In a New York State Health Department study, a comparison of original death certificates and certificates prepared from autopsy protocols revealed an appreciable degree of inaccuracy in cause-of-death statements.

Accuracy of Cause-of-Death Statements On Death Certificates

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THE BASIC DATA on which public health activities have been planned have come primarily from vital statistics. Birth and death certificates have provided information essential to the operation of nearly all health programs. Since the start of the vital registration systems in this country, the emphasis has been on completeness of reporting. The entrance of a State into the birth or death registration area was determined primarily by its achieving a stated percentage of completeness of reporting, and no other criterion for accuracy in vital statistics has yet been generally employed.

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Questions have been raised, however, as to the accuracy of the information on these certificates, and some attempts have been made to assess the accuracy of various items. Swartout and Webster (*1*) reviewed earlier studies of the accuracy of cause-of-death statements and compared autopsy diagnoses for 8,080 persons in Los Angeles Hospital with the cause of death which they believed would have been listed had no autopsy been performed. They found 79 percent agreement between the diagnoses, with the percentage by categories varying from 100 percent for measles, scarlet fever, and cancer of the mouth to 16 percent for softening of the brain. When they used broader categories for their comparisons, the agreement reached 90 percent. Agreement was only 50 percent for those patients who were admitted to the hospital within 48 hours of death. All diagnoses were made by the authors themselves, using the fifth revision of the International List of Causes of Death, and multiple causes were resolved through the Manual of Joint Causes. They did not study the actual certificates filed by the attending physician.

In 1949, Dr. A. G. Evans, in an unpublished study, analyzed a sample of 3,900 from a total

of 161,600 death certificates for the years 1946 and 1947. Based upon his own judgment as to what constituted a satisfactory statement of the cause of death and without any consideration of autopsy data, he discovered that 57 percent were defective. Of this defective group, almost half had incomplete medical certification, 24 percent used obsolete or unacceptable terms, and 28 percent represented inaccurate medical certification. He suggested greater emphasis on querying of death certificates by health officers. On the average, only about 3 percent of death certificates in the Nation as a whole are queried, and, according to a recent survey, only 8 State and Territorial health departments estimate that they are querying more than 5 percent of death certificates submitted (*2*).

Pohlen and Emerson (*3*) obtained cause-of-death data based on both ante-mortem and post-mortem findings from 15 cooperating hospitals in New Jersey and New York State. Deaths from cancer were analyzed in an attempt to determine the accuracy of the diagnosis and of the determination of the anatomical site of the cancer when based on clinical data alone. Of 3,462 deaths found at autopsy to have been due to cancer of various sites, the diagnosis for 77 percent was etiologically correct; for 77 percent it was topologically correct; and for 67 percent it was correct in both ways. Cancers of certain sites, such as the breast, the pharynx, and the rectum, were correctly diagnosed ante mortem relatively more often than were those of sites such as the brain, the liver, and the bile ducts. In addition, the autopsy data revealed that 148 deaths attributed to cancer on the clinical diagnosis were actually due to some other cause.

Korns and Lintz (*4*) concluded from a review of 500 autopsy protocols from 5 hospitals that there was an 11 to 20 percent disagreement between the medical statements appearing on death certificates and the pathological findings at autopsy. They used the fifth revision of the International List of Causes of Death and the Manual of Joint Causes.

The present study was made to determine how closely the reporting of the cause of death under the current system tallies with the best possible estimation of the facts. The initial problem was to determine what could be used as a standard for comparison; in other words what was the "true" underlying cause of death? In general, a diagnosis made on the basis of a complete, competently performed autopsy and a good clinical history is as close to the truth as modern medical science can come. This procedure, of course, does not completely solve the problem, because the pathologist does not and cannot always state the underlying cause of death singly and unequivocally. Multiple factors may be present, any one of which could cause death or whose effect may lie only in their particular combination. The present vital statistics system, however, is geared in such a way that each death must be attributed to one and only one cause. Needed to measure the accuracy of this system, therefore, is a theoretically true underlying cause of death, defined as that cause of death which a well-trained physician would enter on the death certificate after he had obtained all possible information, including a clinical history and findings of a complete autopsy. In this study, such a theoretically true cause of death was determined for a large number of deaths occurring in upstate New York and compared with the cause entered on the original death certificate. Data obtained were then used to evaluate the accuracy of the cause-of-death statements on the original certificates.

Study Method

The records of all autopsied deaths occurring in 12 hospitals in the Albany, N. Y., region in 1951 and 1952 were examined by a team of three third-year medical students working under the junior public health intern program of the New York State Department of Health. These students had received special training in how to complete a medical certification section of a death certificate, and their abilities in this regard were tested carefully by the authors. Each autopsy protocol, including the clinical summary, was reviewed, and if the autopsy was complete, a standard death certificate was filled out, the pathologist's results being used in completing the cause-of-death statement. A total of 1,889 such certificates were completed and analyzed. All of the pathology services in

the cooperating hospitals were under the direction of a physician qualified under New York State's public health law, which requires qualifications equal to those required by the American Board of Pathology.

These certificates, called autopsy certificates in this report, were then coded by the regular coding staff of the New York State Department of Health according to the sixth revision of the International Lists of Diseases and Causes of Death in the same manner as are all death certificates. The regularly filed death certificate, called original certificate, was then examined for each of these cases, and the originally coded cause of death was entered on the completed autopsy certificate. The data were grouped according to 30 broad categories of cause of death similar to those used by the New York State Department of Health in its published vital statistics reports.

In developing the method used in this study, two questions had to be answered by small methodological studies:

1. Could the three reviewers, working independently, draw the same conclusions as to the underlying cause of death from identical autopsy data?

To answer this question, each of the three reviewers prepared autopsy death certificates from a series of 50 consecutive autopsy protocols from the files of a teaching hospital. For 46 of the 50 cases (92 percent), there was complete agreement within New York State's vital statistics groupings; for 2 cases (4 percent) 2 of the three reviewers were in agreement; for the remaining 2 (4 percent) each reviewer listed a different cause of death. Of the 46 autopsy certificates on which all 3 agreed, there was disagreement with the original certificate on 6 (13 percent). When each reviewer was tested

Table 1. Number of deaths by cause according to original death certificate and autopsy certificate

Cause of death [1]	Number according to original certificate	Number according to autopsy certificate	Percent change when autopsy data were used
Total	1,889	1,889	
Tuberculosis (001–019)	48	56	16.7
Syphilis (020–029)	12	5	−58.3
Other infective and parasitic diseases (040–138)	28	28	0
Malignant neoplasms (140–205)	402	409	1.7
Other neoplasms (210–239)	15	14	−6.7
Diabetes mellitus (260)	36	16	−55.6
Vascular lesions affecting central nervous system (330–334)	131	119	−9.2
Various diseases of sense organs (340–399)	21	25	19.0
Rheumatic fever (400–402)	5	4	−20.0
Chronic rheumatic heart disease (410–416)	41	50	22.0
Arteriosclerotic heart disease (420)	276	267	−3.3
Chronic endocarditis (421, 422)	23	20	−13.0
Other diseases of heart (430–434)	10	6	−40.0
Hypertension with heart disease (440–443)	41	19	−51.2
Hypertension (444–447)	29	41	41.4
General arteriosclerosis (450)	17	36	111.7
Other diseases of arteries (451–456)	18	24	33.3
Other diseases of circulatory system (460–468)	8	4	−50.0
Chronic and unspecified nephritis (592–594)	23	26	13.0
Acute nephritis and nephrosis (590, 591)	6	9	50.0
Pneumonia, except pneumonia of newborn (490–493)	57	57	0
Other respiratory diseases (470–527, excluding 490–493)	33	33	0
Diseases of digestive system (530–587)	171	181	5.8
Hyperplasia of prostate (610)	12	16	33.3
Congenital malformations (750–759)	62	71	14.5
Certain diseases of early infancy (760–776)	121	111	−8.3
Senility and ill-defined causes (780–795)	6	5	−16.7
Accidents, poisonings, and violence (E800–E962)	156	165	5.8
Suicide, homicide, etc. (E963–E999)	14	12	−14.3
All others (241–252, 261–289, 290–299, 300–326, 600–609, 611–749)	67	60	−10.4

[1] Numbers in parentheses are category numbers of the sixth revision of the International Lists of Diseases and Causes of Death.

Table 2. Distribution of deaths according to cause given on original

Cause of death according to original certificate [1]	Cause of death, by International List									
	Total	001–019	020–029	040–138	140–205	210–239	260	330–334	340–399	400–402
Total	1,889	56	5	28	409	14	16	119	25	4
Tuberculosis (001–019)	48	45			1					
Syphilis (020–029)	12		3					2		
Other infective and parasitic diseases (040–138)	28	1		16	1				5	
Malignant neoplasms (140–205)	402			1	372	5		5		
Other neoplasms (210–239)	15				3	5		3		
Diabetes mellitus (260)	36						11	2		
Vascular lesions affecting central nervous system (330–334)	131	3		1	4			78	2	
Various diseases of sense organs (340–399)	21	1		1	1			1	12	
Rheumatic fever (400–402)	5									
Chronic rheumatic heart disease (410–416)	41	1								2
Arteriosclerotic heart disease (420)	276	3			10		1	5		
Chronic endocarditis (421, 422)	23				1		1	4		
Other diseases of heart (430–434)	10									
Hypertension with heart disease (440–443)	41		1				1	4		
Hypertension (444–447)	29	2			1			2		
General arteriosclerosis (450)	17				1			2		
Other diseases of arteries (451–456)	18		1					3		
Other diseases of circulatory system (460–468)	8				1			1		
Chronic and unspecified nephritis (592–594)	23							2		2
Acute nephritis and nephrosis (590, 591)	6									
Pneumonia, except pneumonia of newborn (490–493)	57			2	3		1	2	1	
Other respiratory diseases (470–527, excluding 490–493)	33			2	1			1		
Diseases of digestive system (530–587)	171			1	7	1				
Hyperplasia of prostate (610)	12				2					
Congenital malformations (750–759)	62					1			3	
Certain diseases of early infancy (760–776)	121									
Senility and ill-defined causes (780–795)	6									
Accidents, poisonings, and violence (E800–E962)	156			1				2	1	
Suicide, homicide, etc. (E963–E999)	14									
All others (241–252, 261–289, 290–299, 300–326, 600–609, 611–749)	67			3		2	1		1	

separately against the 50 original certificates, the disagreements were 8, 8, and 9, or 16, 16, and 18 percent. Hence, not only did the reviewers agree well among themselves, but each disagreed about equally with the original. Although this test did not provide conclusive evidence that there was no reviewer bias, it was decided to permit each reviewer to work independently on different sets of autopsy protocols and to combine their results for the final analysis.

2. If there should be marked differences between the autopsy and original certificates, how would it be known that it was partly due to the additional data uncovered at autopsy instead of wholly to avoidable errors by the physician who completed the death certificate?

To answer this question, the reviewers, working as a team, studied the ante-mortem clinical records for 98 consecutive autopsied deaths, agreed upon a medical certification of death for each, and prepared new death certificates without reference to autopsy data. Then they studied the autopsy protocols and prepared another set of certificates based upon all available information. If the certificates prepared from the clinical records did not compare much more favorably with the autopsy certificates than did the original ones, the errors in cause-of-death statements on the originals could not be attributed wholly to avoidable errors by the physician who completed the death certificate.

When the three sets of certificates were compared, it was found that the original and autopsy certificates for 20 (20 percent) of the 98 deaths studied disagreed, but that in only 4 of these did the certificate prepared from the clinical records agree with the autopsy certificate.

certificate, by cause given on autopsy certificate

numbers, according to autopsy certificate																				Percent of certificates agreeing
410–416	420	421, 422	430–434	440–443	444–447	450	451–456	460–468	592–594	590, 591	490–493	470–527	530–587	610	750–759	760–776	780–795	800–962	963–999	All others	
50	267	20	6	19	41	36	24	4	26	9	57	33	181	16	71	111	5	165	12	60	71.0
												1	1								93.8
							7														25.0
	1										2				1	1					57.1
	6						1		1		1	1	5					1		3	92.5
	1											1								2	33.3
	8				2	5			2	1	1		3							1	30.6
2	8			2	8	2			3		5		5	1			1	4		2	59.5
1	1									1	1							1			57.1
3	1					1															0
30	1	2	1				1		1		2										73.2
3	201	8		4	1	14	2				2	5	6	1	1		1	4		4	72.8
1	5	5	1			2			1				2								21.7
2	3	1									1		1		2						0
4	3	1	1	7	13	1	1				2	1						1			17.1
	3			4	9	1			3		1		3								31.0
1	4					4							5								23.5
	1					1	11											1			61.1
								3			1		1					1			37.5
					4		1		12	1		1									52.2
										3			1							2	50.0
	6		2		1	1		1		1	25	1	5		1		1	3			43.9
	2			1		1			1		3	11	3					1		6	33.3
2	5	3	1	1	2	2					5	2	135				1			3	78.9
														10							83.3
											1				52	3		1		1	83.9
												2	1		13	105					86.8
										1	2					1			1	1	0
	1				1	1						4	1			1	1	136	5	1	87.2
																		8	6		42.9
1	6								2	1	2	3	3	4	1			3		34	50.7

[1] Numbers in parenthesis are category numbers of the sixth revision of the International Lists of Diseases and Causes of Death.

Hence, if the physician had completed the certificate properly on the basis of the ante-mortem evidence, agreement between the original and autopsy certificates would have been only 4 percent greater. It was concluded that in this sample, taken from a large teaching hospital where physician practices on death certification were good, there was an appreciable amount of new information supplied by autopsy which could refine the cause-of-death statistics.

This study made no attempt to assess the physician error in recording the ante-mortem data for the total group of 1,889 cases separately from the error due to inadequate information. The methodological study mentioned above was taken as an indication that a sizable portion of the difference between the autopsy and the original certificates was due to additional data found at post mortem.

Cause-of-Death Comparisons

Table 1 shows the deaths tabulated by cause groups, both by the original coding and the coding of the autopsy certificates. As can be seen, inaccuracies in the original cause-of-death statement led to an overstatement or understatement of the importance of several major causes of death. For instance, the use of autopsy data changed the number of deaths from tuberculosis (001–019) from 48 to 56. Since the deaths studied were not a representative sample of deaths in the State, this finding cannot be considered as proof that the death rate from tu-

berculosis as given by the reports of the New York State Department of Health is too low. It merely suggests that there may be some underreporting of deaths due to tuberculosis.

Although the number of deaths from syphilis and its sequelae (020–029) was numerically small, there was a significantly large difference in the number of deaths from this cause when the autopsy data were used. Furthermore, an investigation of the incorrectly allocated certificates showed that the difference could be attributed to deaths from "aneurysm of the aorta." Of the 8 deaths ascribed to this cause on the original certificate, 7 of them were found at autopsy to be nonsyphilitic. Three of these certificates had been queried to discover whether or not the aneurysm was syphilitic, but the physician certifying the death in each case had not replied to the query. If this practice of listing "aneurysm of the aorta" as the cause of death occurs throughout the State, many of the deaths attributed to syphilis are wrongly allocated.

The cardiovascular renal group as a whole (330–334, 400–468, and 592–594) showed little change, although there were many differences within the group. The number of deaths attributed to general arteriosclerosis (450) showed a significantly large increase when autopsy data were used. The hypertensive heart disease group (440–443), in particular, showed a significantly large decrease. The lack of clinical information or the lesser attention given to this group of diseases by pathologists may be a partial explanation for these differences, as well as for the significantly large decrease in the proportion of deaths attributed to diabetes mellitus (260). In certifying these deaths, the physician may have given more weight to clinical information than did the pathologist.

Certain categories, such as malignant neoplasms and accidents, were relatively unchanged by the use of autopsy data. The cause of death in these categories seemed to be relatively well reported.

Although the similarity, rather than the difference, in the overall distribution of the two groups of records by cause of death is perhaps the striking factor in table 1, it can be seen from table 2, which shows the distribution of the deaths by the cause given on the original certificate and by the cause given on the autopsy certificate, that the similarity is due in part to compensating errors. Actually, there was complete agreement between the originally coded four-digit cause of death and the four-digit cause coded on the autopsy certificate for only 865, or 45.8 percent, of the deaths. There was agreement for 52.2 percent of the deaths in terms of three-digit codes as used in the International List and for 71.0 percent in terms of the 30 broad cause groups shown in table 2. Thus, slightly more than one-fourth of the deaths were certified in such a way as to be

Table 3. Distribution of deaths by age and sex, upstate New York, 1951, and study group

Age in years	Total number deaths		Males				Females			
			Number deaths		Percent of total		Number deaths		Percent of total	
	Upstate	Study	Upstate	Study	Upstate	Study	Upstate	Study	Upstate	Study
Total	75, 632	1, 889	41, 373	1, 250	54. 7	66. 3	34, 259	639	45. 3	33. 7
Under 1	3, 725	223	2, 152	122	2. 8	6. 5	1, 573	101	2. 1	5. 3
1–14	1, 190	72	702	38	. 9	2. 0	488	34	. 6	1. 8
15–24	898	47	624	35	. 8	11. 9	274	12	. 4	. 6
25–34	1, 460	72	834	42	1. 1	2. 2	626	30	. 8	1. 6
35–44	3, 083	130	1, 783	83	2. 4	4. 4	1, 300	47	1. 7	2. 5
45–54	6, 964	313	4, 287	226	5. 7	12. 0	2, 677	87	3. 5	4. 6
55–64	13, 556	422	8, 449	304	11. 2	16. 1	5, 107	118	6. 8	6. 2
65–74	19, 082	382	10, 777	254	14. 2	13. 4	8, 305	128	11. 0	6. 8
75–84	18, 179	194	8, 702	124	11. 5	6. 6	9, 477	70	12. 5	3. 7
85 and over	7, 495	34	3, 063	22	4. 1	1. 2	4, 432	12	5. 9	. 6

classified in a different major group, but compensating errors did decrease these differences, as shown in table 1.

The deaths allocated to pneumonia are a good example of the compensating effect of the differences in allocating causes of death on the two groups of certificates. According to the original certificate, there were 57 deaths from pneumonia among the 1,889 studied. There were also 57 deaths attributed to pneumonia on the autopsy certificates, but only 25 of these 57 were the same ones. In other words, less than one-half of the deaths attributed to pneumonia were actually due to pneumonia according to the autopsy report, but other errors completely compensated for this error.

Characteristics of Study Group

As previously mentioned, the deaths included in this study are not a representative sample of all deaths in upstate New York, nor are the hospitals in which they occurred a representative sample of all hospitals.

Table 3 shows the differences in the age and sex composition of the study group and of all deaths in upstate New York in 1951. There is a lower proportion of deaths in the study group at ages 65 years and over for males and at ages 55 years and over for females. Table 4 shows some marked differences in the distribution of deaths by cause for the study group and for all deaths. These differences undoubtedly occurred because deaths from certain causes are selectively autopsied. The great underrepresentation of deaths due to heart disease in the study group indicates that the conclusion regarding the inaccuracy of reporting of death due to this cause is conservative. One might expect that the differences between the stated and "true" cause of death among nonhospital heart disease deaths would be greater than among the study group since physicians attending persons dying at home from heart disease may have seen their patients only in the terminal stages and may not have had access to the diagnostic facilities of a modern hospital.

Tables 5 and 6 show the proportion of the deaths in upstate New York in 1952 that occurred in a hospital and the proportion that came to autopsy. The percentage of the deaths from such conditions as cancer, tuberculosis, acute nephritis, and diseases of the digestive system occurring in hospitals is much higher than the percentage of deaths from such a cause as heart disease. Of all causes of death, cancer, tuberculosis, pneumonia, diseases of the digestive system, accidents, and some of the diseases of infancy stand out as those selectively brought to autopsy. On the other hand, several extremely significant causes of death, such as arteriosclerotic heart disease, diabetes, and vascular lesions affecting the central nervous system, are decidedly underrepresented among the autopsied deaths. This latter group of disorders is frequently difficult to diagnose and is often found in association with many other degenerative processes. That the cause-of-death data in the degenerative diseases lack a firm basis is futher substantiated by the data in tables 7 and 8. At the older ages when these diseases are particularly prevalent, the proportion of all deaths autopsied is especially low.

Discussion

Inaccuracies in cause-of-death data may occur because:

1. The physician does not list the available material correctly on the death certificate.
2. The clinical and laboratory data available before an autopsy is performed are not sufficient to enable the physician to determine the cause of death correctly.
3. In some cases where all information, including the autopsy data, is available, it is still difficult to decide on one underlying cause of death.

The present study did not seek to assess numerically the factor of the physician's ability to record information correctly on the original certificate, although this factor was considered in the analysis of the cause of death among the 98 consecutive autopsies performed in a medical school teaching hospital with excellent attending physicians, house staff, consultants, and laboratory facilities. Using ante-mortem data of unusually high quality, the resulting diagnosis of cause of death on the so-called clinical certificate was quite similar to

Table 4. Distribution of deaths by cause, upstate New York, 1951, and study group according to original certificate

Cause of death[1]	Study group		Upstate New York	
	Number	Percent	Number	Percent
Total	1, 889	100. 00	75, 632	100. 00
Tuberculosis (001–019)	48	2. 54	1, 140	1. 51
Syphilis (020–029)	12	. 64	221	. 29
Other infective and parasitic diseases (040–138)	28	1. 48	243	. 32
Malignant neoplasms (140–205)	402	21. 28	12, 047	15. 93
Other neoplasms (210–239)	15	. 79	225	. 34
Diabetes mellitus (260)	36	1. 91	1, 400	1. 85
Vascular lesions affecting central nervous system (330–334)	131	6. 93	8, 034	10. 62
Various diseases of sense organs (340–399)	21	1. 11	670	. 89
Rheumatic fever (400–402)	5	. 26	87	. 11
Chronic rheumatic heart disease (410–416)	41	2. 17	1, 071	1. 42
Arteriosclerotic heart disease (420)	276	14. 61	21, 916	28. 97
Chronic endocarditis (421, 422)	23	1. 22	4, 875	6. 44
Other diseases of heart (430–434)	10	. 53	633	. 84
Hypertension with heart disease (440–443)	41	2. 17	3, 729	4. 93
Hypertension (444–447)	29	1. 54	638	. 84
General arteriosclerosis (450)	17	. 90	1, 987	2. 63
Other diseases of arteries (451–456)	18	. 95	270	. 36
Other diseases of circulatory system (460–468)	8	. 42	139	. 18
Chronic and unspecified nephritis (592–594)	23	1. 22	959	1. 27
Acute nephritis and nephrosis (590, 591)	6	. 32	95	. 13
Pneumonia, except pneumonia of newborn (490–493)	57	3. 02	1, 534	2. 03
Other respiratory diseases (470–527, excluding 490–493)	33	1. 75	868	1. 15
Diseases of digestive system (530–587)	171	9. 05	2, 785	3. 68
Hyperplasia of prostate (610)	12	. 64	291	. 38
Congenital malformations (750–759)	62	3. 28	927	1. 23
Certain diseases of early infancy (760–776)	121	6. 41	2, 371	3. 13
Senility and ill-defined causes (780–795)	6	. 32	241	. 32
Accidents, poisonings, and violence (E800–E962)	156	8. 26	3, 929	5. 19
Suicide, homicide, etc. (E963–E999)	14	. 74	872	1. 15
All others (241–252, 261–289, 290–299, 300–326, 600–609, 611–749)	67	3. 54	1, 405	1. 87

[1] Numbers in parentheses are category numbers of the sixth revision of the International Lists of Diseases and Causes of Death.

that made by the physician on the original certificate. Nevertheless, there existed a large difference between either the clinical or original and the autopsy certificate. This study emphasized the source of inaccuracy listed as number 2, that is, the lack of sufficient information to determine the "true" cause of death.

It is not possible to compare the results of this study directly with those of the studies by Swartout and Webster or by Korns and Lintz. In both of those studies, cause data were categorized according to the fifth revision of the International List and the Manual for Joint Causes, whereas in this study the underlying cause specified according to the sixth revision of the International List by the person completing the death certificate was accepted by the vital statistics coding unit. Nevertheless, the results are generally similar in that they demonstrate an appreciable degree of inaccuracy in general cause-of-death data.

Epidemiological studies based upon mortality data gleaned from death certificates present elaborate analyses, by age, sex, and other factors, while accepting with little question the accuracy of the basic record itself. Concern over accuracy of the specific measurement of cause of death should precede the question of the association of these causes with certain characteristics of the general population.

The present study points out a paradox: Although a large number of death certificates give an inaccurate cause of death, this error does not necessarily exert a great influence on the overall cause-of-death statistics. Approximately the same number of deaths from cancer, for example, are reported to be due to heart disease as there are heart disease deaths which are at-

tributed to cancer. This observation, however, is made for autopsied deaths among hospitalized patients, and the same compensating effect of the errors may not be found for other deaths. Within certain cause-of-death classifications, the assignment by the physician of the underlying cause of death seems to behave like a statistically random process. Even if this group of deaths were a representative sample of all deaths in New York State, the autopsy results would change the cause-specific death rates significantly in only a few of the categories; namely, syphilis, diabetes, hypertension with heart disease, generalized arteriosclerosis, and hypertension.

Although such a compensating mechanism may give us more confidence in the overall mortality statistics, it raises serious doubts about

Table 5. Hospital and autopsied deaths among males, by cause, upstate New York, 1952

Cause of death [1]	Total		Hospital deaths			Hospital autopsied deaths		
	Number deaths	Percent	Number deaths	Percent of total deaths	Percent of total hospital deaths	Number deaths	Percent of total deaths	Percent of total hospital autopsied deaths
Total	43, 352	100. 0	25, 206	58. 1	100. 0	7, 049	16. 2	100. 1
Tuberculosis (001–019)	769	1. 8	673	87. 5	2. 7	293	38. 1	4. 2
Syphilis (020–029)	161	. 4	137	85. 1	. 5	42	26. 1	. 6
Malignant neoplasms (140–205)	6, 270	14. 5	3, 932	62. 7	15. 6	1, 293	20. 6	18. 3
Diabetes mellitus (260)	521	1. 2	309	59. 3	1. 2	49	9. 4	. 7
Rheumatic fever (400–402)	31	. 1	26	83. 9	. 1	15	48. 4	. 2
Vascular lesions affecting central nervous system (330–334)	3, 704	8. 5	2, 333	63. 0	9. 3	329	8. 9	4. 7
Chronic rheumatic heart disease (410–416)	512	1. 2	322	62. 9	1. 3	117	22. 8	1. 7
Arteriosclerotic heart disease (420)	14, 761	34. 1	6, 605	44. 7	26. 2	1, 318	8. 9	18. 7
Chronic endocarditis (421, 422)	2, 174	5. 0	1, 151	52. 9	4. 6	100	4. 6	1. 4
Other diseases of heart (430–434)	329	. 8	166	50. 4	. 7	47	14. 3	. 7
Hypertension with heart disease (440–443)	1, 596	3. 7	1, 062	66. 5	4. 2	187	11. 7	2. 7
Hypertension (444–447)	295	. 7	174	59. 0	. 7	36	12. 2	. 5
General arteriosclerosis (450)	873	2. 0	548	62. 8	2. 2	81	9. 3	1. 2
Other diseases of arteries (451–456)	184	. 4	130	70. 6	. 5	76	41. 3	1. 1
Other diseases of circulatory system (460–468)	87	. 2	60	69. 0	. 2	33	37. 9	. 5
Chronic and unspecified nephritis (592–594)	452	1. 0	297	65. 7	1. 2	54	11. 9	. 8
Acute nephritis and nephrosis (590, 591)	62	. 1	47	75. 8	. 2	21	33. 9	. 3
Pneumonia, except pneumonia of newborn (490–493)	944	2. 2	726	76. 9	2. 9	291	30. 8	4. 1
Diseases of digestive system (530–587)	1, 841	4. 2	1, 588	86. 2	6. 3	673	36. 6	9. 5
Hyperplasia of prostate (610)	263	. 6	218	82. 9	. 8	53	20. 2	. 8
Congenital malformations (750–759)	501	1. 2	445	88. 8	1. 8	240	47. 9	3. 4
Certain diseases of early infancy (760–776)	1, 447	3. 3	1, 415	97. 8	5. 6	463	32. 0	6. 7
Senility and ill-defined causes (780–795)	119	. 3	37	31. 1	. 1	9	7. 6	. 1
Accidents, poisonings, and violence (E800–E962)	2, 682	6. 2	1, 255	46. 8	5. 0	574	21. 4	8. 1
Suicide, homicide, etc. (E963–E999)	714	1. 6	141	19. 7	. 6	79	11. 1	1. 1
Other infective and parasitic diseases (030–139)	195	. 4	164	84. 1	. 6	80	41. 0	1. 1
Neoplasms (210–239)	106	. 2	78	73. 6	. 3	37	34. 9	. 5
Various diseases of sense organs (335–398)	367	. 8	239	65. 1	. 9	95	25. 9	1. 3
Influenza and bronchitis (480–483, 500–502)	153	. 4	77	50. 3	. 3	31	20. 3	. 4
All others	1, 239	2. 9	851	68. 7	3. 4	333	26. 9	4. 7

[1] Numbers in parentheses are category numbers of the sixth revision of the International Lists of Diseases and Causes of Death.

the use of present death-certificate data for research purposes, particularly in the field of chronic degenerative diseases. Epidemiological studies of deaths from heart disease, for example, based on such artifacts must be reexamined to determine whether there are significant biases in the way the errors are associated with the factors under investigation. Material to be used for such studies must first be refined, especially since the deaths from heart disease are so underrepresented among autopsied deaths.

Suggestions for Improvement

This study, as well as others cited, indicates a need for the consideration of procedures that will improve the accuracy and, consequently,

Table 6. Hospital and autopsied deaths among females, by cause, upstate New York, 1952

Cause of death [1]	Total		Hospital deaths			Hospital autopsied deaths		
	Number deaths	Percent	Number deaths	Percent of total deaths	Percent of total hospital deaths	Number deaths	Percent of total deaths	Percent of total hospital autopsied deaths
Total	36, 198	100. 1	21, 647	59. 8	99. 9	4, 174	11. 5	99. 6
Tuberculosis (001–019)	269	. 7	229	85. 1	1. 1	74	27. 5	1. 8
Syphilis (020–029)	68	. 2	54	79. 4	. 2	12	17. 6	. 3
Malignant neoplasms (140–205)	5, 991	16. 6	3, 532	59. 0	16. 3	781	13. 0	18. 7
Diabetes mellitus (260)	955	2. 6	613	64. 2	2. 8	83	8. 7	2. 0
Rheumatic fever (400–402)	31	. 1	25	80. 6	. 1	13	41. 9	. 3
Vascular lesions affecting central nervous system (330–334)	4, 770	13. 2	2, 787	58. 4	12. 9	269	5. 6	6. 4
Chronic rheumatic heart disease (410–416)	575	1. 6	355	61. 7	1. 6	123	21. 4	2. 9
Arteriosclerotic heart disease (420)	10, 116	28. 0	5, 386	53. 2	24. 9	651	6. 4	15. 6
Chronic endocarditis (421, 422)	2, 234	6. 2	1, 093	48. 9	5. 0	56	2. 5	1. 3
Other diseases of heart (430–434)	262	. 7	125	47. 7	. 6	22	8. 4	. 5
Hypertension with heart disease (440–443)	2, 195	6. 1	1, 344	61. 2	6. 2	184	8. 4	4. 4
Hypertension (444–447)	301	. 8	161	53. 5	. 7	29	9. 6	. 7
General arteriosclerosis (450)	1, 073	3. 0	576	53. 7	2. 7	60	5. 6	1. 4
Other diseases of arteries (451–456)	87	. 2	63	72. 4	. 3	37	42. 5	. 9
Other diseases of circulatory system (460–468)	71	. 2	43	60. 6	. 2	21	29. 6	. 5
Chronic and unspecified nephritis (592–594)	426	1. 2	242	56. 8	1. 1	39	9. 2	. 9
Acute nephritis and nephrosis (590, 591)	48	. 1	41	85. 4	. 2	10	20. 8	. 2
Pneumonia, except pneumonia of newborn (490–493)	705	1. 9	506	71. 8	2. 3	149	21. 1	3. 6
Diseases of digestive system (530–587)	1, 239	3. 4	1, 029	83. 0	4. 8	386	31. 2	9. 2
Hyperplasia of prostate (610)	0	0	0	0	0	0	0	0
Congenital malformations (750–759)	428	1. 2	359	83. 9	1. 7	186	43. 4	4. 5
Certain diseases of early infancy (760–776)	982	2. 7	954	97. 1	4. 4	292	29. 7	7. 0
Senility and ill-defined causes (780–795)	105	. 3	39	37. 1	. 2	10	9. 5	. 2
Accidents, poisonings, and violence (E800–E962)	1, 362	3. 8	866	63. 6	4. 0	214	15. 7	5. 1
Suicide, homicide, etc. (E963–E999)	233	. 6	49	21. 0	. 2	31	13. 3	. 7
Other infective and parasitic (030–139)	142	. 4	120	84. 5	. 6	60	42. 2	1. 4
Neoplasms (206–239)	127	. 4	97	76. 4	. 4	46	36. 2	1. 1
Various diseases of sense organs (335–398)	329	. 9	220	66. 9	1. 0	56	17. 0	1. 3
Influenza and bronchitis (480–483, 500–502)	127	. 4	69	54. 3	. 3	25	19. 7	. 6
All others	947	2. 6	670	70. 7	3. 1	255	26. 9	6. 1

[1] Numbers in parentheses are category numbers of the sixth revision of the International Lists of Diseases and Causes of Death.

the usefulness of cause-of-death data. Presented here are a few suggestions that, it is hoped, local health departments may wish to develop further through demonstration projects. The suggestions apply particularly to collection of data which are to be used for epidemiological studies of the degenerative diseases. Emphasized are steps that might be taken to prevent some of the inaccuracies resulting from the absence of post-mortem data at the time the death certificate is filled out, but attention is also given to the improvement of accuracy through correct recording of available data and to the problem of multiple causes of death.

Obtaining Post-Mortem Data.

One possible method of correcting inaccurate cause-of-death statements would be for the pathologist to send a copy of each autopsy summary to the local health department. This practice might be of help in resolving many of the questions posed by the present medical certifications, and it should reduce the number of certificates requiring queries to the attending physician. Many deaths, of course, do not go to autopsy, but the provision of an autopsy summary for those that do should increase the body of trustworthy data.

Another possible approach would be the revamping of procedures for correcting medical certifications of the cause of death after the certificate has been filed. Some States, with legal considerations in mind, have made it difficult to make changes in the cause-of-death statement, often requiring the physician to submit special legal forms. As a first step, arrangements might be made for public health administrators to obtain changes, even if the "legal" certification of death remains the same. Physicians and hospital record rooms could be encouraged to submit supplemental unofficial data on deceased patients when such information effects a significant change in the cause of death already recorded. At least one registration area (New York City) is now employing a certificate form in which the medical portion of the record is filed separately from the "legal" portion.

Some improvement in accuracy of medical certification of cause of death can probably be made by increased efforts to educate physicians to evaluate the various pathological factors properly and to communicate their decisions accurately by means of uniform disease terms, as well as to complete the certificate accurately. Local health agencies should renew their interest in these problems. By maintaining alert, medically oriented querying programs, they can insure that physicians correct and adjust the causes of death. The daily sheaf of death certificates passing through the local health

Table 7. Hospital and autopsied deaths among males, by age, upstate New York, 1952

Age in years	Total number deaths	Hospital deaths		Hospital autopsied deaths	
		Number	Percent of total	Number	Percent of total
Total	43, 352	25, 206	58. 1	7, 049	16. 2
Under 1	2, 293	2, 033	88. 7	801	34. 9
1–14	718	404	56. 3	209	29. 1
15–24	585	290	49. 6	134	22. 9
25–34	919	518	56. 4	247	26. 9
35–44	1, 820	1, 021	56. 1	434	23. 8
45–54	4, 379	2, 400	54. 8	872	19. 9
55–64	8, 964	5, 125	57. 2	1, 722	19. 2
65–74	11, 275	6, 333	56. 2	1, 544	13. 7
75–84	9, 265	5, 329	57. 5	899	9. 7
85 and over	3, 134	1, 743	55. 6	187	6. 0

Table 8. Hospital and autopsied deaths among females, by age, upstate New York, 1952

Age in years	Total number deaths	Hospital deaths		Hospital autopsied deaths	
		Number	Percent of total	Number	Percent of total
Total	36, 198	21, 647	59. 8	4, 174	11. 5
Under 1	1, 611	1, 421	88. 2	520	32. 3
1–14	539	366	67. 9	175	32. 5
15–24	264	163	61. 7	71	26. 9
25–34	645	460	71. 3	207	32. 1
35–44	1, 229	801	65. 2	274	22. 3
45–54	2, 607	1, 655	63. 5	447	17. 1
55–64	5, 256	3, 162	60. 2	696	13. 2
65–74	9, 081	5, 357	59. 0	914	10. 1
75–84	10, 182	5, 736	56. 3	684	6. 7
85 and over	4, 784	2, 524	52. 8	186	3. 9

unit should be examined by a person with medical training, one who can select those requiring followup. In addition, arrangements might be made for the health agency to receive routine reports or periodic samplings of postmortem examinations as a guide in taking steps to correct inaccurate cause-of-death data in those records forming a basis for the agency's programs.

The Problem of Multiple Causes

The present study suggests also the need for changes in the methods of collecting and analyzing mortality data if such data are to be used for epidemiological studies of chronic disease. Even among the patients dying from these chronic diseases who are autopsied, the problem of sorting out a single underlying cause is not simple. In many of these cases, several degenerative processes have been at work, and it is sometimes difficult to attribute death to a single underlying cause. With the present aging of the population and the decrease of communicable disease fatalities, the problem of multiple degenerative processes is increasing proportionately so as to overshadow all of the excellent steps taken so far to improve cause-of-death reporting. This situation is responsible for the third type of inaccuracy in cause-of-death data mentioned above.

If present trends continue, an ever-increasing number of deaths will be attributable to any of several combinations of diabetes, hypertension, pulmonary fibrosis, atherosclerosis, heart disease, obesity, cirrhosis, senility, nephritis, and cerebral hemorrhage. The exact one of these recorded as the primary cause will often be largely a matter of the physicians' opinions of the sequence of the processes. Even pathologists observing end results with all available clinical data at hand can hardly be expected to be consistent and infallible in arranging disease patterns so as to select the underlying cause. Moreover, even if the "true" cause of death were, for example, cerebral hemorrhage, perhaps the only public health control measure available to postpone its occurrence would be an attack against an accompanying hypertension, diabetes, obesity, or nephritis. Public health recognizes that chronic diseases seem more often due to diffuse multiple causes than to specific ones. The weakest link in the chain of disease, the best potential point for attack, may reside in an attribute rarely or inadequately counted among the pathological conditions associated with fatal illness. Moreover, the present reporting system prevents us from being able to study the total prevalence of certain serious conditions at time of death. An awareness of these facts may be partly the reason for the current emphasis on morbidity instead of mortality surveys in a search for epidemiological factors in chronic disease.

For these reasons, physicians and pathologists might record not only the underlying cause of death on the death certificate, but whatever data are available on the type and duration of each pathological or pathophysiological condition present. A real challenge awaits specific local health units who wish to explore this possibility on a pilot basis. Preliminary studies based upon multiple cause analysis of routinely submitted certificates are interesting. Sagen and Vinyard (*5*) report that in all diseases except tuberculosis, malignant neoplasms, other diseases of the heart, and accidents, at least 50 percent of the death certificates they reviewed indicate a multiple cause. The diabetes group had the largest proportion, 87 percent, with multiple causes. Such data, however, are not as meaningful as they would be had the reporting physician been instructed to list all pathology which was present, since under current practice it is common to omit listing some conditions in completing a death certificate. The available space for the medical certification is too limited to permit the inclusion of all the many pathological processes which may be involved, a fact which suggests that the certificate might be redesigned or supplemented for special studies in selected areas. Thought might be given to including on the reverse of such death certificates a checklist of the medical conditions which are important to modern public health practice.

Summary

1. Autopsy protocols for 1,889 consecutive deaths occurring during 1951 and 1952 in 12 hospitals in the area of Albany, N. Y., were reviewed, and new death certificates were prepared from the autopsy information. These

certificates were coded and compared with the original certificates on file in the New York State Department of Health.

2. When causes of death given on the original certificates were matched with the "true" cause as determined at autopsy, the errors in the original certificates were often found to be compensating. Despite such a compensating effect, the extent of the error in a large number of specific cases raises serious doubts as to the validity of the use of cause-of-death data as a basis for epidemiological studies of degenerative diseases.

3. Certain of the degenerative diseases which figure importantly as causes of death, such as arteriosclerotic heart disease, diabetes, and vascular diseases of the central nervous system, are decidedly underrepresented among the deaths autopsied. For these causes, the percentage agreement between the original death certificate and the autopsy certificate was 72.8, 30.6, and 59.5, respectively. The fact that a large number of such deaths do not occur in hospitals suggests that even greater errors exist in the present mortality data for these conditions.

4. Suggestions made for improving the accuracy of cause-of-death data include more querying of physicians, submission of autopsy summaries to local health departments, encouraging physicians to report additional data after the death certificate has been filed, redesign of the death certificate, and analysis of multiple causes of death after physicians have been instructed to report all of the pathological conditions present at time of death.

5. Programs for improving the accuracy of cause-of-death data should be developed through local demonstration projects in order to improve the practicability and usefulness of the resulting data for epidemiological studies in the degenerative diseases.

ACKNOWLEDGMENT

The assistance of Harri Janssen, John P. Leonard, and John V. Skiff, junior public health interns in the New York State Department of Health, and of the staffs of the local health department and hospitals in the Albany region in carrying out this study is acknowledged.

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