

Cancer Mortality Among Mormons in California During 1968-75^{1, 2}

James E. Enstrom, Ph.D.^{3, 4, 5}

ABSTRACT—On the basis of Church records, detailed cancer and total death rates were determined for an average of 360,000 California Mormons during 1968-75, for an average of 700,000 Utah Mormons during 1970 and 1975, and for a subgroup of active Mormon males known as High Priests and Seventies. For cancer as a whole, the standardized mortality ratio was 68% for all California Mormon males, 83% for all California females, and 50% for active Mormon males in California and Utah compared with 1970 U.S. whites. Age-specific and age-adjusted total mortality rates were substantially lower in Mormons than in 1970 U.S. whites, with the greatest differences occurring between 35 and 64 years of age, where the rates for active Mormon males were reduced by more than 60%. Methodologic issues and sources of error were discussed, and the overall quality of the data was good. Some health-related characteristics of Mormons are also summarized.—*JNCI* 65: 1073-1082, 1980.

The Church of Jesus Christ of Latter-Day Saints (more popularly known as the Mormon Church) has approximately 2.5 million members in the United States and about 4 million worldwide. Church members are located mainly in the Rocky Mountain States, particularly Utah where they comprise about 900,000 of the State's 1.3 million population; about 400,000 Mormons reside in California (1, 2). They are interesting from an epidemiologic standpoint because their "Word of Wisdom" advises against the use of tobacco, alcohol, coffee, tea, and addictive drugs (1, 2). Also, the Church recommends a well-balanced diet, particularly the use of whole grains and fresh fruits and vegetables, moderation in the eating of meat, and good health habits in general. Adherence to these practices varies depending on how actively members participate in the Church. I previously examined cancer and total mortality rates among all Mormons in California during 1970-72 (1) and among active Mormon males in California during 1968-75 and in Utah during 1970 and 1975 (2); currently, I am examining the life-style characteristics of a well-defined cohort of active California Mormons (3). Lyon et al. studied cancer incidence among all Mormons in Utah during 1966-70 (4) and cardiovascular mortality among Mormon white adults in Utah during 1969-71 (5). This paper will present cancer mortality and total mortality for all Mormons in California during 1968-75 and for active Mormon males both in California during 1968-75 and in Utah during 1970 and 1975.

Active Mormon males are defined in this paper as those Church members designated as High Priests and Seventies in the Church's lay priesthood. High Priests are the local Church leaders, such as bishops, patriarchs, and members of various quorums and councils; Seventies are the adult missionaries who proselytize

and attempt to convert nonmembers to the Mormon faith (2). These active Mormon males are most likely to adhere to the Church-advocated life-style, and they have been selected as active Mormons in lieu of more direct information on individual Church members. No equivalent classification exists for Mormon females. Various questionnaire data from Alameda County, California (1), and throughout California (3) indicated that active Mormon males abstain almost completely from tobacco, alcohol, coffee, and tea in accord with the Word of Wisdom. Mormon males and females as a whole appear to use about one-half as much tobacco and alcohol as does the general population (1, 3). These data are only suggestive and not necessarily representative of all California Mormons. In addition, the socio-economic status and urban-rural distribution of the active Mormon males (2, 3) and Mormons as a whole (1) appear to be fairly similar to those of the California white population. Furthermore, the overall Mormon diet is fairly similar to the average American diet (2, 3), but differences could occur in some specific dietary components when extensive Mormon dietary histories are collected.

The sole emphasis of this paper will be an analysis of Mormon mortality data and a discussion of errors associated with these data. For additional information, reference can be made to previously published aspects of this subject (1-3).

ABBREVIATIONS USED: ICD=International Classification of Diseases; NCHS=National Center for Health Statistics; SMR=standardized mortality ratio(s).

¹ Presented at the Workshop on Populations at Low Risk of Cancer conducted at Snowbird, Utah, August 23-25, 1978.

² Supported by grants PDT-51 and PDT-51A from the American Cancer Society and by cancer research funds of the University of California. Computer assistance was obtained from the Health Sciences Computing Facility of the University of California at Los Angeles.

³ School of Public Health and Jonsson Comprehensive Cancer Center, University of California, Los Angeles, Calif. 90024.

⁴ Address reprint requests to Dr. Enstrom at the School of Public Health.

⁵ I am grateful to all the people who have assisted me in this research. In particular, I thank the staff in the Historical and Membership Departments and in the Office of the Presiding Bishopric of the Mormon Church and Dr. Lester Breslow, University of California, without whose cooperation and help this work would not have been possible. I also thank Virginia Hansen, Sylvia Hooper, Honoree McCarthy, Eva Operskalski, Edward Robertson, Donna Seid, and John Wright for technical assistance.

MATERIALS AND METHODS

The mortality rates determined in this paper were based on Mormon Church membership and death records stored in Salt Lake City, Utah. The record-keeping system was described in detail in (1, 2). The Church clerks throughout the world are instructed to file complete and accurate records in an annual ward report, which includes membership and death data. Both the bishop and clerk of each ward (local church) must certify that their report is complete and accurate before mailing it to Salt Lake City. The ward reports are stored in the Church Historical Department, and copies of the membership statistics and death sections of these reports were obtained for essentially all the California wards during 1968 through 1975 and all the Utah wards during 1970 and 1975. During these periods, the number of wards averaged approximately 700 for California and 1,700 for Utah. The only ward reports omitted were those that were not sent to Salt Lake City or were misfiled; these amounted to only a small percentage of the total.

The procedure for the analysis of these data was also described in (1, 2). For each deceased person listed in the ward reports, the full name and other identifying information, including sex, date and place of birth, date and place of death, reported cause of death, and the priesthood level, were transferred to computer records and processed. For California, the identifying information for each deceased Mormon was compared with the State indices, which alphabetically list the names of and equivalent identifying information on all deceased residents. The State file number was obtained whenever a match occurred between the Mormon and the State lists.

Of a total of 6,820 male and 6,386 female deaths identified in the ward reports, a total of 6,460 male and 6,109 female deaths was confirmed with California State death records. Of the 5% of the deaths not confirmed, about one-half occurred out of California according to the ward reports. These out-of-state deaths included deaths of young men killed in military action in Southeast Asia and persons who often died suddenly from accidents, heart attacks, and other causes according to the Church ward reports. Only rarely was cancer listed as the primary cause of the unconfirmed out-of-state deaths. Most of the out-of-state decedents were not California residents at the time of their deaths according to the information on the non-California death certificates obtained for a sample of these persons. About one-half of the unconfirmed deaths appeared to be probable California deaths, and why they were not listed in the State files is hard to understand. Most likely, the name of the deceased was misspelled or the incorrect date and/or place of death was recorded in the ward report. We will make further attempts to clarify these unconfirmed deaths. Inasmuch as the calculations of death rates were made with only the confirmed California deaths, the true death rate might be slightly higher if most of the unresolved deaths are

eventually determined to be genuine California deaths. Also, some additional deaths among California Mormons may not have been listed in the ward reports; this point is discussed later.

Among the total of 6,820 Mormon male deaths in California was a subset of 1,352 active Mormon male deaths. Of this subset, 1,327 (98%) were confirmed with California death records, and additional attempts are being made for verification of the remaining 25 deaths. The percentage of unconfirmed deaths was lower among the active Mormon males because the ward report information is more accurate and complete than it is for inactive Mormons (all other Mormon males). Computer tape records containing death certificate information were obtained from the California Department of Health for all confirmed California deaths, including out-of-state deaths occurring among California residents. The underlying cause of death for these Californians was assigned by the Department of Health nosologist who used the ICD (Eighth Revision) (1).

For Utah, deaths were verified differently. The 2,577 deaths among Mormon males were compared with the 4,104 deaths among Utah male residents in 1970, as summarized on a national mortality tape obtained from the NCHS (6). Because most individual identifying information, such as name and date and place of birth, was removed from the NCHS tape, the matching was done with the data that remained on the tape. Specifically, the sex, month of death, age at death, county of residence, and underlying cause of death available for each Utah decedent were matched with corresponding information available for most of the Mormon decedents. Inasmuch as a nearly one-to-one correspondence was found in the comparison of the 2,577 deaths among Mormon males with the 4,104 total deaths among Utah males, unique and unequivocal matches could be made without name and date of birth for 1,824 Mormons, including 703 of the 904 High Priests and Seventies. For the remaining 201 active Mormon males who could not be unequivocally identified with the use of this matching procedure, death certificates were requested from the Utah Department of Health for verification. To date, 884 deaths (98%) among the High Priests and Seventies have been correctly identified, but the remaining 20 Church-reported deaths have not been found in the State files.

A similar matching procedure was used for 1975. The 2,555 deaths among Mormon males were compared with the 4,333 deaths among male residents of Utah in 1975 that were summarized on the NCHS national mortality tape (6). The matching for this year was done by sex, month and day of death, age at death, and county of residence. Again, unique and unequivocal matches could be made for 2,041 Mormons, including 814 of the 987 High Priests and Seventies; death certificates were requested for the 173 unmatched. To date, 972 deaths (98%) among the High Priests and Seventies have been correctly identified, but the remaining 15 Church-reported deaths have not been

found in the State files. Deaths of active Mormon males in Utah during 1970 and 1975 were tabulated according to cause of death as coded by the Utah State nosologist [ICD (Eighth Revision)].

The population-at-risk was determined by the tabulation of the number of California and Utah Mormon males, by priesthood level, listed in the same annual ward reports that contained the information on deceased members. The number of members reported for each ward was assumed to represent the precise population for which deaths were also reported. Averaged over the 8-year period (January 1, 1968, to December 31, 1975), there were in California about 190,000 Mormon females and about 170,000 Mormon males, including 11,800 High Priests and 3,700 Seventies for a total of 15,500 active males.

During 1970, Mormon membership in Utah amounted to about 394,000 females and 375,000 males, including 40,900 High Priests and 9,700 Seventies for a total of 50,600 active males. In 1975, membership was increased to about 430,000 females and 410,000 males, including 50,300 High Priests and 9,100 Seventies for a total of 59,400 active males. The averages for 1970 and 1975 were 45,600 High Priests and 9,400 Seventies for a total of 55,000 active Mormon males in Utah.

The age distribution of California and Utah Mormon males by priesthood level was determined from the computerized Church membership files as of July 1, 1975, and September 15, 1976. In lieu of direct questionnaire data on individual Mormons, the computerized records provided the best available estimate of their age distribution. The accuracy of the computerized records was limited because of certain errors e.g., a small percentage of the members was not included, a small percentage was included twice under different addresses, and some members were entered incorrectly. However, the records for the active members were presumably more accurate than were those for members as a whole because inactive members were more likely to be in lost or unknown status. The 1975 computerized records for all members have been discussed in (1). The 1975 and 1976 age distributions were averaged and then assumed to be the actual age distribution for the 190,000 Mormon females and 170,000 males, including 15,500 active males in California during 1968-75 and 55,000 active Mormons in Utah during 1970 and 1975. For all California Mormon males and females, this was equivalent to what was previously called the "modified" age distribution in the earlier paper (1). In each 10-year age group, the 1975 and 1976 distributions differed from their combined average by at most 6%, which was a reasonable estimate of the error present. The number of High Priests and Seventies at least 35 years of age averaged 13,880 in California and 50,390 in Utah. Although race was not recorded in the membership records, Mormons can be considered to be all white; evidence for this is the fact that about 99% of their deceased members are categorized as white in the State records. The assumption that the average age distributions in 1975-76 were

the same as those in 1968-75 and 1970 and 1975 was reasonable because the California and Utah Mormon populations have not been subject to any abnormal influx or outgo of members during this period, although they have grown steadily by about 25% from 1968 to 1975. Furthermore, the age distribution of deceased California Mormons has remained stable from 1968 to 1975, which indicates that the age distribution of the population-at-risk is probably unchanged, if one assumes that the age-specific Mormon death rates remained the same from 1968 through 1975. However, these age distributions may contain some as yet undetermined systematic error; thus they must be qualified as the best currently available.

Inasmuch as the Mormon mortality rates are based entirely on Church records, using available death and population-at-risk data, one must confirm the accuracy of these mortality rates with a well-defined cohort of individually identified Mormons. For this purpose, a historical biographical book written around 1950 by Leo J. Muir about active California Mormons of that era was used (7). For each Mormon included, this book gives demographic information, including full name, date and place of birth, parents' names, occupation, and residence, and allows a Church-independent historical prospective determination of mortality for a 30-year period. Listed in the book are 426 males and 407 females, primarily husband and wife pairs, who were alive and at least 35 years of age as of January 1, 1945. These persons, many of whom lived in Los Angeles County, have been followed individually so their current vital status could be determined. All have been positively assessed as being either alive or dead as of January 1, 1975.

The following procedures were used to identify 442 deceased members: Four separate searches of the deceased membership file maintained since 1942 by the Mormon Church in Salt Lake City located 409 deaths; personal contact with members of the cohort families and other Church leaders in Los Angeles County and a thorough search of the California State death indices for all members of uncertain status located 33 additional deaths. Verification of death status was done by a check of all 442 death certificates obtained; 95 deaths occurred outside of California including 2 in foreign countries.

Identification of 391 living members included four separate searches of the files of the living members (computerized and card files) of the Mormon Church, personal contact with cohort members and Church leaders in Los Angeles County, a check with the Department of Motor Vehicles for the existence of a California driver's license as of 1970 or later, and a search of the Church file of deceased members and the California State death indices to ascertain deaths since January 1, 1975. A search of the California State death indices from 1970 through 1974 yielded no deaths among cohort members believed to be alive according to information from the other sources.

Verification of living status was based on the fact

that these members had a specific residence address as of January 1, 1975, or later, that agreed with information obtained from at least two of the following independent sources: telephone directories, Church membership records, Department of Motor Vehicle records since January 1, 1975, or direct personal contact. Because of the consistency and overlapping comprehensiveness of the various sources, direct contact with only those individuals with major uncertainty in their status was considered necessary.

RESULTS

Mormon age-specific death rates in California from 1968 to 1975 and in Utah during 1970 were calculated for all cancer and all causes by our combining the deaths and population-at-risk as determined above. The rates and number of deaths on which they were based are given in table 1 for all causes of death and in table 2 for total cancer and cancers of the colon, lung, and breast. The populations-at-risk in 5-year age intervals up to 85 years are presented in table 3. For comparison with death rates for Mormons, those for white males in the United States, California, and Utah (6, 8) and Utah-born Californians are given in table 1 for 1970 (6, 9).

To obtain the expected deaths (tables 4 and 5), I multiplied the population-at-risk given in table 3 by the age-specific 1970 U.S. cancer death rates (6, 8) and then added them for all the 5-year age intervals.

The data in tables 4 and 5 show that, compared with 1970 U.S. whites, the SMR for all cancer (total malignant neoplasms) were 50 and 49 for active Mormon males in California and Utah, respectively, and 68 for all Mormon males and 83 for all Mormon females in California. The SMR for the smoking-related sites (defined here as lip, oral cavity, pharynx, esophagus, lung, and bladder) and non-smoking-related sites (arbitrarily defined as all those except the smoking-related ones) are as follows:

Cancer sites	California Mormons			Utah Mormon active males
	Active males	All males	Females	
Smoking related	26	58	80	19
Non-smoking related	67	74	83	68

These SMR values were statistically significantly less than 100 (at the level of $P < 0.01$), if one assumes a Poisson variation (1, 2). I have chosen not to test

TABLE 1.—Average annual age-specific total mortality rates for Mormons in California and Utah and several comparison populations (deaths/1,000)

Age, yr	Average annual age-specific total mortality rates ^a								
	1945-74: California active Mormons in the Muir cohort (7)	1968-75: California active Mormons	1970 and 1975: Utah active Mormons	1968-75: California Mormons	1970: Utah Mormons	1970: Utahans ^b	1970: Californians born in Utah ^c	1970: California whites	1970: U.S. whites
Males									
35-44	1.60 (1)	1.18 (35)	1.21 (23)	1.98 (312)	2.89 (99)	3.09 (167)	2.09 (18)	3.33	3.44
45-54	3.55 (7)	3.39 (110)	3.12 (78)	4.88 (684)	7.42 (228)	8.39 (417)	6.44 (85)	8.25	8.83
55-64	9.56 (28)	8.20 (208)	9.25 (228)	13.78 (1,263)	15.76 (395)	18.12 (675)	19.89 (178)	20.64	22.03
65-74	30.18 (77)	22.55 (351)	25.61 (505)	33.66 (1,452)	43.45 (602)	44.25 (967)	46.15 (210)	45.60	48.10
75-84	77.95 (90)	61.66 (405)	68.83 (687)	73.05 (1,118)	70.71 (556)	88.46 (858)	126.92 (165)	97.25	100.99
≥85	181.31 (39)	151.20 (206)	139.44 (328)	139.53 (413)	140.19 (240)	157.74 (372)	—	176.25	185.52
≥35 ^d	11.63 (242)	9.36 (1,315)	10.09 (1,849)	12.91 (5,242)	15.42 (2,120)	17.21 (3,456)	—	18.41	19.41
Total deaths (all ages)	(242)	(1,327)	(1,856)	(6,460)	(2,577)	(4,104)	(741)		
Females									
35-44	0.0 (0)			1.65 (298)	1.57 (59)	1.84 (100)	2.61 (29)	2.11	1.93
45-54	2.54 (5)			3.43 (558)	3.57 (123)	3.57 (185)	6.19 (74)	4.94	4.63
55-64	8.17 (24)			8.56 (908)	7.73 (217)	8.84 (345)	12.48 (126)	10.43	10.15
65-74	18.24 (47)			18.87 (1,195)	21.96 (423)	22.93 (601)	26.54 (142)	23.15	24.71
75-84	61.88 (79)			51.39 (1,483)	56.86 (585)	60.29 (825)	70.38 (183)	62.59	66.99
≥85	139.97 (45)			128.41 (980)	122.62 (347)	140.47 (510)	—	154.71	159.80
≥35 ^d	8.12 (200)			8.57 (5,422)	8.99 (1,754)	9.87 (2,566)	—	10.71	10.91
Total deaths (all ages)	(200)			(6,109)	(2,015)	(2,957)	(687)		

^a Number of deaths upon which rate is based is given in parentheses.

^b The population was 72% Mormon.

^c Of the Californians born in Utah, ≈40% were Mormon.

^d Values were age adjusted by the direct method to the 1940 U.S. population within the stated age interval.

TABLE 2.—Average annual age-specific Mormon cancer mortality rates (deaths/100,000)

Age, yr	Average annual age-specific cancer mortality rates ^a						
	1968-75: Mormons in California				1968-75: California active Mormons— all cancer ^b	1970 and 1975: Utah active Mormons— all cancer ^b	1970: U.S. whites— all cancer ^b
	All cancer ^b	Colon cancer ^c	Lung cancer ^d	Breast cancer ^e			
Males							
0-24	8.7 (63)	0.0 (0)	0.0 (0)	—	—	8.6	
25-34	15.8 (29)	0.5 (1)	1.1 (2)	7.9 (1)	22.4 (2)	16.2	
35-44	29.8 (47)	2.5 (4)	7.0 (11)	33.6 (10)	21.0 (4)	50.1	
45-54	97.1 (136)	8.6 (12)	24.3 (34)	83.3 (27)	71.9 (18)	172.0	
55-64	303.3 (278)	34.9 (32)	117.8 (108)	165.6 (42)	129.8 (32)	498.1	
65-74	670.0 (289)	53.3 (23)	208.6 (90)	443.3 (69)	466.6 (92)	997.0	
≥75	1,275.7 (233)	147.8 (27)	197.1 (36)	1,185.2 (94)	1,128.4 (139)	1,617.4	
75-84	1,241.5 (190)			1,141.9 (75)	1,183.8 (118)	1,592.7	
≥85	1,452.7 (43)			1,397.1 (19)	892.9 (21)	1,772.2	
Total deaths (all ages)	(1,075)	(99)	(281)	(243)	(287)		
Females							
0-24	5.7 (43)	0.0 (0)	0.0 (0)	0.0 (0)		6.0	
25-34	17.7 (38)	0.5 (1)	0.9 (2)	3.7 (8)		16.3	
35-44	59.6 (108)	2.8 (5)	5.5 (10)	26.0 (47)		62.4	
45-54	127.2 (207)	11.1 (18)	12.3 (20)	44.2 (72)		177.3	
55-64	290.5 (308)	23.6 (25)	38.7 (41)	72.6 (77)		338.6	
65-74	459.6 (291)	66.3 (42)	26.9 (17)	90.0 (57)		554.7	
≥75	734.5 (268)	148.0 (54)	32.9 (12)	115.1 (42)		945.3	
75-84	682.7 (197)					903.5	
≥85	930.3 (71)					1,126.6	
Total deaths (all ages)	(1,263)	(145)	(102)	(303)			

^a Number of deaths upon which rate is based is given in parentheses.

^b ICD (Eighth Revision) code Nos. 140-209.

^c ICD (Eighth Revision) code No. 153.

^d ICD (Eighth Revision) code No. 162.

^e ICD (Eighth Revision) code No. 174.

TABLE 3.—Age distribution of Mormon populations-at-risk

Age, yr	Average No. of Mormons in California during 1968-75		Average No. of active Mormon males in California during 1968-75	Average No. of active Mormon males in Utah during 1970 and 1975
	Males	Females		
	0-4	16,775		
5-9	18,735	19,560	0	0
10-14	21,594	22,291	0	0
15-19	19,935	20,378	0	0
20-24	13,678	15,529	40	142
25-29	12,315	14,388	418	1,304
30-34	10,607	12,430	1,163	3,163
35-39	9,744	11,619	1,727	4,251
40-44	9,972	11,015	1,994	5,290
45-49	9,106	10,580	2,103	6,170
50-54	8,407	9,765	1,948	6,341
55-59	6,601	7,478	1,761	6,344
60-64	4,856	5,775	1,409	5,978
65-69	3,133	4,493	1,084	5,378
70-74	2,259	3,422	862	4,479
75-79	1,248	2,280	526	3,129
80-84	665	1,327	295	1,855
≥85	370	954	170	1,176
Total (all ages)	170,000	190,000	15,500	55,000

individual cancer sites for statistically significant differences because underlying uncertainties that invalidate the tests may still exist in the data. These uncertainties will be discussed.

DISCUSSION

On the basis of all the data presented in tables 1, 2, 4, and 5, Mormons have unusually low cancer and total death rates. These low rates are not entirely explained by their lack of smoking, because they also have low SMR for all non-smoking-related cancer sites combined. These latter sites account for 41 and 39% of the deficit in observed versus expected cancer deaths seen in active Mormon males in California and Utah, respectively, and 49 and 86% of that seen in all Mormon males and females in California, respectively. In representative U.S. white male nonsmokers in 1966-68 compared with U.S. white males in 1970, the SMR for all non-smoking-related cancer sites was essentially 100 (2). More extensive data on representative U.S. nonsmokers are presented in this monograph (10). In specially selected nonsmokers, such as nonsmokers in the American Cancer Society and U.S. veteran cohorts, the SMR for all non-smoking-related cancer sites was less than 100 (11), but these non-

TABLE 4.—Observed (Obs) and expected (Exp) numbers and SMR for cancers by site occurring among male and female Mormons in California during 1968–75

Primary site ^a	Male			Female		
	Obs	Exp	SMR	Obs	Exp	SMR
Total malignant neoplasms	1,075	1,577.2	68	1,263	1,525.7	83
Lip, oral cavity, and pharynx	26	49.3	53	25	21.2	118
Lip	2	1.6	125	0	0.2	0
Tongue	3	11.4	26	3	4.9	61
Salivary glands	6	3.3	182	6	2.7	222
Gum and mouth	1	10.3	10	7	5.4	130
Nasopharynx	6	3.9	154	3	1.8	167
Other and unspecified pharynx	8	18.9	42	6	6.3	95
Digestive organs and peritoneum	282	436.8	65	337	430.7	78
Esophagus	15	33.7	45	9	13.1	69
Stomach	53	76.2	70	51	54.9	93
Small intestine	1	3.3	30	2	3.1	65
Colon	99	138.2	72	145	182.1	80
Rectum, rectosigmoid junction, and anal canal	32	49.4	65	30	42.2	71
Liver	10	24.4	41	10	19.6	51
Gallbladder	3	5.1	59	8	18.3	44
Other biliary passages	10	8.5	118	9	9.1	99
Pancreas	55	87.1	63	60	72.7	83
Retropertoneum, peritoneum, and unspecified digestive organs	4	10.4	38	13	15.8	82
Respiratory system	293	512.7	57	111	139.3	80
Larynx	7	23.5	30	3	3.4	88
Lung	281	480.7	58	102	131.1	78
Other respiratory organs	5	8.4	60	6	4.8	125
Bones and joints	7	11.6	60	7	9.7	72
Connective, subcutaneous, and other soft tissues	6	8.8	68	4	8.0	50
Skin, melanoma	28	20.0	140	26	17.6	148
Breast	1	2.2	45	303	324.4	93
Female genital system				159	231.1	69
Cervix				48	64.4	75
Corpus uteri				14	18.2	77
Uterus NOS ^b				16	31.7	50
Ovary				75	106.9	70
Vagina				1	2.7	37
Vulva and clitoris				3	4.6	65
Other female genital system				2	2.4	83
Male genital system	92	127.9	72			
Prostate gland	88	115.0	77			
Testis	4	10.9	37			
Penis	0	1.7	0			
Scrotum and other male genital system	0	0.3	0			
Urinary system	58	88.3	66	32	48.6	66
Bladder	36	49.8	72	16	23.9	67
Kidney and renal pelvis	19	36.7	52	16	23.0	70
Other urinary organs	3	1.8	167	0	1.7	0
Eye	2	1.7	118	4	1.9	211
Nervous system	40	54.0	74	38	43.3	88
Brain	28	40.7	69	29	33.0	88
Other nervous system	12	13.3	90	9	10.3	87
Endocrine system	4	6.1	66	8	9.2	87
Thyroid gland	2	3.5	57	4	6.7	60
Other endocrine glands	2	2.6	77	4	2.5	160
Lymphomas	69	77.0	90	53	64.7	82
Lymphosarcoma and reticulum cell sarcomas	36	39.5	91	28	33.7	83
Hodgkin's disease	17	23.6	72	16	18.0	89
Other lymphomas	16	13.8	116	9	12.9	70
Multiple myeloma	18	19.1	94	18	18.9	95
Leukemia	88	83.2	106	71	72.3	98
Lymphatic (lymphocytic)						
Acute	16	14.6	110	9	11.7	77
Chronic	13	10.4	125	5	7.7	65
Other	3	4.2	71	4	3.5	114
Other leukemia (e.g., granulocytic or monocytic)						
Acute	31	33.4	93	34	30.6	111
Chronic	15	9.6	156	7	9.1	77
Other	10	11.2	89	12	9.7	124
Other and unknown primary	61	78.5	78	67	84.8	79

^a The ICD (Eighth Revision) codes were used. See Appendix, p. 1191.^b NOS= not otherwise specified.

TABLE 5.—Observed (Obs) and expected (Exp) numbers and SMR for cancers by site occurring among active Mormon males (High Priests and Seventies) in California during 1968-75 and Utah during 1970 and 1975

Primary site ^a	California			Utah		
	Obs	Exp	SMR	Obs	Exp	SMR
Total malignant neoplasms	242	481.1	50	286	578.6	49
Lip, oral cavity, and pharynx	2	15.0	13	1	17.3	6
Lip	1	0.5	200	0	0.7	0
Tongue	0	3.5	0	0	4.0	0
Salivary glands	0	1.0	0	1	1.3	77
Gum and mouth	0	3.2	0	0	3.7	0
Nasopharynx	0	1.0	0	0	1.1	0
Other and unspecified pharynx	1	5.7	18	0	6.5	0
Digestive organs and peritoneum	80	142.7	56	103	176.2	58
Esophagus	0	10.6	0	5	12.5	40
Stomach	19	25.2	75	26	31.6	82
Small intestine	1	1.0	100	0	1.2	0
Colon	34	46.1	74	32	58.1	55
Rectum, rectosigmoid junction, and anal canal	6	16.3	37	10	20.3	49
Liver	2	7.6	26	2	9.2	22
Gallbladder	1	1.8	56	3	2.3	130
Other biliary passages	3	2.7	111	0	3.3	0
Pancreas	13	28.0	46	24	33.7	71
Retroperitoneum, peritoneum, and unspecified digestive organs	1	3.2	31	1	4.0	25
Respiratory system	37	157.6	23	33	180.4	18
Larynx	1	7.3	14	0	8.5	0
Lung	34	147.8	23	32	169.1	19
Other respiratory organs	2	2.4	83	1	2.8	36
Bones and joints	0	2.1	0	1	2.5	40
Connective, subcutaneous, and other soft tissues	0	1.9	0	2	2.1	95
Skin, melanoma	9	4.9	184	4	5.0	80
Breast	0	0.7	0	2	0.9	222
Male genital system	35	46.1	76	70	64.4	109
Prostate gland	35	44.3	79	66	62.6	105
Testis	0	1.2	0	4	1.0	400
Penis	0	0.6	0	0	0.7	0
Scrotum and other male genital system	0	0.1	0	0	0.1	0
Urinary system	15	29.1	52	12	36.6	33
Bladder	13	17.7	73	5	23.4	21
Kidney and renal pelvis	2	10.8	19	6	12.5	48
Other urinary organs	0	0.6	0	1	0.7	143
Eye	0	0.5	0	1	0.5	200
Nervous system	7	11.0	64	7	10.9	64
Brain	4	8.7	46	3	8.6	35
Other nervous system	3	2.3	130	4	2.3	174
Endocrine system	2	1.6	125	2	1.8	111
Thyroid gland	2	1.0	200	1	1.2	83
Other endocrine glands	0	0.6	0	1	0.6	167
Lymphomas	17	18.5	92	14	20.5	68
Lymphosarcoma and reticulum cell sarcomas	6	10.2	59	7	11.4	61
Hodgkin's disease	4	4.5	89	3	4.5	67
Other lymphomas	7	3.8	184	4	4.5	89
Multiple myeloma	10	6.0	167	2	7.3	27
Leukemia	19	18.8	101	18	22.8	79
Lymphatic (lymphocytic)						
Acute	1	1.2	83	0	1.4	0
Chronic	2	3.6	56	2	4.7	43
Other	0	1.3	0	1	1.7	59
Other leukemia (e.g., granulocytic or monocytic)						
Acute	7	7.3	96	11	8.4	131
Chronic	3	2.5	120	2	3.0	67
Other	6	2.9	207	2	3.7	54
Other and unknown primary	9	24.6	37	14	29.4	48

^a The ICD (Eighth Revision) codes were used. See Appendix, p. 1191.

smokers differed from average Americans in many ways besides smoking status.

A major concern of any scientific study should be the quality of the data on which it is based. This consideration is particularly true of the present investigation, which is based on several secondary sources not originally intended for use in epidemiologic studies. Some of the problems with the completeness and accuracy of the populations-at-risk and the deaths have already been mentioned, and additional considerations will now be made. The validity of the results, as opposed to the results themselves, will be the primary focus of this discussion.

The vital status of all the members of the Muir biographical cohort (7) was ascertained and verified over a 30-year period, and there was no loss to follow-up. Analysis was done by the accumulation of deaths and person-years of observation by attained age with the use of the standard procedures (12, 13). Age-specific death rates were then calculated and are presented in table 1. The 1940 U.S. population was selected as the standard for age adjustment because this population was used in other major NCHS publications (6, 14). The 1945-74 Muir cohort has an age-adjusted mortality rate of 11.63 deaths/1,000 for males at least 35 years of age, which was 24% higher than the rate of 9.36 for active Mormon males in California during 1968-75 and 15% higher than the rate of 10.09 for active Mormon males in Utah during 1970. For females of the Muir cohort, the age-adjusted mortality rate was 8.12 deaths/1,000, which was 5% lower than the rate of 8.57 for all Mormon females in California during 1968-75 and 10% lower than the rate of 8.99 for all Mormon females in Utah during 1970. Within the 95% confidence interval of Poisson statistical variation (15), the age-specific death rates for the Muir cohort were consistent with all the corresponding Utah and California rates except those for active male Mormons between 65 and 84 years of age. The rates for the Muir cohort could be expected to be higher than corresponding rates centered around 1970 because they occurred from 1945 through 1974, a period during which the age-adjusted U.S. rates declined by 18 and 38% for white males and females, respectively (6, 14). The males of the Muir cohort were initially selected without knowledge of their priesthood status, but they have since been determined to be active Mormons according to Church death records (about 90% of the deceased males were High Priests and 5% were Seventies). The females of the Muir cohort had no priesthood status, but essentially all of them were wives of active members and hence could be considered to be active members. Unfortunately, no Church-based data can be calculated for active Mormon females, who might be expected to be healthier than Mormon women as a whole, if the experience of active Mormon men is used as a basis.

Other indications about the quality of the Mormon mortality rates should be noted. As discussed earlier, an indication of the accuracy of the deaths listed in the Church ward reports was the fact that 95% of all deaths

of Mormons in California and 98% of those of active Mormons in California and Utah were verified with official State records. As summarized in table 6, an indication of the completeness of the lists in the 1968-75 California ward reports was the fact that 94% (103/109) of the California deaths that occurred in the Muir cohort during 1968-74 were included in these reports. Totals of 88% (96/109) were recorded in the deceased membership file and 96% (105/109) in either the ward reports or deceased file. The 4 deaths entirely unknown to the Church may have occurred among persons who were lost or removed from the Church membership files between 1945 and 1968 and hence not reported in the death records because of unknown membership status. A more direct check of the completeness of the ward reports of deaths was obtained by following 277 males and 487 females who were living members of four Los Angeles wards and at least 50 years of age as of January 1, 1974. Of the 33 California deaths among ward members confirmed by State death certificate records for 1974 and 1975, 29 (88%) were reported in the 1974 and 1975 California ward reports (table 7). The 4 deaths not listed in the ward reports included deaths of 2 inactive males and 2 elderly widows, according to the membership lists used to identify the members who have been followed.

On the basis of the information above, the California ward reports may underreport deaths up to 5% for active Mormons and by about 10% for all members of the Church. The deceased membership file appears to underreport deaths by at least 10% for active Mormons and possibly even more for Mormons as a whole (1). These error estimates are only approximate, but they are the best available until more extensive checks can be made.

The 1970 Utah ward reports listed 4,591 deaths of a total of 7,061 deaths in the State during 1970 (table 8). Thus Mormon deaths comprise 65% of all Utah deaths, and, if the ward reports are 10% incomplete, then Mormon deaths would actually comprise at least 70%

TABLE 6.—Completeness of death reporting by Mormon Church annual ward reports and deceased membership file for California deaths during 1968-74 among active Mormons in the Muir cohort (7) who were California residents at the time of their deaths^a

Sex	Deaths recorded in California ward reports, % of total deaths	Deaths recorded in deceased membership file, % of total deaths	Deaths recorded in ward reports or deceased file, % of total deaths	Total California deaths confirmed by death certificate
Male	96 (52)	89 (48)	96 (52)	100 (54)
Female	93 (51)	87 (48)	96 (53)	100 (55)
Both sexes	94 (103)	88 (96)	96 (105)	100 (109)

^a Numbers in parentheses represent the actual No. of deaths upon which the completeness percentage (% of total deaths) is based.

TABLE 7.—Completeness of death reporting by Mormon Church annual ward reports for California deaths during 1974 and 1975 among 277 males and 487 females who were members of 4 Los Angeles wards^a

Sex	Deaths recorded in California ward reports, % of observed deaths ^b	Total No. of observed deaths confirmed by death certificate	Total No. of deaths expected based on 1970 U.S. white death rates	SMR of observed to expected deaths, % (95% confidence limits)
Male	88 (15)	17	26.6	64 (37-102)
Female	88 (14)	16	31.5	51 (29-83)
Both sexes	88 (29)	33	58.1	57 (39-80)

^a Members were at least 50 yr old as of January 1, 1974.

^b Numbers in parentheses represent the actual No. of deaths upon which the completeness percentage (% of observed deaths) is based.

of all in the State. Using the Mormon living and deceased membership files, but not the Church ward reports, Lyon et al. (4) found only 60% of the patients with cancer in Utah during 1966-70 reported and only 55% of the cardiovascular deaths among whites in Utah during 1969-71 (5). These varying percentages, as summarized in table 4, point out the difficulty of proper identification of all Mormon deaths in Utah

with the use of existing Church records. The best estimate on the basis of the above findings is that at least 65% of all Utah deaths occurred among Utah Mormons.

One indication of the general accuracy of the California Mormon age distribution was obtained by a comparison of the age distribution of California Mormons with the age distribution of California residents born in Utah, as reported in the public use samples of basic records from the 1970 census (9). Of all 1970 deceased Californians born in Utah, 40% were determined to be Mormons by a comparison of records of deaths in California with those in the ward reports. This observation suggests that about 40% of Californians born in Utah are Mormons, and hence the age distribution of this migrant group might be similar to that of California Mormons, many of whom immigrated from Utah. Table 9 shows that the age distribution of persons at least 35 years old was in fact similar for the Mormons in California during 1968-75 and the Californians in 1970 who were born in Utah. However, the similarity did not hold for age-specific death rates. As seen in table 1, the death rates in 1970 for Californians born in Utah were about 50% higher than those for California Mormons and higher than those for California whites as a whole. The direction of this difference was not surprising, if one considers that the type of Utahans likely to migrate to California are non-

TABLE 8.—Percentage of Mormons among total Utah population and various vital statistics as determined by Mormon Church files of living and deceased members and annual ward reports

Cohort examined	Source of Mormon data	No. of Mormons in Utah	Total population in Utah	Percent Mormon	References
July 1, 1970, Utah population	Annual ward reports	770,000	1,066,000	72	(1)
1970 Utah deaths	Annual ward reports	4,591	7,061	65	(1, 6)
1966-70 Utah cancer cases	Living and deceased membership files	6,350	10,605	60	(4)
1969-71 Utah white cardiovascular deaths among persons at least 30 yr old	Living and deceased membership files	3,376	6,108	55	(5)

TABLE 9.—Comparison of age distribution for Mormons in California during 1968-75 and Utah-born residents of California in 1970^a

Age, yr	Mormon males in California during 1968-75, % ^b	Utah-born males in California in 1970, % ^{b,c}	Mormon females in California during 1968-75, % ^b	Utah-born females in California in 1970, % ^{b,c}
35-44	35.0 (19,716)	23.4 (8,600)	33.0 (22,634)	25.7 (11,100)
45-54	31.0 (17,513)	35.9 (13,200)	29.6 (20,345)	30.9 (13,350)
55-64	20.3 (11,457)	24.3 (8,950)	19.3 (13,253)	23.4 (10,100)
65-74	9.6 (5,392)	12.4 (4,550)	11.5 (7,915)	12.4 (5,350)
75-84	3.4 (1,913)	3.5 (1,300)	5.2 (3,607)	6.2 (2,700)
≥85	0.7 (370)	0.5 (200)	1.4 (954)	1.4 (600)
≥35	100.0 (56,361)	100.0 (36,800)	100.0 (68,708)	100.0 (43,200)

^a Both cohorts were at least 35 yr old.

^b Numbers in parentheses are No. of persons upon whom percentage distribution is based.

^c Values are based on $(1/5 \times 5\% + 1/15 \times 15\%)$ public use samples $\times 50$.

Mormons who want to avoid the strong influence of the Mormon Church in Utah. The magnitude of difference was surprising and was definitely not a confirmation of the California Mormon rates.

The best available confirmation of the rates of California Mormons is the fact that they were similar to those of Utah Mormons and Utahans as a whole. Another confirmation came from the 1974-75 mortality follow-up of the 277 males and 487 females in the 4 Los Angeles wards (table 6). For both sexes combined, 33 deaths were observed compared with 58.1 deaths expected on the basis of 1970 death rates of whites in the United States. The SMR was 57%, with 95% confidence limits from 39 to 80%, if one assumed a Poisson variation (15). This confidence interval, though large, was significantly less than 100% and consistent with the total mortality rates of Mormons in California (table 1).

Another particular concern is the possible error in the Mormon population-at-risk introduced by the Mormons assigned to the "lost and unknown" category. As of December 31, 1970, 287,899 persons were lost and unknown out of a total of 2,926,473 Mormons, and as of December 31, 1975, these numbers increased to 478,123 and 3,572,202, respectively. The California and Utah Mormon population-at-risk described above supposedly does not include the lost and unknown persons, but if many of these resided in California or Utah, then a substantial error could be introduced if they actually contributed to either the population-at-risk or the reported deaths. Presumably, most of these persons of uncertain status are inactive members and should in no way affect the statistics for active Mormons. These various types of errors underscore the desirability that epidemiologists use cohorts of well-defined individuals who can be followed independently. Although the Church records can serve as effective means of obtaining information about Mormons, they should be used for epidemiologic purposes only with a full understanding of their limitations.

CONCLUSION

The major conclusion to be drawn from the results so far is that California Mormons, particularly active Mormon males, are a low-risk population, with cancer mortality patterns not clearly explained by their smoking habits. This population is excellent for epidemiologic investigation because it appears to be demo-

graphically and socioeconomically similar to the general white population and yet has several distinct health-related characteristics that could be related to its low risk of cancer. The existence of extensive Church membership and death records makes the conduct of an epidemiologic study easier than would be possible among the general population. A prospective cohort study of active California Mormons, currently underway (3), will relate in detail the health characteristics of individual Mormons to their subsequent cancer mortality. The goal is to gain new understanding with regard to reducing cancer risk.

REFERENCES

- (1) ENSTROM JE. Cancer mortality among Mormons. *Cancer* 1975; 36:825-841.
- (2) ———. Cancer and total mortality among active Mormons. *Cancer* 1978;42:1943-1951.
- (3) ———. Health and dietary practices and cancer mortality among California Mormons. In: Cairns J, Lyon JL, Skolnick M, eds. Banbury report 4: Cancer incidence in defined populations. Cold Spring Harbor, N.Y.: Cold Spring Harbor Laboratory, 1980:69-92.
- (4) LYON JL, KLAUBER MR, GARDNER JW, SMART CR. Cancer incidence in Mormons and non-Mormons in Utah, 1966-1970. *N Engl J Med* 1976;294:129-133.
- (5) LYON JL, WETZLER HP, GARDNER JW, KLAUBER MR, WILLIAMS RR. Cardiovascular mortality in Mormons and non-Mormons in Utah, 1969-1971. *Am J Epidemiol* 1978;108:357-366.
- (6) National Center for Health Statistics. Vital statistics of the United States, annual reports for 1970 and 1975, including mortality tape files and outline of items and codes. Rockville, Md.: National Center for Health Statistics, 1979.
- (7) MUIR LJ. A century of Mormon activities in California. Vol 2. Biographical. Salt Lake City: Deseret News Press, 1952.
- (8) U.S. Bureau of the Census. United States census of the population—1970. Washington, D.C.: U.S. Govt Print Off, 1974.
- (9) ———. Public use samples of basic records from the 1970 census: Description and technical documentation. Washington, D.C.: U.S. Govt Print Off, 1972.
- (10) ENSTROM JE, GODLEY FH. Cancer mortality among a representative sample of nonsmokers in the United States during 1966-68. *JNCI* 1980;65:1175-1183.
- (11) GARFINKEL L. Cancer mortality in nonsmokers: Prospective study by the American Cancer Society. *JNCI* 1980;65:000-000.
- (12) HILL ID. Computing man years at risk. *Br J Prev Soc Med* 1972;26:132-134.
- (13) MONSON RR. Analysis of relative survival and proportional mortality. *Comput Biomed Res* 1974;7:325-332.
- (14) GROVE RD, HETZEL AM. Vital statistics rates in the United States, 1940-1960. Washington, D.C.: U.S. Govt Print Off, 1968 [DHEW publication No. (PHS)1677].
- (15) BAILAR JC III, EDERER F. Significance factors for a ratio of a Poisson variable to its expectation. *Biometrics* 1964;20:639-643.