues ...	9	2	17	28	32.1
720-749 ...	Diseases of the bones and organs of movement ...	36	7	46	89	40.4
750-759 ...	Congenital malformations ...	123	28	21	172	71.5
760-776 ...	Certain diseases of early infancy ...	337	251	96	684	49.3
782 ...	Cardial failure, etc. ...	20	1,162	311	1,493	1.3
794 ...	Senility without mention of psychosis ...	43	104	165	312	13.8
795 ...	Respiratory failure, etc. ...	3	532	95	630	0.5
Rem.-799	Other ill-defined diseases ...	19	291	86	396	4.8
800-999 ...	Accidents and other external causes	26	33	77	136	19.1
	TOTAL ...	5,510	5,116	1,793	12,419	44.4

TABLE 5.

Deaths classified by Underlying Cause and with a Percentage Distribution for each Cause according to Number of Causes.

Group Number	International List Number	Cause	Total underlying causes	Percentage distribution according to number of causes				Total
				1	2	3	4 or more	
1	001-019	Tuberculosis, all forms ...	299	45.8	31.8	16.7	5.7	100.0
2	140-205	Malignant neoplasms, etc.	935	36.1	34.4	19.8	9.6	100.0
3	331	Cerebral haemorrhage ...	213	16.0	46.9	27.7	9.4	100.0
4	330, 332-334	Other vascular lesions ...	340	15.6	41.5	30.3	12.6	100.0
5	340-398	Other diseases of nervous system and sense organs	136	26.5	47.8	20.6	5.1	100.0
6	420	Arteriosclerotic heart disease including coronary disease	474	21.7	38.0	27.2	13.1	100.0
7	422	Other myocardial degeneration	648	24.5	46.1	22.4	6.9	100.0
8	Rem. of 410-434	Other diseases of the heart	310	15.8	50.3	20.6	13.2	100.0
9	440-443	Hypertension with heart disease	160	—	48.8	36.9	14.4	100.0
10	444-447	Hypertension without mention of heart ...	150	4.7	46.0	30.7	18.7	100.0
11	450	General arteriosclerosis ...	78	12.8	39.8	33.3	14.1	100.0
12	490-493	Pneumonia	184	32.6	42.9	16.3	8.2	100.0
13	500-502	Bronchitis	214	6.1	42.0	40.2	11.7	100.0
14	Rem. of 470-527	Other diseases of the respiratory system ...	68	10.3	52.9	19.1	17.7	100.0
15	530-587	Diseases of the digestive system	190	11.6	36.8	29.5	22.1	100.0
16	590-637	Diseases of the genito-urinary system ...	139	5.0	29.5	43.2	22.3	100.0
17	750-759	Congenital malformations	123	25.2	52.0	15.5	7.3	100.0
18	760-776	Certain diseases of early infancy	337	36.8	50.7	11.9	0.6	100.0
19	782	Cardiac failure, etc. ...	20	70.0	30.0	—	—	100.0
20	794	Senility without mention of psychosis	43	44.2	39.5	16.3	—	100.0
21	795	Respiratory failure, etc.	3	33.3	66.7	—	—	100.0
22	Rem.-799	Other diseases	420	19.8	36.4	29.3	14.5	100.0
23	800-999	Accidents and other external causes	26	3.8	7.7	30.8	57.7	100.0
TOTAL			5,510	23.7	41.2	24.2	10.9	100.0

conditions, and for any valid international comparisons of such figures it would seem essential to exclude the enumeration of ill-defined conditions such as cardiac failure and respiratory failure.

The effect of the inclusion of ill-defined conditions as complications or contributory conditions is more clearly seen from Table 6 which shows the complications classified by cause and by underlying cause of death.

Of the 5,510 underlying causes of death, 1,957 were without complications and 3,553 were with one or more complications, the total number of complications being 5,116. About one-third of these complications were cardiac failure or respiratory failure. The final horizontal row in the table shows the 5,116 complications classified

by cause, while each column shows the complications classified by underlying cause of death. The rows of the table show the frequency of occurrence of any complication with any particular underlying cause. For example, the first row in the table yields the following facts: Out of 299 deaths from tuberculosis, 178 certificates had no complication stated, and 121 had at least one complication on each certificate. These complications numbered in all 171 distributed as follows: 23 were other forms of tuberculosis, 10 were heart diseases, 19 respiratory diseases, 6 were diseases of the digestive system, 1 was a disease of the genito-urinary system, 47 were cardiac failure, 46 were respiratory failure and 19 were other diseases. I will not trouble you by reading out the facts shown in other rows of the table. Perhaps the most notable fact revealed by the table is the wide range of combinations that occur on death certificates. Combinations which frequently occur on certificates are heart diseases with respiratory diseases, and these may be coded either heart diseases or respiratory diseases as underlying causes of death, depending on the order of terms on the certificate. A study of the frequency of combinations in different countries would probably throw considerable light on whether differences in death rates in individual diseases were real or whether they arose from different methods of completion of certificates.

A cross-classification of contributory conditions by underlying cause of death is shown in Table 7, the list of causes being the same as in Table 6. Care must be exercised in drawing any inferences from a comparison of the figures in Tables 6 and 7 as it is by no means certain that all doctors appreciate fully the distinction between complications and contributory conditions in the completion of certificates. Apart from this difficulty, it should be realised also that the number of contributory conditions in Table 7 is far smaller than the number of conditions originally entered in Part II of the medical certificate for the reason that on the basis of the rules adopted for multiple tabulation all conditions in Part II which were combined with conditions in Part I to form underlying causes are themselves repeated as complications and not as contributory conditions.

Table 7 is read in exactly the same way as Table 6. For example, the first row shows the 81 contributory conditions that were present on 59 of the 299 death certificates which had tuberculosis as the underlying cause of death. Several interesting facts are apparent from an examination of the figures. There are 21 cases of tuberculosis appearing as contributory conditions, and 54 cases of malignant neoplasms, etc. In the majority of cases these contributory conditions are on certificates which do not have a similar condition stated as underlying cause of death. Bronchitis accounts for 105 contributory conditions, pneumonia for 28, and other diseases of the respiratory system for 74 cases. Diseases of the digestive system are responsible for 88 contributory conditions and diseases of the genito-urinary system for a further 66 cases. In general it can be observed that contributory conditions tend to be spread equally over all underlying causes of death, whereas in the case of complications there is a tendency for a fairly high proportion of complications to occur with those underlying causes of death in the same group.

TABLE 6.

Deaths classified by Underlying Cause, and Complications classified by Cause and by Underlying Cause of Death.

Group No.	International List Nos.	Underlying cause of death	Underlying causes			Complications classified by group number of cause																							Total comp cation	
			Total	Without compli-cations	With compli-cations	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23		
1	001-019	Tuberculosis, all forms	299	178	121	23	—	—	—	—	6	4	—	—	—	9	2	8	6	1	—	—	47	—	46	19	—	171		
2	140-205	Malignant neoplasms, etc.	935	478	457	—	174	2	3	8	5	8	7	—	1	—	14	1	20	48	8	—	1	146	28	108	108	—	696	
3	331	Cerebral haemorrhage ...	213	40	173	—	—	—	9	8	—	6	1	4	130	50	—	—	—	—	—	—	1	21	1	10	2	—	245	
4	330, 332-334	Other vascular lesions ...	340	82	258	—	—	4	16	19	1	4	2	3	108	111	4	1	5	—	—	—	—	59	2	49	6	—	394	
5	340-398	Other diseases of nervous system and sense organs	136	58	78	—	—	1	2	12	1	4	5	1	2	—	12	—	3	4	—	—	—	—	—	—	—	—	105	
6	420	Arteriosclerotic heart disease including coronary disease...	474	147	327	—	—	1	4	—	—	80	49	28	74	117	1	2	4	1	3	—	—	87	5	22	6	—	484	
7	422	Other myocardial degeneration ...	648	257	391	—	—	2	10	2	—	—	68	—	—	120	9	15	24	3	3	—	—	173	37	41	13	—	520	
8	Rem. of 410-434	Other diseases of the heart ...	310	72	238	—	—	1	16	6	8	24	96	2	2	5	8	1	18	—	—	—	—	98	4	23	9	—	321	
9	440-443	Hypertension with heart disease...	160	2	158	—	—	—	3	—	—	93	83	—	—	17	—	4	5	—	1	—	—	—	12	2	3	3	—	226
10	444-447	Hypertension without mention of heart ...	150	15	135	—	—	—	—	2	—	—	19	—	—	28	—	—	8	—	—	—	—	92	—	37	30	—	216	
11	450	General arteriosclerosis ...	78	17	61	—	—	—	—	1	—	—	22	—	—	—	2	—	2	—	1	—	—	34	3	12	11	—	88	
12	490-493	Pneumonia ...	184	102	82	—	—	1	2	1	6	2	—	—	—	1	1	—	5	—	—	—	13	48	2	20	7	—	109	
13	500-502	Bronchitis ...	214	29	185	—	—	—	1	—	2	57	37	—	—	—	10	1	72	2	—	—	1	60	3	10	12	—	268	
14	Rem. of 470-527	Other diseases of the respiratory system ...	68	17	51	—	—	1	2	3	—	4	8	—	1	—	3	2	2	—	—	—	2	22	3	12	6	—	71	
15	530-537	Diseases of the digestive system...	190	39	151	—	—	—	—	1	1	2	3	—	—	—	5	1	1	66	6	—	4	62	2	39	49	—	242	
16	590-637	Diseases of the genito-urinary system ...	139	12	127	—	—	3	2	1	2	8	5	—	25	—	1	—	2	2	10	—	4	31	2	14	90	—	202	
17	750-759	Congenital malformations	123	62	61	—	—	—	1	2	—	1	1	—	—	—	2	1	2	1	1	28	27	8	2	6	2	—	85	
18	760-776	Certain diseases of early infancy ...	387	169	168	—	—	1	—	—	—	—	—	—	—	—	3	—	—	—	—	—	190	—	—	—	—	—	194	
19	782	Cardiac failure, etc. ...	20	17	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	2	—	3
20	794	Senility without mention of psychosis ...	43	20	23	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	16	—	—	—	—	—	
21	795	Respiratory failure, etc. ...	3	1	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	
22	Rem.-799	Other diseases ...	420	142	278	—	—	8	6	7	12	37	27	—	7	8	21	7	12	27	9	—	8	108	7	57	56	—	424	
23	800-999	Accidents and other external causes ...	26	1	25	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
TOTAL ...			5,510	1,957	3,553	23	174	24	76	74	33	340	439	38	350	457	105	38	195	160	43	28	251	1,102	104	532	437	33	5,116	

TABLE 7.

Deaths classified by Underlying Cause, and Contributory Conditions classified by Cause and by Underlying Cause of Death.

Group No.	International List Nos.	Underlying cause of death	Underlying causes			Contributory conditions classified by group number of cause																							Total contributory conditions	
			Total	Without contributory conditions	With contributory conditions	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23		
1	001-019	Tuberculosis, all forms	299	240	59	3	1	—	—	2	—	3	3	—	1	2	—	4	4	3	4	—	1	27	1	6	14	2	8	
2	140-205	Malignant neoplasms, etc.	985	712	273	2	12	1	—	1	4	13	6	—	3	4	2	8	10	11	10	—	1	106	13	40	46	—	29	
3	831	Cerebral hæmorrhage...	213	177	36	1	3	—	—	1	1	2	2	—	—	—	2	1	1	1	—	—	10	2	2	13	—	4		
4	830, 832-834	Other vascular lesions...	340	253	87	2	4	—	1	6	—	5	7	—	—	—	3	13	7	4	2	—	—	16	10	4	15	4	10	
5	340-398	Other diseases of nervous system and sense organs	186	105	81	—	1	—	—	2	—	1	1	—	2	1	1	2	—	1	1	—	2	9	1	5	7	2	3	
6	420	Arteriosclerotic heart disease including coronary disease...	474	347	127	2	10	—	3	5	—	—	13	—	—	—	3	19	11	16	10	—	—	11	11	2	35	10	16	
7	422	Other myocardial degeneration...	648	461	187	—	6	—	3	11	—	—	5	—	—	—	2	19	10	8	7	1	—	21	68	2	37	14	21	
8	Rem. of 410-434	Other diseases of the heart	310	238	72	1	3	1	2	2	—	1	4	—	—	2	—	10	5	1	3	—	—	7	9	1	25	12	8	
9	440-443	Hypertension with heart disease...	160	124	36	—	2	1	3	1	—	—	2	—	—	—	1	7	3	1	3	—	—	2	4	—	10	—	4	
10	444-447	Hypertension without mention of heart	150	128	22	1	2	—	—	2	—	—	—	—	—	—	2	2	2	6	3	—	—	8	—	1	3	2	3	
11	450	General arteriosclerosis...	78	53	25	—	—	—	—	1	—	—	1	—	—	—	1	4	1	2	2	—	—	4	7	1	2	3	2	
12	490-493	Pneumonia	184	122	62	1	—	1	—	1	—	4	3	—	1	4	—	3	3	6	2	3	6	7	4	2	23	3	7	
13	500-502	Bronchitis	214	148	66	—	3	—	—	1	—	4	2	—	1	3	1	—	5	1	—	—	1	20	14	1	17	6	8	
14	Rem. of 470-527	Other diseases of the respiratory system	68	44	24	—	—	1	—	3	—	2	1	—	1	4	—	1	—	—	—	—	1	2	3	3	3	4	2	
15	530-587	Diseases of the digestive system	190	133	57	1	1	1	1	1	1	3	2	3	1	3	—	3	3	9	2	1	2	13	2	9	11	2	7	
16	590-637	Diseases of the genito-urinary system	139	89	50	3	1	—	1	1	—	4	3	1	3	4	5	4	2	4	7	2	1	9	1	—	11	2	6	
17	750-759	Congenital malformations	123	82	41	—	—	—	—	—	—	—	—	—	—	—	2	1	1	3	1	6	22	1	—	1	11	—	4	
18	760-776	Certain diseases of early infancy	337	275	62	—	—	—	—	2	—	—	—	—	—	275	—	—	—	—	—	—	5	50	—	—	—	4	4	6
19	782	Cardiac failure, etc.	20	17	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
20	794	Senility without mention of psychosis	43	35	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
21	795	Respiratory failure, etc.	3	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
22	Rem.-799	Other diseases	420	289	131	4	4	—	3	5	2	4	12	—	1	7	3	3	4	10	8	3	9	23	12	11	43	5	17	
23	800-999	Accidents and other external causes	26	5	21	—	1	—	2	—	1	1	1	—	—	1	1	—	2	1	—	—	—	12	2	4	5	2	3	
		TOTAL	5,510	4,080	1,430	21	54	6	19	43	9	47	68	4	14	35	28	105	74	88	66	21	96	311	165	95	342	77	1,79	

The tables so far considered have shown the total frequency of certain conditions as complications or contributory conditions with certain underlying causes of death, but the tables do not yield information regarding the frequency of certain combinations of diseases on certificates. Perhaps an example will clarify this point. In Table 6, 474 cases of arteriosclerotic heart disease are shown among the underlying causes, and on the 474 certificates there are 117 cases of arteriosclerosis mentioned as complications, but no information is given as to how many of these 117 cases appear on certificates as the only complication, how many of the 117 cases involve arteriosclerosis with myocarditis, etc. To answer such questions it is necessary to prepare yet another tabulation. Table 8 shows such a tabulation for the 474 cases of arteriosclerotic heart disease, including coronary disease.

TABLE 8.

Deaths from arteriosclerotic heart disease including coronary disease, classified by type of complication.

Type of Complication	Without contributory conditions	With contributory conditions	Total
Without complication	150	52	202
With			
(a) Myocarditis (422)	33	12	45
(b) Other and undefined diseases of the heart (434)	12	3	15
(c) Hypertension (444)	32	3	35
(d) Arteriosclerosis (450)	46	22	68
(e) Other single complications	16	1	17
(f) Myocarditis and hypertension (443 and 422)	13	3	16
(g) Hypertension and arteriosclerosis (447 and 450)	21	7	28
(h) Other double complications	31	6	37
(i) Three complications	6	5	11
TOTAL	360	114	474

In the preparation of this table, both cardiac failure and respiratory failure were ignored as complications or contributory conditions. Of the 474 cases, 202 had no complications, 45 had myocarditis, 15 had other and unspecified diseases of the heart, 35 had hypertension, 68 had arteriosclerosis, and 17 had various other single conditions. Myocarditis and hypertension appeared together as complications in 16 cases, and hypertension and arteriosclerosis were present together in 28 cases. There were 37 other cases of double complications, and 11 cases of three complications. The number of cases in which contributory conditions also appeared on the certificates are shown separately. The figures in the table could be analysed further by classifying the deaths by contributory condition, but, on account of the small number of deaths in each group, to do so in the present case would serve no useful purpose.

It is evident that it would be impracticable to produce tabulations of the type shown in Table 8 for every cause of death, but consideration

might be given to the production of such tables for the special study of certain diseases. Such studies would be particularly useful in connection with morbidity statistics, for much useful information would be lost if illnesses are classified according to one disease only. The question of the tabulations to be produced and the use to be made of them must be left to the medical profession to decide.

Sufficient has, I think, been said and shown in the tables to lead to the conclusion that tabulations of multiple causes of death and equally of multiple causes of illnesses are not easily produced in short and succinct terms. The study has, however, led to the following conclusions :

- (1) Careful consideration will have to be given to the adoption of rules for coding multiple-causes of death in order that the tabulations produced will be comparable internationally.
- (2) Modes of dying, such as cardiac failure and respiratory failure, should be omitted from all multiple cause tabulation since variations in the frequency of mention of these conditions would blur the picture presented by the tabulations, and would make international comparability difficult.
- (3) Tabulations of the type shown in Tables 4 and 5 are comparatively easy to prepare, and the list of causes could be extended. Tabulations of the type shown in Tables 6 and 7 are very interesting, but the list of causes for tabulation should be limited in order that reasonably large figures will emerge in the various groups and in order that the labour of preparing such statistics will be kept within bounds. Tabulation of the type in Table 8 should be limited to the study of particular diseases. All multiple cause tabulations should be kept within bounds if valuable and interesting information is to be derived from them. There is a tendency in such work to go in for too much detail in the final tables, and if this is done the resulting figures will be meaningless, particularly in the smaller countries where the number of deaths per year is less than 100,000.
- (4) The tabulations are useful in two respects. Within countries they serve to show how the doctors are interpreting the rules for completion of the medical certificates. A study of such tabulation over a period of years would indicate any changes in methods of completion of certificates that would otherwise go undetected. International comparisons between different countries will indicate whether differences between countries in the death rates from certain diseases are real or arise from variations in the methods of completion of certificates or in the statements of sequences of causes leading to death.

In order to solve satisfactorily the problems that still remain in connection with cause of death classification, it is essential for the doctors and the statisticians in statistical offices to work in close collaboration. The doctor should be acquainted with statistical

analysis and should be aware of all the uses to which the statistics can be usefully put. Equally the statistician should have a medical background and should be acquainted with the course of diseases that cause illness and death. This co-operation should extend further than to the environs of statistical offices. The general medical practitioners are the ultimate source of the statistics, and it is they who use the final product after the statistician has suitably collated and analysed the individual figures. They, too, should have an interest in the final statistics, and by their co-operation with the central office should help to produce better statistics. It is only by this mutual co-operation between the medical profession and the statistician that better medical statistics of every sort can be produced.

DISCUSSION.

Dr. Deeny proposed a vote of thanks to Mr. Broderick for his paper, and said that he was delighted to hear a medical paper read at the Society. Formerly the Society's papers were frequently of a medical nature, but lately, with developing interest on the part of the profession in medical societies, medical subjects were being less discussed at the Statistical Society. He felt that this was a pity, since there were many subjects of general medical interest in which the views of persons other than medical men would be most valuable. He wished to congratulate Mr. Broderick on his excellent paper which dealt with a subject of wide interest, and one to which he had obviously given a very great deal of study.

Commenting on the paper, Dr. Deeny first pointed out that the subject was one of great difficulty because of the inexactitudes of so many of the death certificates. In a recent study, which he, Dr. Deeny, had carried out, and in which he had related the findings of the three Dublin Lying-in Hospitals as regards causes of infant death to the national figures compiled from death certificates of infants by doctors from all over the country, it was obvious that the Dublin hospital figures, where the cause of death was usually confirmed by post mortem examination, differed to a very considerable extent for some diseases from the national figures. He also pointed out other instances of the impossibility of establishing the true cause of death without post mortem examination. In some categories, of course, the cause of death was obvious and could be readily established. This meant that the same exact definition was being given to exact and true causes of death in some categories, whereas in other categories the same exact definition was being applied to vague or ill-defined material.

Dr. Deeny went on to say that study of the cause of death in some elderly people indicated that there seemed to be "patterns" of death where a certain series of multiple causes of one kind terminated a life as opposed to another series terminating another life. Thus, one person might die from a chain of pathological circumstances associated with failure of the respiratory organs, whereas another person's death might be occasioned by a series of cardiac and arterial degenerations as shown by arteriosclerosis. In this respect, Mr. Broderick's paper was of great value, since it seems likely to commence a line of study which one would hope might eventually demonstrate the association

of these various patterns of death, and would lead to the cessation of names of diseases being put on death certificates, particularly of old people, where it was not possible to define the exact cause of death.

Dr. Deeny again congratulated Mr. Broderick on an excellent paper, and felt that more might be expected from Mr. Broderick in the future, and that he should be encouraged to pursue this valuable line of research.

Dr. Geary : I have great pleasure in supporting the vote of thanks to Mr. Broderick. May I say that I also feel proud since as I direct the office in which Mr. Broderick is a statistician, I must be deemed to have had a part in his training. This is a significant occasion in the relationship between the Society and the office for Mr. Broderick's paper is the first paper from our corps of statisticians. Our lecturer has set both himself and his colleagues a high standard for future papers.

Before coming here to-night, I had made some notes on the paper dealing in particular with the relationship between a nomenclature and a classification to which the lecturer referred in his opening paragraph. I was also going to suggest that the founder of Vital Statistics in Ireland, Sir William Wilde, should have been mentioned in his historical review. I leave these and other points, however, because I have been so interested in the previous contributions to the debate which, may I say, are worthy of the paper. Dr. Deeny has said that considerable doubt attaches to a large proportion of the statements of causes of deaths by medical practitioners, a point which Dr. Murphy emphasised in his striking instances of the lack of concordance, in so large a number of cases, between statements of causes of death by different doctors or even by the same doctors at different times. This was one of the reasons why, after producing in 1950 the number of deaths classified according to the 600 rubrics of the Sixth Revision of the International Classification of Causes of Death, we decided for subsequent years to work with the Intermediate Classification, which contains only 150 rubrics. We were also influenced in this decision by the very small number of deaths returned for a large number of headings in the Detailed List. I would like to ask Dr. Deeny if, in view of the imprecision of the certificates, he thinks it would be wise to curtail the list still further.

Dr. Deeny : Yes and no. The list should be made shorter as regards the less precise categories, but where it was possible to achieve precision in certifying the cause of death it was undesirable to reduce such headings. He would like to acknowledge that Mr. Broderick had, in connection with the work of the Department of Health, already impressed him with the necessity for a shorter list.

Dr. Geary : In all the divisions of statistics with which the office deals, scepticism has invariably been expressed about the reliability of statements on the returns used for compiling these statistics. It is probably true that in varying degree all statistics are inaccurate. All I can say is that we believe that they faithfully reflect changes when significant changes occur ; in other words, the biases, if any, are constant. In the case of Vital Statistics, the trends in mortality from tuberculosis and cancer, for example, are probably quite reliable.

The main use of statistics is not so much to measure the absolute level of phenomena at any particular time as to indicate trends.

With regard to the difficulties mentioned by Dr. Quinlan, I would like to make two remarks. The first is that doctors, registrars, etc. are unfamiliar with the new form, and that these difficulties will tend to diminish with increase in familiarity. The second is that in Volume I of the Manual of the International Statistical Classification of Diseases, Injuries and Causes of Death, produced by the World Health Organisation, deals in considerable detail with the kind of difficulties which Dr. Quinlan mentioned. This volume is a very remarkable piece of work, and it would be very useful, during their medical courses, if students could be made familiar with it. I believe that the accuracy of statement of causes of death on the certificates can only be improved by an appreciation on the part of doctors of the value of the resulting statistics for the improvement of public health. To this end it would be very useful if an intensive course on Vital Statistics generally were included in medical courses in the universities, etc., dealing especially with the Manual.

It would also be very useful if, quite apart from the official Vital Statistics which will always be somewhat imprecise and generalised, it would be possible to assemble a series of statistics on the results of post mortems. If we had, say, a thousand records each year of the results of post mortems from the hospitals, etc., a most valuable set of statistics could be compiled, especially if the thousand or so cases could be regarded as a random sample of all deaths. I realise that this proposal is rather unrealistic since the number of post mortems performed annually in Ireland is very small.

Mr. Honohan thought that, having regard to the difficulties presented to the medical certifier in filling in the new form, there was something to be said for leaving discretion to the official statistician in deciding what cause should be selected for the main classification in published tabulations. Classifications might well be determined in the light of their importance from the public health point of view or for their social or practical significance.

It should not be overlooked that while the study of the multiple causes of death, which were the subject of the paper, gave "a more complete picture of the morbid process," the real or fundamental causes of death were not included in this picture. The weather, for instance, was frequently responsible for the deaths of old people, and one could name the pace and stress of life, drink, worry, etc., and even "operations," not to speak of the immediate "medical" cause for the start of the morbid process, a matter which was, no doubt, frequently in doubt.

As regards international comparisons, *Mr. Honohan* said that the age factor was very important, and should always be borne in mind. The incidence of diseases which occurred mainly at the higher ages would obviously be heavier in countries with longer life expectations than in countries where many people did not live to the ages when such diseases took place.

Actuaries are always on the look-out for an underlying mathematical law of mortality, but it appeared to the speaker that the multiplicity of causes of death made such a pursuit well-nigh farcical, unless mortality could be divided as one actuary suggested into what he

described as "senescent" deaths and "anticipated" deaths (R. D. Clarke in Vol. II of the Proceedings of the Centenary Assembly of the Institute of Actuaries). The last-mentioned category presumably represented the field for the future work of the medical profession, and the former might conceivably prove to be a more rewarding field in the search for a law of mortality. Mr. Clarke suggested that causes which might be regarded as falling into the senescent group included cerebral vascular lesions, myocardial diseases, angina pectoris, arteriosclerosis, other diseases of the circulatory system, etc. This suggested to the speaker that the range of Mr. Broderick's "modes of dying," as distinct from causes of death, might be reconsidered with a view to the inclusion of some of these other degenerative causes which were not properly regarded as diseases at all.