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SOME DEMOGRAPHIC CHARACTERISTICS OF AN AUTOPSIED POPULATION*

WILLIAM G. BEADENKOPF, M.D.†, ADELE K. POLAN, M.A.‡, RENÉE U. MARKS, Ph.D.§ and LOUISE M. TORNATORE, M.A.||

The Bureau of Heart Disease, New York State Department of Health, Albany Medical College, and the University of Michigan, U.S.A.

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THE demographic characteristics of that special type of population that is made up of individuals who died in a hospital and were autopsied are necessarily of great interest to the many investigators whose studies employ postmortem data. Examination of certain of the characteristics of a series of autopsied individuals may aid the pathologist in determining the extent to which he may, with a reasonable degree of firmness, make generalizations beyond his immediate postmortem observations. Research utilizing autopsy data has proven itself to be of great importance, particularly when the condition investigated has crucial aspects that are detectable only at autopsy.

When an institution is conducting investigations based upon autopsy findings, in general it would seem desirable, at regular intervals, to analyze available records regarding the demographic characteristics of those patients who come to autopsy. Only limited efforts, however, have been made either in this direction or in attempting to reach an understanding of autopsied populations generally. Almost 40 years ago, PEARL and BACON described the age, sex, and racial distribution of patients autopsied at Johns Hopkins Hospital during the preceding 35 years. Those autopsied were compared with the living population of Baltimore, Maryland, and with all deaths in Maryland. These comparisons amply demonstrated "the special nature and mode of formation" of the autopsied population [1]. More recently, MCMAHAN analyzed national mortality data in an effort to describe both the nature of the data as to whether an autopsy was or was not performed, and also selected demographic characteristics of those individuals reported as having been autopsied. He found that autopsy status was not reported on almost 20 per cent of the death certificates for whites and almost 30 per cent of those for nonwhites. Because of this lack of information, he concluded that death certificate evidence regarding the characteristics of individuals autopsied in the United States was "not sufficient to justify even tentative conclusions," though the data did "lend statistical support" to several hypotheses regarding selection by sex, race, and state of residence [2]. WALLACH and BORGATTA

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†New York State Department of Health and the Albany Medical College.
‡New York State Department of Health.
§University of Michigan.
||Albany Medical College.

analyzed mortality data from New York City to determine the likelihood of autopsy according to each of the following characteristics: sex, race, age, type of cemetery (as an index of religious affiliation), income, marital status, and nativity. They concluded that selective factors were operating to a significant extent in the case of each of the variables studied [3].

Two of the studies referred to above were concerned with the demographic characteristics of broad populations of autopsied deaths. Within these populations, great variation would be anticipated among individual hospitals in the types of patients autopsied, stemming both from characteristics of the total patient clientele and from policies of the hospital with respect to seeking autopsy permission in case of death. The variation in demographic characteristics reported in these broad studies therefore provides only limited assistance to the investigator faced, at his own hospital, with the need to make a decision regarding the extent to which inferences drawn from findings arising from a series of autopsies will permit generalization.

The need to obtain information regarding similarities and differences between a specific autopsy series and deaths in the general population became strikingly apparent to the authors while conducting a study designed to investigate the relationship between certain epidemiological variables and coronary artery atherosclerosis as observed postmortem. A quantitative estimate had been made of the extent of preclinical levels of disease in the walls of the coronary arteries, as was described in an earlier report [4]. Relationships between level of disease and a number of variables such as age, sex, occupation, smoking, diet, and physical activity were then examined. These same variables, among others, however, might quite properly be suspected of differentiating the population of autopsied patients from deaths in the general population. It was not possible, therefore, to assess the significance of such relationships as were found, to the extent desired, without evidence regarding selection in the composition of the study population. These considerations led to the present attempt to investigate the consequences of selective factors as evidenced by differences in the distributions of certain demographic characteristics between the autopsied population under study and the general population of deaths from which it was drawn.

A more complete view would have been obtained had three population groups been compared, namely: (1) the autopsied, (2) the general population of deaths, and (3) the living population in which the deaths occurred. The present effort, however, was restricted to a comparison between the first two of these because this was the basic concern of the study and because practical considerations would not permit the addition of the third group. A number of studies made by demographers are available in which the latter two types of groups are compared.

Although the populations examined here are limited to deaths at one hospital and deaths in the county which this hospital serves, it is hoped that these results may indicate the need for giving special attention to the effects of selective factors on the composition of populations used in autopsy-based research. More specifically, it is hoped that these analyses may serve to illustrate a practicable means by which the extent of selection in a particular autopsy series may be gauged, and also may provide some clues as to the direction such selection is likely to take. Finally, perhaps, these findings may have some direct applicability to hospitals in areas with similar medical care, vital, and other demographic characteristics.

To these ends, then, a population of consecutively autopsied individuals at a large general hospital was examined in terms of the distribution of each of several demographic characteristics. The composition of the autopsied population was compared with that of all deaths at this same hospital and that of all deaths in the northeastern metropolitan county in which the hospital is located. The basic question was: In what ways does this autopsied population resemble the general population of deaths that occurred in the county? In view of the fact that hospitalization was a requirement for inclusion in the autopsied population and thereby served as an important factor in its selection, a similar question was asked regarding the resemblance of all deaths at this hospital to all deaths in the county. And, finally, the logically remaining question was asked: In what ways does the autopsied population resemble the total group of deaths at this hospital, the universe from which it was directly drawn?

MATERIALS AND METHODS

Three population groups provided the basis for the analyses presented here. These groups share two characteristics:

1. They consist only of deaths among individuals 15 years of age and older. This limitation was imposed because of the underlying interest of the parent study, referred to earlier, in manifest disease of the coronary arteries.
2. They include all deaths that occurred during one specific four-year period, 15th March 1955–14th March 1959.

The three populations are as follows:

1. All deaths recorded in Albany County, New York, a total of 12,930. The term 'recorded' refers to the fact that any death that took place in Albany County was included regardless of the usual residence of the decedent.
2. All deaths recorded at the Albany Medical Center Hospital, Albany, New York, a total of 2574. A small group of individuals who were dead on arrival at the hospital, 88 in number, were not included since they had not been admitted to the hospital in the usual sense. They were, of course, included in the first group, all deaths in the county.
3. All deaths recorded at the Albany Medical Center Hospital among patients who were autopsied, a total of 1586, excepting again those pronounced dead on arrival.

It should be noted that each of the two smaller groups described above was derived from the next larger group. Thus, the autopsied deaths were included in the total group of deaths that occurred at this hospital, and, in turn, all deaths at this hospital were included in the total group of deaths in the county.

Approximately 20 per cent of the deaths in Albany County occurred at the Albany Medical Center Hospital. The remaining 80 per cent were distributed among two smaller general hospitals, the Albany Veterans Administration Hospital, several small institutions including some nursing homes, and, finally, private residences and public places.

The demographic characteristics available for study were the following: sex, age, nativity, race, marital status, usual place of residence, religious preference, and cause of death.* The sources of information were: (1) death certificates in the Office of

*Data concerning occupation were not utilized in the study because of the imprecise and uncertain quality of hospital and death certificate information regarding this characteristic, particularly when pertaining to the elderly.

Vital Records of the New York State Department of Health, and (2) hospital records at the Albany Medical Center Hospital. Information regarding each of the variables under analysis was obtained from both sources and compared for agreement, with the exception of religious preference, which was available only in the hospital record, and the coded cause of death, for which the death certificate statement was employed. Although occasionally the two sources of data were not in accord as to one or another characteristic of a specific individual, the frequency of such discrepancies was not such as would have materially altered the results.

RESULTS

The number of deaths in each of the three populations under comparison is shown according to sex in Table 1. Percentages of all deaths in Albany County that occurred at Albany Medical Center Hospital, hereafter referred to as AMCH, and percentages of all deaths in the county that were autopsied at AMCH are also presented. Finally, autopsy rates at AMCH are shown, i.e., percentages of all deaths at AMCH that were autopsied.

TABLE 1. PERCENTAGE OF DEATHS IN ALBANY COUNTY*, THAT OCCURRED AT ALBANY MEDICAL CENTER HOSPITAL (AMCH) AND WERE AUTOPSIED AT AMCH, ACCORDING TO SEX

Sex	Total no. of deaths in Albany Co.*	Deaths at AMCH		Deaths autopsied at AMCH		
		No.	% of total	No.	% of total	% of AMCH deaths
Total	12,930	2574	19.9	1586	12.3	61.6
Male	7,543	1460	19.4	917	12.2	62.8
Female	5,387	1114	20.7	669	12.4	60.0

*All deaths recorded in Albany County, 1955–1959, among individuals aged 15 and older.

During the four-year study period, of the 12,930 deaths that took place in Albany County, one out of five occurred at AMCH (19.9 per cent) and one out of eight (12.3 per cent) was autopsied at AMCH. The proportions within each sex group were almost identical to these figures (19.4 per cent of the males died at AMCH, and 12.2 per cent were autopsied there; 20.7 per cent of the females died at AMCH, and 12.4 per cent were autopsied there). The number of deaths among males that occurred in the county exceeded the number among females in a ratio of 58: 42 (i.e., 7,543 males to 5,387 females). It follows then that the sex ratio in the total AMCH group (57: 43) and that in the AMCH autopsied group (58: 42) were approximately the same as the ratio found in the total group of deaths in the county.

The median age at death of males and females in each of the three groups under study is shown in Table 2. Among all deaths in the county, the median age of females (72.8) was appreciably higher than that of males (67.0). This age difference, however, was reflected in neither the population of deaths that occurred at AMCH nor the group autopsied at AMCH. In fact, surprisingly, the median age of males in each of these groups exceeded slightly that of females.

Age and sex were next examined in combination, as is presented in Table 3. Among males, the number of deaths in the county increased with increasing age through the

TABLE 2. MEDIAN AGE OF ALL DEATHS IN ALBANY COUNTY*, OF THOSE OCCURRING AT ALBANY MEDICAL CENTER HOSPITAL (AMCH), AND OF THOSE AUTOPSIED AT AMCH, ACCORDING TO SEX

Sex	Median age		
	Deaths in Albany Co.*	Deaths at AMCH	Deaths autopsied at AMCH
Total	69.3	65.2	63.2
Male	67.0	65.4	63.4
Female	72.8	64.8	62.8

*All deaths recorded in Albany County, 1955–59, among individuals aged 15 and older.

category of 65–74 years, but declined somewhat in the category of 75 years and over. Among females, the number of deaths in the county increased without exception in each succeeding age category. Men considerably outnumbered women in each of the age categories from 15 to 74 years, while women were in the majority in the oldest category, 75 years and over.

The proportion of deaths in the county that occurred at AMCH varied markedly by age within each sex group, as did the proportion autopsied at AMCH. These proportions tended to be largest in those age groups in which the total number of deaths

TABLE 3. PERCENTAGE OF DEATHS IN ALBANY COUNTY*, THAT OCCURRED AT ALBANY MEDICAL CENTER HOSPITAL (AMCH) AND WERE AUTOPSIED AT AMCH, ACCORDING TO SEX AND AGE

Sex and age in years	Total no. of deaths in Albany Co.*	AMCH deaths as % of total	Autopsies at AMCH	
			% of total deaths	% of AMCH deaths
Both sexes				
Total	12,930	19.9	12.3	61.6
15–34	313	40.3	32.3	80.2
35–44	536	28.5	21.1	73.9
45–54	1,334	31.6	21.9	69.2
55–64	2,696	21.3	13.0	60.9
65–74	3,731	19.5	11.5	59.0
75+	4,320	13.2	7.0	52.7
Males				
Total	7,543	19.4	12.2	62.8
15–34	226	29.6	23.9	80.6
35–44	348	21.6	16.1	74.7
45–54	894	26.5	18.1	68.4
55–64	1,849	18.2	12.0	65.8
65–74	2,279	19.0	11.3	59.6
75+	1,947	16.0	8.5	53.2
Females				
Total	5,387	20.7	12.4	60.1
15–34	87	67.8	54.0	79.6
35–44	188	41.5	30.3	73.1
45–54	440	42.0	29.5	70.3
55–64	847	28.2	15.2	54.0
65–74	1,452	20.2	11.8	58.2
75+	2,373	10.9	5.7	52.1

*All deaths recorded in Albany County, 1955–1959, among individuals aged 15 and older.

in the county was smallest. Thus individuals who died at younger ages were more likely to die at AMCH and also to be autopsied at AMCH. Particularly striking age differences were found among females. Of the 'younger' females who died in Albany County (those 15–34, 35–44, and 45–54 years of age) the proportions who died at AMCH (67.8, 41.5, and 42.0 per cent, respectively), were two to three times larger than the proportion of deaths in Albany County among females of all ages that occurred at AMCH (20.7 per cent). In addition, among these groups of younger females, the proportions autopsied at AMCH (54.0, 30.3, and 29.5 per cent) ranged from more than two to four times the proportion of all female deaths in the county autopsied at this institution (12.4 per cent). In the youngest group of males (15–34 years), the proportions of deaths and autopsies at AMCH (29.6 and 23.9 per cent) were very much smaller than those found among the youngest females. However, when the proportions of deaths and autopsies at AMCH among males in this youngest group were compared with those found in the oldest group (16.0 and 8.5 per cent), a similar tendency to that found among females was evident, i.e., for hospitalization and autopsy at AMCH to decrease with increasing age. In the oldest age categories, males and females differed to a lesser degree in the proportions of deaths that occurred at AMCH and that were autopsied at AMCH. Finally, among both males and females, with the single exception of females aged 65–74, the proportion of AMCH deaths autopsied (i.e., the autopsy rate) decreased regularly with increasing age, a factor which contributed substantially to the large differences found between the younger and the older groups in the proportion of deaths in the county autopsied at AMCH.

Subsequent tables indicate the extent to which the distributions of the remaining variables under analysis in the two AMCH populations are representative of deaths in the general population of Albany County. As in the analysis of age and sex, for each category of each variable there is shown the proportion of deaths in the county that appeared in each of the two AMCH populations. In addition, because of the large age and sex variation demonstrated (Table 3) adjusted percentages are given that were calculated on the basis of the age–sex distribution of all deaths in the county. The direct method of adjustment was employed.

TABLE 4. PERCENTAGE OF DEATHS AMONG WHITES IN ALBANY COUNTY*, THAT OCCURRED AT ALBANY MEDICAL CENTER HOSPITAL (AMCH) AND WERE AUTOPSIED AT AMCH, ACCORDING TO NATIVITY

Place of birth	Total no. of deaths in Albany Co.*	AMCH deaths as % of total		Autopsies at AMCH: % of total deaths		Autopsies at AMCH: % of AMCH deaths
		Crude	Adj.†	Crude	Adj.†	Crude
Total	12,593	19.5	19.7	11.9	12.1	61.2
Native-born	10,007	19.4	19.2	12.3	12.1	63.3
Foreign-born	2,498	19.8	22.2	10.4	12.4	52.4
Not stated	88	21.6	20.1	14.8	21.7	68.4

*All deaths recorded in Albany County, 1955–1959, among individuals aged 15 and older.
†Percentages are age–sex adjusted to the population of deaths recorded in Albany County by the direct method of adjustment.

The first of these analyses, presented in Table 4, is concerned with the nativity of whites in the three study populations.* The number who were native-born among deaths in the county as a whole was approximately four times the number foreign-born. When adjusted for age and sex, the percentage who died at AMCH of all foreign-born (22.2 per cent) exceeded somewhat the percentage of all native-born (19.2 per cent). On the other hand, the proportions autopsied of all native-born and of all foreign-born were almost the same (adjusted percentages: 12.1 and 12.4). The autopsy rates at AMCH of native- and foreign-born, therefore, differed considerably (63.3 per cent and 52.4 per cent).

A comparison between white and Negro deaths is shown in Table 5. Although the Negro group was relatively small in number (319 deaths in Albany County), it is worthy of note that a large difference was found between the proportions of Negroes and whites who died at AMCH. Considerably smaller proportions of whites died at AMCH and were autopsied there (adjusted percentages: deaths, 19.7; autopsies, 12.1) than of Negroes (adjusted percentages: deaths, 29.6; autopsies, 21.7). The large proportion of Negro deaths in the county autopsied at AMCH was in part the result of a high autopsy rate among Negroes who died at AMCH (73.6 per cent in contrast to a rate among whites of 61.0 per cent).

TABLE 5. PERCENTAGE OF DEATHS IN ALBANY COUNTY*, THAT OCCURRED AT ALBANY MEDICAL CENTER HOSPITAL (AMCH) AND WERE AUTOPSIED AT AMCH, ACCORDING TO RACE

Race	Total no. of deaths in Albany Co.*	AMCH deaths as % of total		Autopsies at AMCH		
				% of total deaths		% of AMCH deaths
		Crude	Adj.†	Crude	Adj.†	Crude
Total	12,930	19.9	—	12.3	—	61.6
White	12,593	19.5	19.7	11.9	12.1	61.0
Negro	319	34.5	29.6	25.4	21.7	73.6
All others	18	33.3	20.1	5.6	4.5	16.7

*All deaths recorded in Albany County, 1955–1959, among individuals aged 15 and older.
†Percentages are age-sex adjusted to the population of deaths recorded in Albany County by the direct method of adjustment.

The proportions of deaths in Albany County occurring and autopsied at AMCH according to marital status appear in Table 6. Almost one-half of the individuals who died in the county were married; approximately one-third, widowed; and one-sixth, single. In addition, there was a relatively small number (272) of divorced individuals. The ratio of males to females in the total group (58: 42, as noted earlier) was approximated in each of these marital status groupings except one, the widowed. Although this does not appear in Table 6, it may be of interest to point out that among a total of 4242 widowed, the male–female ratio was extremely unbalanced (36: 64).

A smaller proportion of deaths among single individuals occurred at AMCH (adjusted percentage, 16.9) than of deaths among the remaining three marital status

*The Vital Statistics section of the New York State Health Department does not code the nativity of Negroes.

TABLE 6. PERCENTAGE OF DEATHS IN ALBANY COUNTY*, THAT OCCURRED AT ALBANY MEDICAL CENTER HOSPITAL (AMCH) AND WERE AUTOPSIED AT AMCH, ACCORDING TO MARITAL STATUS

Marital status	Total no. of deaths in Albany Co.*	AMCH deaths as % of total		Autopsies at AMCH: % of total deaths		Autopsies at AMCH: % of AMCH deaths
		Crude	Adj.†	Crude	Adj.†	Crude
Total	12,930	19.9	—	12.3	—	61.6
Single	2,146	17.5	16.9	11.9	11.2	67.8
Married	6,191	23.4	21.5	14.1	12.4	60.3
Widowed	4,242	15.6	19.3	9.1	12.6	58.6
Divorced	272	24.6	25.9	18.4	20.6	74.6
Not stated	79	31.6	27.2	27.8	24.4	88.0

*All deaths recorded in Albany County, 1955–1959, among individuals aged 15 and older.
†Percentages are age–sex adjusted to the population of deaths recorded in Albany County by the direct method of adjustment.

groups. However, only a slightly smaller proportion of deaths among the single was autopsied at AMCH (adjusted percentage, 11.2) relative to other categories of marital status. Thus, necessarily, there was a high autopsy rate at AMCH in this group (67.8 per cent).

Among the married and widowed, the proportions who died at AMCH (adjusted percentages: 21.5 and 19.3) and were autopsied at AMCH (adjusted percentages: 12.4 and 12.6) were similar to those of all deaths occurring and autopsied at AMCH. The autopsy rate among the married (60.3 per cent) also was almost the same as that for all deaths, but the autopsy rate among the widowed (58.3 per cent) was slightly lower. The latter was, in fact, the lowest rate found in any of the several marital status groups. This was probably because the autopsy rates were not adjusted to control the effects of age and sex. In this connection it may be noted that the crude percentages of the widowed who died and were autopsied at AMCH were substantially smaller than the proportions of other marital status groups.

Finally, the divorced were found to be both hospitalized and autopsied at AMCH at markedly higher rates than were other marital status groups (adjusted percentages: 25.9 and 20.6). The autopsy rate at AMCH for this group was also high (74.6). It is evident, however, that the numbers on which these percentages are based were relatively small.

The population size of each decedent's usual place of residence was examined in order to obtain an indication as to the rural–urban distribution within each of the groups under study. Places within the State of New York were dichotomized according to population size: (1) fewer than 10,000 and (2) 10,000 or more inhabitants. Individuals were then classified accordingly, with the addition of a third category: residents of other states. The results appear in Table 7.

Among all individuals who died in Albany County, approximately two-thirds had resided in the group of larger places. A majority of these, of course, had resided in the city of Albany or another city in the metropolitan area. Only a small number, 243, were out-of-state residents. Although this is not shown in Table 7, it may be noted that there was a remarkable preponderance of males in the latter group (sex ratio 80: 20). Among individuals who had lived in rural areas or smaller cities, and

TABLE 7. PERCENTAGE OF DEATHS IN ALBANY COUNTY*, THAT OCCURRED AT ALBANY MEDICAL CENTER HOSPITAL (AMCH) AND WERE AUTOPSIED AT AMCH, ACCORDING TO SIZE OF PLACE OF RESIDENCE

Place of residence	Total no. of deaths in Albany Co.*	AMCH deaths as % of total		Autopsies at AMCH		
				% of total deaths		% of AMCH deaths
		Crude	Adj.†	Crude	Adj.†	Crude
Total	12,930	19.9	—	12.3	—	61.6
New York State:						
10,000 inhabitants	3,738	24.1	23.9	15.5	15.3	64.4
10,000 or more inhabitants	8,949	17.9	18.1	10.7	11.0	59.7
Outside New York State‡	243	27.2	27.2	18.9	17.1	69.7

*All deaths recorded in Albany County, 1955–1959, among individuals aged 15 and older.
†Percentages are age–sex adjusted to the population of deaths recorded in Albany County by the direct method of adjustment.
‡Includes 'Not stated'.

especially among those from out-of-state, larger proportions died at AMCH (adjusted percentages: 23.9 and 27.2) and were autopsied there (adjusted percentages: 15.3 and 17.1) than was the case among residents of places of 10,000 or more inhabitants (adjusted percentages: deaths, 18.1; autopsies, 11.0). The autopsy rates at AMCH for residents or rural areas and smaller cities (64.4 per cent) and for out-of-state residents (69.7 per cent) were also higher than the autopsy rate for residents of larger cities (59.7 per cent).

The religious preferences of all individuals who died at AMCH were compared with those of individuals autopsied there. The results appear in Table 8. Data with respect to the religion of those who died outside AMCH were not available since death certificates do not, as mentioned earlier, require this information. Therefore, the only comparisons possible were among autopsy rates at AMCH. To facilitate making these, adjusted autopsy rates were calculated based upon the age–sex distribution of all deaths at AMCH. It may be noted, however, that the adjustment made little or no difference to these percentages.

TABLE 8. PERCENTAGE OF DEATHS AT ALBANY MEDICAL CENTRE HOSPITAL (AMCH), ACCORDING TO RELIGIOUS PREFERENCE, THAT WERE AUTOPSIED

Religious preference	No. of AMCH deaths	No. of AMCH autopsies	Autopsies as % of AMCH deaths	
			Crude	Adj.*
Total	2574	1586	61.6	—
Major Protestant	1236	818	66.2	66.8
Catholic	962	564	58.6	58.1
Jewish	165	60	36.4	36.8
Other	32	23	71.9	70.0
None and not stated	179	121	67.6	68.7

*Percentages are age–sex adjusted to the population of deaths at AMCH, 1955–1959, among individuals aged 15 and older by the direct method of adjustment.

Approximately one-half of those who died at AMCH had stated a preference for one of the major Protestant denominations. The balance consisted largely of Catholics, but contained also a small number of Jews (165), individuals who had named some other religious group (32), and individuals for whom no preference was recorded (179).

Among those who had designated one of the three major religions, Protestants were found to have the highest autopsy rate (66.8 per cent); Catholics, a somewhat lower rate (58.1 per cent); and Jews, a markedly lower rate (36.8 per cent). It should be recalled, however, in comparing these rates, that the last group was fairly small in number. Interestingly, the highest autopsy rates occurred among those classified under 'Other preference' (70.0 per cent) and 'None and not stated' (68.7 per cent).

An analysis of cause of death, as coded on the death certificate, is presented in Table 9. As in earlier tables, three populations are once more under comparison. Approximately three-fifths of the deaths in the county were classified as having been caused by cardiovascular disease, one-fifth by cancer, and a small proportion, one-twentieth, by trauma. The remaining 15 per cent of the deaths were combined into one category, 'All other causes', for the purpose of this analysis. Three-fourths of the deaths from cardiovascular disease were attributed to heart disease specifically. Although the data are not included in Table 9, it is worthy of note that among all deaths in Albany County, the sex ratio within each causal category was comparable to the sex ratio in the total group, with the exception of the category of trauma in which there was a large preponderance of males (78: 22).

The proportion of deaths in the population of the county that appeared in each of the AMCH study groups varied considerably according to the cause of death. The proportion of deaths attributed to cancer that occurred at AMCH (adjusted percentage, 23.3) was larger than that for all deaths (19.9 per cent). However, since the autopsy rate at AMCH for cancer deaths was somewhat low (57.6 per cent), the pro-

TABLE 9. PERCENTAGE OF DEATHS IN ALBANY COUNTY*, THAT OCCURRED AT ALBANY MEDICAL CENTER HOSPITAL (AMCH) AND WERE AUTOPSIED AT AMCH, ACCORDING TO CAUSE OF DEATH

Cause of death	Total no. of deaths in Albany Co.*	AMCH deaths as % of total		Autopsies at AMCH		
				% of total deaths		% of AMCH deaths
		Crude	Adj.†	Crude	Adj.†	Crude
Total	12,930	19.9	—	12.3	—	61.6
Cancer	2,486	24.8	23.3	14.3	13.2	57.6
All cardiovascular disease	7,790	13.8	15.4	8.0	9.2	57.8
Heart	5,898	11.6	12.4	6.4	7.0	55.1
Vascular	1,298	19.3	23.7	11.2	14.3	58.2
Other	594	23.7	24.8	16.7	17.4	70.2
Trauma	577	30.5	32.9	21.7	22.2	71.0
All other causes	2,077	34.1	32.1	23.4	21.4	68.5

*All deaths recorded in Albany County, 1955–1959, among individuals aged 15 and older.
†Percentages are age-sex adjusted to the population of deaths recorded in Albany County by the direct method of adjustment.

portion of cancer deaths autopsied (adjusted percentage, 13.2) was similar to that for all deaths (12.3 per cent). The proportion of all deaths from cardiovascular disease that occurred at AMCH (adjusted percentage, 15.4) was smaller than that for any other causal category; and the proportion of deaths specifically attributed to heart disease was even smaller (adjusted percentage, 12.4). Similarly, relative to deaths from any other category of cause, the proportions of cardiovascular disease deaths in general and heart disease deaths specifically that were autopsied at AMCH were substantially smaller (adjusted percentages: 9.2 and 7.0). These proportions reflect both the lower rates of hospitalization noted above and the lower autopsy rates at AMCH for these disease categories (57.8 and 55.1).

Almost one-third of the deaths in Albany County attributed to trauma and to 'All other causes' occurred at AMCH (adjusted percentages: 32.9 and 32.1), and more than one-fifth of each of these groups was autopsied there (adjusted percentages: 22.2 and 21.4). High autopsy rates at AMCH for deaths in these categories contributed to the latter figures (trauma, 71.0 per cent; 'All other causes', 68.5 per cent). Thus, deaths in Albany County attributed to trauma and 'All other causes' were more than twice as likely as those from cardiovascular disease, and almost three times as likely as those from heart disease, both to occur and to be autopsied at AMCH.

DISCUSSION

As a limited step toward investigating the problem of selection in an autopsy series, a population of patients who died and were autopsied at one large general hospital in the course of a four-year period was examined with respect to the distribution of several demographic characteristics. Both differences and similarities were found when this population was compared with the population from which it was immediately derived, and with all deaths that occurred at this hospital, and also when both of these groups were compared with the population from which the latter, in turn, was drawn, all deaths that occurred in the county served by this hospital.

It may be profitable at this point to consider an autopsy series as a population which is selected in three stages—autopsy itself being the third and final stage. In the first, there is selection arising from all the factors, biological, social, and psychological, that are involved in the decision to enter a hospital and, more specifically, to enter the particular hospital from which a specific autopsy series is drawn. In the second stage, following hospital admission, the many complex pathological processes leading to death rather than to survival clearly operate selectively. Finally, a variety of factors play a part in determining whether an autopsy will in fact be sought, and whether the legally responsible relative of the deceased patient will be contacted and then will give his consent. Thus, at each of these stages—hospitalization, death, and autopsy—many types of factors intervene which affect the likelihood that a given individual will join a specific series of autopsied patients.

The selective factors involved at each of these stages will vary, of course, in their impact. The material presented here illustrates some of the results of the interplay of these factors at two of the stages though not the nature and operation of the factors *per se*. Selection at the stage of hospitalization was found to influence the composition of this autopsied population to a greater degree than selection at the stage of autopsy request. That is, the comparisons permitted by these data revealed, in most instances, greater differences between deaths in the general population and deaths at

the hospital under study than between deaths at this hospital and deaths which were autopsied there.

Perhaps the most striking difference found was in the age and sex distributions of the three populations. With respect to the autopsied population, a systematic decrease in the autopsy rate at the hospital (AMCH) with increasing age suggests a greater interest, both medical and familial, in the cause of death of patients who die when young, rather than when they are older. This trend (a decrease in the autopsy rate from 80 to 53 per cent) was slight, however, in comparison with the decrease with increasing age in the proportion of deaths in the population of Albany County that occurred at AMCH. In the youngest age group, this proportion was three times that in the oldest when both sexes were considered together; when females were considered separately, the proportions in the younger groups were four to six times that in the oldest.

These differences probably reflect such factors as the availability of insurance or other means to pay the costs of hospitalization, and belief on the part of the patient, his family, and his physician that hospitalization will be likely to aid in his recovery. The relative chronicity of illnesses of older persons together with the existence of nursing homes designed for long-term care are probably also related factors.

These findings with respect to age and sex are potent reminders of the need to devote special attention to these variables in studies employing postmortem data. This requirement, of course, is a familiar one in the analysis of biological data. The comparative demographic evidence presented here serves to emphasize this need, and indicates that these variables appear to be especially subject to the effects of selective factors that are social, in addition to those that are more strictly biological and traditionally have been of concern in medical research. The problem under consideration, as stated earlier, is the representativeness of an autopsy series *vis à vis* deaths in a general population. In the course of examining this question, however, it should not be forgotten that the great differences between a population of the dead and a population of the living in terms of such characteristics as age constitute equal if not even more important considerations for investigators who are working with postmortem data.

With respect to the remaining differences that were encountered, the majority require only enumeration. First, foreign-born individuals were somewhat more likely to be hospitalized at AMCH than those who were native-born, but, in comparison with the native-born hospitalized at AMCH, were considerably less likely to be autopsied. Second, Negroes and divorced individuals were more likely to be hospitalized and autopsied at AMCH than those in other categories of race and marital status. Each of these two groups, Negroes and the divorced, were relatively small in number, however. Third, residents of towns in New York State having less than 10,000 inhabitants and residents of other states who died in Albany County were more likely to be hospitalized and autopsied at AMCH than residents of towns of 10,000 or more in New York State. This, it is believed, was in part a result of the fact that residents of smaller towns in counties of New York neighboring Albany and adjacent states are frequently referred to AMCH for special work-up and care. In addition, it seems probable that people who become seriously ill while away from home, unless they are able to return there, are more likely to enter a hospital than those who become ill at home.

These findings may be of general interest to those concerned with the sociological and epidemiological aspects of hospitalization and autopsy. More specifically, they suggest that, in the design of a study which would employ autopsy data, it would be well to consider the types of biases that could result from selection according to race, marital status, urban or rural residence, and similar factors. In many instances, these variables could be controlled by special analyses, particularly when it is possible to ascertain their distribution in the general population.

The two remaining variables under examination deserve some special comment. The first to be discussed is religious preference, with particular reference to its relationship to autopsy, and the second, certified cause of death, in terms of selection in the process of hospitalization. As regards religious preference, it will be recalled that this variable could be examined only within the two AMCH populations, not in the population of the county. Since the treatment and disposition of the human body after death is an important aspect of the funeral rites of most cultures, including our own, and since these rites are usually prescribed by religion and involve supernatural sanctions, personal religious orientations may be rather directly related to attitudes regarding autopsy. Although autopsy is not now altogether proscribed by any of the three large religious bodies, Protestant, Catholic, or Jewish, it seems probable that members of certain of the more conservative or fundamentalist sub-groups of each would be likely to have personal misgivings regarding the secular intrusion on the body of the dead that an autopsy may represent.

The available data did not permit a search for such sub-groups, but it was possible to calculate autopsy rates at AMCH for each of the three major religions. The findings, however, are somewhat difficult to interpret. First, it will be recalled that members of major Protestant denominations had the highest autopsy rate of these three groups. This rate was almost 10 per cent higher than the rate among Catholics. Whether or not a similar difference would be likely to exist at other hospitals, however, is impossible to predict. Since there is a large Catholic general hospital in the City of Albany, it cannot be assumed without additional information that Catholic patients at AMCH are representative of Catholics hospitalized in the county as a whole. The nature of such differences as may exist between Catholic patients at the two institutions is not known, though it seems reasonable to expect there would be a tendency for the more devout to seek hospitalization at a Catholic institution. Whether such a tendency would, in turn, have produced an atypical rate among Catholics at AMCH, is, of course, unknown.

Among those designating a Jewish preference, the autopsy rate was only slightly more than one-half of the rate for the AMCH population as a whole. Although this group was relatively small in number, this large difference appears to deserve some explanation. Since Rabbinical comments scattered throughout Judaic history have viewed autopsy as a form of disrespect to the dead, it was expected that a low autopsy rate would be found among Jews. In the past, autopsy was not to be condoned except possibly in certain extreme instances when a postmortem examination could make possible the saving of another human life which was both at hand and in danger. In recent times, a broader interpretation of the temporal and spatial qualifications has been accepted by some groups and individuals, and the performance of autopsies to ascertain disease causation, therefore, has been more frequently sanctioned [5]. A literal interpretation of this injunction is still widely held, however, as is specified,

for example, in a manual of Jewish principles in hospital practice published by the Federation of Jewish Philanthropies of New York [6]. The Judaic requirement of prompt burial probably also negatively influences the decision regarding autopsy.

With regard to the remaining variable to be discussed, certified cause of death, large differences were found in comparisons among the three study populations. Therefore, a matter warranting special attention in considering selection in an autopsy series is the effect that the particular disease or condition under observation may have on the likelihood of hospitalization, death, and finally autopsy. Of great importance among the differences found was the fact that the proportions of all deaths in the county attributed to heart disease that occurred at AMCH and were autopsied there were substantially smaller than those of any other of the causal categories employed. Deaths that occurred too rapidly for hospitalization (i.e., the group often referred to as 'sudden deaths') would necessarily have constituted a part of the deaths in the general population, and these, in turn, undoubtedly included many individuals dying from heart disease. This would explain at least some portion of the difference. In addition, this finding may in part be the result of an overly liberal use of the term 'arteriosclerotic heart disease' in cases of individuals who died at home, and who, therefore, received a less extensive medical work-up than would have been possible in a modern teaching institution such as AMCH. Further, among the cause-of-death categories employed, that of heart disease displayed the lowest autopsy rate at AMCH. Since these were unadjusted figures, the lower rates that were found in the more advanced age categories in which heart disease is a common cause of death may help to account for this autopsy rate among deaths at AMCH. It should be recalled, however, that the age–sex adjusted percentage of heart disease deaths in the county autopsied at AMCH was lower than the percentages of other cause categories autopsied there. Similar findings regarding deaths attributed to arteriosclerotic heart disease have recently been found in studies in New York City by GEARING and associates. They report that individuals certified as having died from this disease were less likely to have died in a hospital and to be autopsied than were individuals whose deaths were attributed to other causes [7].

The very large proportion of deaths in the county from 'All other causes' that were found in the two AMCH populations are also worthy of special note.* These may have resulted from a more frequent detection at AMCH of those relatively rare conditions which require either more elaborate equipment than is presently available for home-attended patients or postmortem examination for their diagnosis. On the other hand, the explanation equally well may be that this excess of deaths from 'other causes' represents the end result of a chain of factors operating to select the more ill-defined or unusual cases of disease for autopsy—beginning with an increased likelihood of hospitalization and of a more extensive diagnostic work-up, and terminating with a greater probability of postmortem examination because of the special contribution necropsy findings may make to the understanding of an unfamiliar disease.

Insofar as crude comparisons will allow, the differences found here were similar in direction to those found by WALLACH and BORGATTA with respect to age, sex, nativity, race, marital status (except the divorced), and religion [3]; by MCMAHON

*It will be recalled that 'All other causes' included causes other than cancer, cardiovascular disease, and trauma.

according to sex, and race [2]; and, to some extent, by PEARL and BACON according to sex, age, and race [1].

Some general comments regarding autopsied populations and their use in research merit inclusion in this discussion. Since these data pertain to a limited geographic area, no assurance can be provided that inferences based upon this particular group of deaths may be extended to other populations, whether they consist of autopsied deaths, hospital deaths, or deaths in a general population. In addition, the variables examined were few in number, the analytic categories, gross, and the findings themselves, more suggestive than conclusive. However, one generalization which does appear proper is that neither of two extreme positions regarding autopsy-based research is justified: neither, first, that inferences can safely be extended beyond a specific autopsy series without a careful examination of potential sources of bias; nor, second, that the possibility of undetected bias requires that all conclusions be limited so strictly to the particular series under investigation that even tentative generalizations are improper. Instead, when a specific autopsy-based study is to be undertaken, it would appear reasonable to determine its relative merits according to two criteria: first, the likelihood that postmortem findings may permit a contribution to medical knowledge not otherwise obtainable, and, second, the degree to which it is possible either to control the effects of important covariables as, for example, age, sex, and race, or to establish that such covariables could have only negligible effects on the results.

Some aspects of the selection process are being studied by one of the authors (R.U.M.). The investigation is concerned with sociological and epidemiological variables that may be associated with the probability that a deceased hospital patient will come to autopsy. Included are variables relating to hospital procedures, the patient's clinical history, and a variety of other matters pertaining to the background and attitudes of both the deceased and the relative from whom permission for autopsy was requested.

BERKSON [8], MAINLAND [9] and CORNFIELD [10], have cogently described some of the circumstances under which fallacious conclusions may be derived from hospital- and autopsy-based data. Selective factors, they point out, may quite readily modify the composition of a study population in such a way as to produce, for example, a spurious association between two diseases when such an association is absent in the general population. MAINLAND continues his discussion with an outline of the many types of interacting factors that may cause bias, and concludes by suggesting some methods to avoid it, including the alternative of "prolonged study of groups of living subjects in health and disease" [9].

The warnings of these writers are important and properly encourage caution in any hospital-based study. However as their discussions were largely limited to the hazards of such research, they did not discuss what is frequently the major reason for employing specifically postmortem findings in the study of a disease: namely, that lesions may be studied which are not detectable by clinical procedures. An important example of such lesions are those of coronary heart disease, of which only a relatively small proportion have manifestations that are at present clinically detectable, and these, usually, of the most severe variety. In such instances, unfortunately, the distribution of sub-clinical lesions in the general population must remain unknown.

When an investigator wishes to study disease manifestations that may only be examined postmortem by the pathologist, he is forced to accept the risks described by the above-named writers. MAINLAND states this obligation clearly: ". . . in each investigation the onus is on the investigator to try to prove that the dangers are negligible—to present evidence in favor of his assumptions, not merely to say that he sees no reason for doubting them" [9]. Thus, when an autopsy-based study appears likely to extend our knowledge of a specific disease, the most reasonable solution would seem to be to proceed with it, meanwhile, however, employing all possible means to avoid bias and exercising great caution in drawing conclusions.

For many characteristics (medical, demographic, or epidemiological), selection may not, in fact, be a formidable problem. Indentification of those characteristics of autopsied populations that appear most susceptible to selection, and measurement of the extent to which their distributions do or do not differ from those found in the general population of deaths are matters amenable to study. As CORNFIELD says in speaking of such special study populations as an autopsy series: "The generalizability of study findings to other populations cannot be taken for granted; it must be thought about and sometimes subjected to empirical investigation. On the other hand, if such generalization were never possible there would be no point to investigation" [10].

In addition to the problem of interpreting autopsy data in general, certain types of study designs present special problems which deserve mention. First, when a study is based upon autopsies carried out at more than one hospital, there is an added dimension of complexity. Although this matter is beyond the scope of the present analysis, it should at least be noted that many hospitals differ widely in their general policies and specialty interests, and that these differences tend to encourage the admission of patients selectively, for example, by age or by type of disease.

Moreover, there are considerable differences among hospitals in autopsy rates [11–15]. A relatively high autopsy rate, such as is maintained by AMCH [11–15], is presumably an indication that an attempt to obtain autopsy permission was consistently made in the case of all, or almost all, deaths and, further, that in some cases these efforts must have been appreciable. Conversely, when an autopsy rate is low, it is probably that the request for permission was not consistently made, but was omitted in some cases, not persistently pursued in others, and vigorously sought in yet a third group. Under these circumstances, institutional factors such as the special interests of attending physicians, the work load of the pathology department, and the relative frequency with which specific diseases were seen probably weigh at least as heavily in determining the composition of a particular autopsy series as factors relating to the characteristics of the patients served by the hospital .

In spite of such differences among institutions, however, many useful findings have been yielded by investigations in geographic pathology in which data from hospitals in widely separated areas and differing cultures have been compared. Especially rewarding have been the clues provided by research on groups in areas with characteristics warranting special study. For example, findings from studies in coronary heart disease which indicate the rarity of the disease in populations in Africa as compared with the United States [16, 17].

In order to avoid some of the problems of selection at the stage of hospitalization, particularly when cultures with widely differing hospitalization practices are being

compared, autopsy services could be made more widely available and one could seek data pertaining to all deaths within a defined cohort. This approach is being successfully employed in Japan among survivors of the Nagasaki and Hiroshima bombings where autopsies of most deaths are being obtained, whether they occur at home or at a hospital [18].

Autopsy findings from a long-term series, though limited to one hospital, are subject to problems similar to those of inter-institutional comparisons because of gradual changes within the institution and in the population served. Some of these were explored by MORRIS in a study of coronary artery pathology based upon autopsy records from a period of almost 50 years [19]. Such studies are beset by additional complications deriving from the vast changes that have occurred in recent decades in medical knowledge, in the interest in specific diseases taken by the medical profession, and in the actual prevalence of many diseases—factors which are almost impossible to disentangle. During the relatively brief period spanned by the present data, 1955–1959, no appreciable changes were apparent. Essentially the same results as those that have been presented for the entire 4-year period were obtained in special tabulations relating to the first two years of the study, 1955–1957.

One further source of selection, briefly alluded to earlier, deserves special mention. Differences in autopsy rates by department or service within a hospital can be such as to produce significant bias and, therefore, may require exploration when an autopsy-based study is to be undertaken. As a supplement to the analyses presented here, the proportion of adult deaths autopsied during a one-year period (1959) was determined for each department at AMCH. It was found that most of the departmental percentages were similar to the percentage for all deaths in AMCH. Although three departments were found to have substantially lower rates, together they accounted for only 5 per cent of all adult deaths. In general, it is likely that institutions with high autopsy rates will exhibit a minimum of interdepartmental variation, since a high rate will not be achieved without the consistent efforts of most of the staff. On the other hand, a relatively low rate would appear likely to be associated with differences in the degree of effort expended, not only by individual staff members, but also among departments. Finally, an extremely low rate is probably an indication that a hospital is lacking in the facilities and personnel to conduct a full-scale autopsy program, and, therefore, that the policy of the institution is to seek autopsy permission only in special cases, thus again minimizing inter-departmental variation.

In conclusion, it is hoped that these comparisons among several types of populations of deaths may prove helpful by indicating the need for critical analysis in studies employing postmortem data and by suggesting a procedure for accomplishing this. In addition, and perhaps of wider interest, certain demographic factors have been pointed out which appear to be related to the probability that an individual who has died will be autopsied. MAINLAND footnotes his discussion of autopsy data with the optimistic comment: "The last decade has witnessed the development of sound methods of therapeutic trial by statistical planning that were previously thought inapplicable in human medicine, and if the dangers of some of the current methods in pathology become fully appreciated it can be hoped that more valid methods will replace them" [9]. Hopefully, this study may contribute some impetus to current efforts to achieve these more valid methods.

SUMMARY

The ways in which a series of autopsied hospital patients may or may not differ from other hospital deaths and from deaths in the general population are necessarily of concern to investigators conducting studies based upon postmortem observations, as well as to those concerned with epidemiological and sociological aspects of hospitalization and autopsy. In an effort to investigate this problem, certain demographic characteristics of a population of adults autopsied during a 4-year period at a large general teaching hospital were examined. This population was compared with its parent population, all deaths that occurred at this hospital, and with the population from which the latter, in turn, was derived, all deaths in the northeastern metropolitan county served by this hospital. The variables analyzed were age, sex, nativity, race, marital status, size of residence, place, religious preference, and cause of death.

The composition of the autopsied population indicated that it had been significantly affected by various selective factors. Age exhibited perhaps the most striking effects: as age at death decreased, the likelihood increased that a person who died in this county had been hospitalized and autopsied at the institution under study. This trend was especially marked among females. Subsequent analyses were therefore adjusted to control the effects of age and sex.

Certified cause of death also was found to be highly subject to selective factors. In particular, the proportions of all deaths in the county from heart disease that occurred and were autopsied at this hospital were strikingly smaller than those of any other of the causal categories employed.

With respect to religion, there was suggestive evidence that deceased hospital patients who had indicated a Jewish preference were considerably less likely to be autopsied than those who had designated a Protestant group. Catholics appeared somewhat less likely to be autopsied than Protestants.

Other differences found were that the foreign-born were somewhat more likely to be hospitalized at this institution than the native-born, but less likely to be autopsied. Negroes, the divorced, and residents of other states and of places in the state with less than 10,000 inhabitants were more likely to be hospitalized and autopsied at this hospital than those in other categories of race, marital status, and place of residence.

In general, deaths at the hospital differed more from deaths in the general population than the autopsied deaths differed from all deaths at the hospital.

These findings indicate a few of the kinds of selection that may be found in the composition of autopsied and hospital death populations. They are interpreted as pointing up the need for giving special attention to the effects of selective factors on populations used in autopsy-based research. More specifically, it is hoped that these analyses may illustrate a practicable means by which the extent of selection in a particular autopsy series may be gauged. Usually it should be possible to examine the distributions of variables that may be relevant to a particular study, to compare these with what is known regarding their distributions in other populations, and to control, by special analyses, the effects of such variables as appear to require this with at least sufficient precision to permit extending tentative inferences beyond the immediate study material. Where a unique contribution can be provided by postmortem observations, their use appears justified in the study of many disease problems with the qualification that appropriate care be given to the exploration and control of potential sources of bias.

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