

## Mortality Experience among Anesthesiologists, 1954-1976

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To determine whether anesthesiologists, because of prolonged exposure to halothane or other inhalational anesthetics, might have higher death rates from all causes, from cancer, and from hepatic or renal disease than other physicians, the mortality rates of male and female members of the American Society of Anesthesiologists (ASA) for the period 1954 to 1976 were examined. Records of all physicians on ASA membership lists in 1954, 1959, 1967 and 1976 were obtained. All members, including life members, retired members and those who had stopped paying dues, were traced. Of the 637 deaths between 1954 and 1976 in male anesthesiologists, death certificates were obtained for 610. Mortality from all causes in those members who were accredited prior to 1960 was 84 per cent of the expected death rate of all physicians. Among male members of record in 1967, it was 93 per cent of the expected rate. There was no suggestion of an increased rate of cancer or hepatic or renal disease. There was a high suicide rate in members less than 55 years old. The overall mortality rate for the relatively small group ( $n = 66$ ) of female anesthesiologists was 75 to 85 per cent of that expected for all female physicians. (Key words: Cancer; Organizations, American Society of Anesthesiologists; Toxicity, trace concentrations.)

IN JUNE 1975, an ad hoc Committee of the American Society of Anesthesiologists (ASA) met with Dr. E. Cuyler Hammond, of the American Cancer Society, and Professor Irving J. Selikoff, of the Mt. Sinai School of Medicine, to consider the desirability of a mortality investigation among anesthesiologists. Dr. Hammond and Professor Selikoff asked me to explore the feasibility of such a study of the membership of the ASA. After visiting the ASA office and examining its records, I undertook to conduct an investigation, focusing on death rates from all causes, cancer, and hepatic and renal disease. The ASA reviewed and approved the design of the study, as well as the suggested procedures and approximate dates of the several stages of the investigation. The ASA furthermore appointed an advisory committee consisting of Drs. P. J. Cohen, N. M. Greene, and J. K. Wagoner to assist me.

### Materials and Methods

To determine whether members of the ASA who had been exposed to inhalational anesthetics for prolonged periods experienced higher mortality from all

causes, some forms of cancer, and some forms of hepatic and renal disease, two subgroups of anesthesiologists were followed separately. One group comprised those who were full members of the ASA in the fall of 1954, and the other group, those who became members between the years 1954 and 1959, inclusive. The former group was exposed to both halothane and anesthetics of similar structure and to the older generation of anesthetics. A supplementary study of mortality among anesthesiologists who were full members in 1967 was conducted as a check on the mortality experienced among those who had become full members in 1959 or prior years.

All of the subjects under study were followed to the end of 1976. To ensure a complete count of deaths among them, special efforts were made to trace those who had retired, those holding life memberships, and those who had stopped paying dues to the ASA. Because some of those who had stopped paying dues might have done so on account of poor health or even imminent death, deaths among all who had stopped paying dues were included in the investigation when they occurred within three years of last payment of dues.

Death certificates were obtained for 610 of 637 total deaths in the study. Where several causes of death were mentioned on the certificate, the available records were reviewed to determine whether lymphoma, myeloma or other rare forms of cancer, and hepatic or renal disease were involved as contributory causes. Use was also made of a searching study of the causes of death among anesthesiologists reported earlier by Dr. D. L. Bruce.<sup>1,2</sup> The actual deaths reported among members of the ASA were compared with the expected death rates among all physicians. The contemporaneous death rates among all physicians were estimated by interpolation from those calculated for 1949-1951 by Drs. Dickinson and Martin<sup>3</sup> and for 1969-1973 by Dr. Louis J. Goodman.<sup>4</sup>

The ASA files contained all the information essential for the study. They included lists of the memberships in the ASA as of 1954, 1959, 1967, and 1976, each coded for category of membership, *i.e.*, active, resident, affiliate, honorary, life, and retired. Only the active members, those who began as residents and subsequently acquired active status, life members, and retired members were traced to determine the mortality among anesthesiologists. The year of birth and sex of each member were as a rule available in the records; where this essential information was

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TABLE 1. Mortality among Male Anesthesiologists, 1954–1976

	Actual Deaths	Expected Deaths*	Mortality Ratio $\pm$ SD
Accredited as members prior to 1954			
75 years old and older†	83	98.7	84.1 $\pm$ 9.2
65–74 years old	122	161.1	75.7 $\pm$ 6.9
55–64 years old	154	195.8	78.6 $\pm$ 6.3
<55 years old	142	144.1	98.5 $\pm$ 8.3
ALL AGES	501	599.7	83.5 $\pm$ 3.6
Accredited as members 1954–1959			
75 years old and older	5	8.0	62.5 ‡
65–74 years old	20	23.7	84.4 $\pm$ 18.9
55–64 years old	46	47.4	97.0 $\pm$ 15.1
<55 years old	65	78.9	82.4 $\pm$ 10.2
ALL AGES	136	158.0	86.1 $\pm$ 7.4
Accredited as members prior to 1960			
75 years old and older	88	106.7	82.5 $\pm$ 8.8
65–74 years old	142	184.8	76.8 $\pm$ 6.4
55–64 years old	200	243.2	82.2 $\pm$ 5.8
<55 years old	207	223.0	92.8 $\pm$ 6.5
ALL AGES	637	758.7	84.0 $\pm$ 3.3

\* Based on estimated contemporaneous death rates among all physicians.

† Attained ages.

‡ See Appendix.

missing it was secured from various other sources, mainly medical directories. The ASA files were also used to identify the deaths among the active members as reported to the ASA, and to determine the last dates of payment of dues of those who had ceased paying dues. The members who had retired, those who held life memberships, and those who had stopped paying dues were checked against obituaries published by the American Medical Association and against various medical directories to find out whether any of them had died without being so reported to the ASA. The person life years of exposure, needed for the computation of expected deaths, were calculated by standard actuarial methods.

TABLE 2. Mortality among Male Anesthesiologists,\* 1967–1976

Attained Age (Years)	Actual Deaths	Expected Deaths	Mortality Ratio $\pm$ SD
75 and older	41	32.0	128.1 $\pm$ 20.0
65–74	83	96.3	86.2 $\pm$ 9.5
55–64	138	155.3	88.9 $\pm$ 1.6
<55	126	133.3	94.5 $\pm$ 8.4
ALL AGES	388	416.9	93.1 $\pm$ 4.8

\* Members of record in 1967.

## Results

The mortality experienced by male members of the ASA is presented in table 1 for all causes of death combined. The data for all members accredited before 1960, traced from 1954 to the end of 1976, show death rates that averaged 84 per cent of the contemporaneous death rates of all male physicians for all ages combined, based on 637 deaths. At attained ages of 55 years or more, the mortality of anesthesiologists was only about 80 per cent of that among all physicians, based on 430 anesthesiologist deaths, but at attained ages of less than 55 years the anesthesiologists' mortality was 93 per cent of that among all physicians, based on 207 anesthesiologist deaths.

Among those anesthesiologists accredited prior to 1960, those accredited from 1954 through 1959, who were exposed to the new halogenated anesthetics, experienced at attained ages 65 years old and older 25 deaths, or about 77 per cent of the mortality that would have been expected if the death rates among all physicians had been operative; at attained ages of less than 65 years, the anesthesiologists' mortality, based on 111 deaths, was 88 per cent of that among all physicians. For all ages combined, the anesthesiologists accredited from 1954 through 1959 had a mortality ratio of about 86 per cent, based on 136 deaths. Those accredited prior to 1954, who were exposed to both the new and the older generation of anesthetics, experienced 501 deaths for all ages combined, or about 83 per cent of the death rate among all physicians. At attained ages of 55 years or more their mortality was only about 76 per cent of that among all physicians, based on 359 anesthesiologists' deaths, but at ages of less than 55 years it was about 98 per cent of that for all physicians. For a discussion of statistical significance of these mortality ratios, the reader is referred to the Appendix.

The mortality of male anesthesiologists from 1967 to the end of 1976 showed a mortality ratio of 93 per cent of that for all physicians for all ages combined (table 2). Mortality among male anesthesiologists accredited prior to 1960 was approximately 70 per cent of the contemporaneous death rates for white males in the general population over the years 1954–1976. Mortality among male anesthesiologists of record in 1967 was likewise about 70 per cent of the contemporaneous death rates for white males in the general population over the years 1967–1976. In other words, the level of mortality among anesthesiologists has remained about the same in relation to the death rates in the general population since 1954. However, the mortality of all physicians as a class has improved appreciably in relation to the death rates in the general population, while the mortality of anes-

thesiologists has drawn closer to the average for all physicians. There is a generally decreasing trend in the mortality ratios by calendar years of experience among male anesthesiologists accredited in 1959 or prior years, but the low mortality during 1975-1976 may in part reflect the incomplete tracing of deaths in 1976 (table 3).

Among male anesthesiologists who were traced from 1954 through 1976, nearly 57 per cent of all deaths were attributed to cardiovascular diseases, and 19 per cent to all types of cancer (table 4). Considering the age distribution of the subjects, almost 20 per cent of all the deaths might have been expected to be reported as due to cancer, if the cancer mortality rates among insured lives had been operative. Among the anesthesiologists who were traced from 1967 to 1976, about 55 per cent of all deaths were attributed to cardiovascular diseases, and 21 per cent to all types of cancer (table 5). Considering the age distribution of these subjects, about 20 per cent of all deaths might have been expected to be reported as due to cancer if the cancer mortality rates among insured lives had been operative. The figures do not suggest any significantly higher mortality among anesthesiologists from all types of cancer combined. The numbers of deaths reported as due to lymphomas and Hodgkin's disease were too small to permit any conclusions. The ten deaths reported as due to lymphosarcomas among anesthesiologists accredited prior to 1960 and the four corresponding deaths among anesthesiologists of record in 1967 were so ill-defined that no recognizable pattern among them could be discerned.

Deaths from hepatic and renal disease among anesthesiologists were distributed over a variety of diagnoses, and no single diagnosis stood out among the relatively small numbers involved. By way of contrast, there were 38 suicides reported among anesthesiologists accredited prior to 1960, and 23 suicides among anesthesiologists of record in 1967. In both instances, suicides accounted for more than 6 per cent of all deaths among anesthesiologists where fewer than 1.5 per cent might have been expected. Furthermore, some additional suicides were probably reported as accidents. This finding agrees with an earlier study by Bruce and with the somewhat increased suicide death rates frequently found among physicians. Thirty-two of the 38 suicide deaths among anesthesiologists accredited prior to 1960 occurred at ages of less than 55 years, as did 18 of the 23 suicide deaths among anesthesiologists of record in 1967. Suicide is clearly the chief reason for the somewhat higher relative mortality rate observed among anesthesiologists at ages of less than 55 years. If the suicide rate among anesthesiol-

TABLE 3. Trend of Mortality among Male Anesthesiologists\*

Calendar Years	Actual Deaths	Expected Deaths	Mortality Ratio $\pm$ SD
1954-1959	124	126.2	98.3 $\pm$ 8.6
1960-1964	125	152.9	81.8 $\pm$ 7.3
1965-1969	160	180.4	88.7 $\pm$ 7.0
1970-1974	167	213.0	78.4 $\pm$ 6.0
1975-1976	61	85.3	71.5 $\pm$ 9.2
TOTAL	637	757.6	84.1 $\pm$ 3.3

\* Members of record in 1959 or prior years.

ogists younger than 55 years old were decreased by two thirds, their relative mortality from all causes would drop to about the level observed among anesthesiologists 55 years old and older.

The data for female anesthesiologists accredited prior to 1960 were few, with only 39 deaths reported among them. This was roughly equivalent to about 85 per cent of the mortality that would have been expected among all female physicians. The data for

TABLE 4. Distribution of Deaths among Anesthesiologists\* by Cause

Cause of Death	Number of Deaths	Per Cent of All Deaths
Arteriosclerotic heart disease	241	39.5
Other heart disease	37	6.1
Cerebrovascular disease	45	7.4
Other circulatory	24	3.9
TOTAL CARDIOVASCULAR	347	56.9
Cancer of the		
Lung	20	3.3
Colon and rectum	15	2.5
Stomach	5	0.8
Liver	7	1.1
Pancreas	10	1.6
Kidney	3	0.5
Bladder	4	0.7
Prostate	12	2.0
Lymphomas and Hodgkin's disease	5	0.8
Leukemia	6	1.0
Lymphosarcoma	10	1.6
Other cancer	17	2.8
TOTAL CANCER	114	18.7
Hepatic disease	6	1.0
Renal disease	10	1.6
Suicide	38	6.2
Accidents	42	6.9
All other causes	53	8.7
	610	100.0
Cause not ascertained	27	
	637	

\* Anesthesiologists accredited prior to 1960.

TABLE 5. Distribution of Deaths among Anesthesiologists\*  
by Cause

Cause of Death	Number of Deaths	Per Cent of All Deaths
Arteriosclerotic heart disease	148	39.2
Other heart disease	17	4.5
Cerebrovascular disease	26	6.9
Other circulatory	17	4.5
<b>TOTAL CARDIOVASCULAR</b>	<b>208</b>	<b>55.0</b>
Cancer of the		
Lung	15	4.0
Colon and rectum	7	1.8
Stomach	4	1.1
Liver	2	0.5
Pancreas	10	2.7
Kidney	1	0.3
Bladder	3	0.8
Prostate	10	2.6
Lymphomas and Hodgkin's disease	2	0.5
Leukemia	5	1.3
Lymphosarcoma	4	1.1
Other cancer	15	4.0
<b>TOTAL CANCER</b>	<b>78</b>	<b>20.6</b>
Hepatic disease	2	0.5
Renal disease	5	1.3
Suicide	23	6.1
Accidents	33	8.7
All other causes	29	7.7
	<b>378</b>	<b>100.0</b>
Cause not ascertained	10	
	<b>388</b>	

\* Anesthesiologists of record in 1967.

female anesthesiologists of record in 1967 were even fewer, with only 27 deaths. This was roughly equivalent to about 75 per cent of the mortality that might have been expected among all female physicians. Death certificates were obtained for 33 of the 39 deaths among female anesthesiologists accredited prior to 1960. Of these, 15 deaths were attributed to all types of cancer: six to cancer of the breast, and the others scattered among cancers at various other sites. These numbers are too small to permit any conclusions. However, the overall mortality among female anesthesiologists appears to have been quite favorable.

### Discussion

The earliest American study of mortality among anesthesiologists was made by Dublin and Spiegelman.<sup>5,6</sup> It spanned the years 1938–1942, involved only 17 deaths, and produced a mortality ratio of 88 per cent of that expected on the basis of death rates among all male physicians during this period.

A study of white male physicians in the United States carried out in connection with the 1950 Census,<sup>7</sup> showed a mortality ratio of 92 per cent of that among white males in the general population; suicide death rates appeared to be about 15 per cent higher among physicians than among white males in the general population.<sup>7,8</sup> A recent study of mortality among American physicians by Goodman<sup>4</sup> indicates that over the period 1969–1973 male physicians were subject to death rates averaging 75 per cent of those among white males in the general population, while mortality among female physicians was about 84 per cent of that among white females in the general population. The death rate among male anesthesiologists was 88 per cent of that among all physicians.

In Britain, a selected group of anesthesiologists who answered questionnaires in November 1951 and were followed through November 1971 had a mortality ratio 92 per cent of that among all British physicians,<sup>9</sup> while physicians who were part-time users of anesthetics registered a mortality ratio 93 per cent of that among all physicians. Neither the anesthesiologists nor the part-time users of anesthetics showed any excess mortality from cancer.

In summary, the high mortality rate from suicide at ages of less than 55 years appears to be the only major health problem among American anesthesiologists.<sup>10,11</sup>

### References

1. Bruce DL, Eide KA, Linde HW, et al: Causes of death among anesthesiologists: A 20-year survey. *ANESTHESIOLOGY* 29: 565–569, 1968
2. Bruce DL, Eide KA, Smith NJ, et al: A prospective survey of anesthesiologist mortality 1967–1971. *ANESTHESIOLOGY* 41:71–74, 1974
3. Dickinson F, Martin LW: Physician mortality 1949–1951. *JAMA* 162:1462–1467, 1956
4. Goodman LJ: The longevity and mortality of American physicians 1969–1973. *Milbank Memorial Fund Quarterly*, Summer 1975
5. Dublin LI, Spiegelman M: The longevity and mortality of American physicians 1938–1942. *JAMA* 134:1211–1215, 1947
6. Dublin LI, Spiegelman M: Mortality of medical specialists. *JAMA* 137:1519–1524, 1948
7. Mortality by Occupation and Industry. U. S. Department of Health, Education and Welfare, Vital Statistics. Special Reports 53(2), Sept 1962
8. Williams SV, Munford RS, Colton T, et al: Mortality among physicians: A cohort study. *J Chronic Dis* 24:393–401, 1971
9. Doll R, Peto R: Mortality among doctors in different occupations. *Br Med J* 1:1433–1436, 1977
10. Thomas CB: Suicide among us: Can we learn to prevent it. *Johns Hopkins Med J* 125:276–285, 1969
11. Blachly PH, Disher W, Roduner A: Suicide by physicians. *Bulletin Suicidology*, National Institute of Mental Health, 1968

# APPENDIX

## Measures of Mortality and Their Reliability

Mortality ratios are generally regarded as the most useful measures of mortality. They have the merit of revealing even small departures from expected mortality, especially for broad groupings. The reliability of mortality ratios depends foremost on the appropriateness of the standard for expected deaths, that is, on the controls. When such a standard is deemed to be a fixed measure, as, for instance, would be the case in comparisons with the mortality of all physicians, then the issue resolves itself into determining whether an observed deviation from the standard is or is not significant in probability terms; if it is significant, then what are the limits in probability terms within which the true value of the observed deviation can be expected to lie? This question is crucial, since most mortality studies involve relatively small numbers of deaths at least in some subdivisions of the experience, so that death rates, mortality ratios, etc., derived therefrom are subject to random fluctuations. One approach to this question is to compute confidence limits for the measures of mortality derived from the study and gauge their statistical reliability in probability terms.

When the distribution of the number of deaths or the death rate can be assumed to be approximately normal, the confidence limits corresponding to a 95 per cent confidence level will lie within 1.96 times the standard deviation of the observed sample estimate. When the normal distribution is assumed, the standard deviation of the mortality ratio is approximately equal to

$$\frac{\text{Mortality ratio}}{\sqrt{\text{Number of deaths}}}$$

Standard deviations computed by the above formula have been shown in Tables 1, 2, and 3, where the numbers of deaths are 20 or more. When the number of deaths is small, say fewer than 20, the error of assuming a normal distribution for deaths or death rates becomes appreciable. In such circumstances a more accurate estimate of the confidence limits can be obtained by assuming a Poisson distribution. The following table shows the upper and lower confidence limits for the number of observed deaths at the 95 per cent confidence level assuming a Poisson distribution:

Confidence Limits at 95 Per Cent Level for Number of Observed Deaths Assuming Poisson Distribution

Number of Observed Deaths	Lower Limit	Upper Limit
3	0.6	8.8
4	1.1	10.2
5	1.6	11.7
6	2.2	13.1
7	2.8	14.4
8	3.5	15.8
9	4.1	17.1
10	4.8	18.4
11	5.5	19.7
12	6.2	21.0
13	6.9	22.2
14	7.7	23.5
15	8.4	24.7
16	9.1	26.0
17	9.9	27.2
18	10.7	28.4
19	11.4	29.7
20	12.2	30.9

Table 1 shows that the mortality ratio and its standard deviation for male anesthesiologists accredited prior to 1960 was  $84 \pm 3.3$ , so that the confidence limits at the 95 per cent level for this mortality ratio were 77.4 and 90.6, indicating that the mortality rate of anesthesiologists was significantly and distinctly lower than that of all physicians at the 95 per cent confidence level.

The corresponding confidence limits for anesthesiologists who were accredited as members prior to 1954 were 77.3 and 90.7, and those for anesthesiologists accredited as members from 1954 to 1959 were 71.3 and 100.9. It cannot be said the mortality experience among the former was significantly different from that among the latter.

The corresponding confidence limits for anesthesiologists who were members of record in 1967 were 83.3 and 102.9. In probability terms, this experience was significantly different from that among anesthesiologists who were accredited as members prior to 1960 only at a 67 per cent confidence level.