TRANSACTIONS OF SOCIETY OF ACTUARIES
1995-96 REPORTS

CONTINUING CARE RETIREMENT COMMUNITY RESIDENT MORTALITY AND LIFE EXPECTANCIES

HAROLD L. BARNEY

I. OVERVIEW AND NEW LIFE EXPECTANCIES

In the state of California over 80 continuing care retirement communities (CCRCs), including 17 life care communities offer retirees residential living and services ranging from the provision of housing with guaranteed access to skilled nursing, to the all inclusive delivery of health care and personal care. Continuing care residents typically pay an entry fee followed by monthly payments, which may or may not increase upon changes in the health care needs of the resident. In return, the provider promises residential and health care services for the life of the resident.

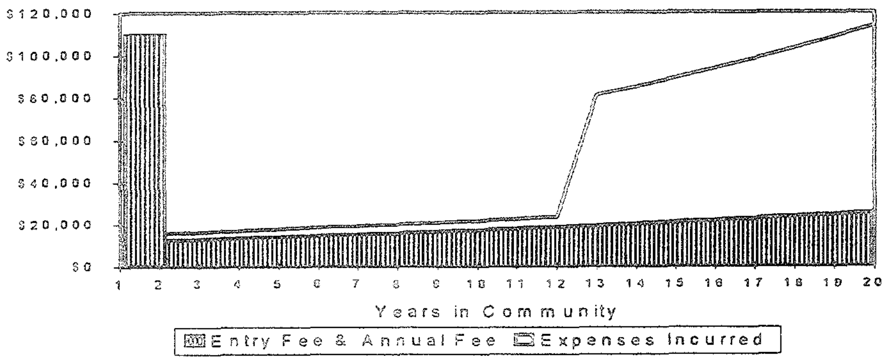
A continuing care contract is defined in the Continuing Care Contract Statutes (State of California Health and Safety Code, Division II, Chapter 10, Continuing Care Contracts, Section 1771) as "a written contract, which includes a promise by a provider to provide one or more elements of care to an elderly resident for the duration of his or her life or for a term in excess of one year, in exchange for the payment of an entrance fee, or payment of periodic charges or both types of payments. A continuing care contract may consist of one or a series of agreements and may have other writings incorporated by reference. A continuing care contract includes a life care contract as defined in subdivision (w)." A "life care" contract is defined as a continuing care contract that includes all levels of care, acute care services as well as nursing and residential services, and which contract provides that no change is made in the monthly fee based on level of service.

As further noted in the statutes, Section 1770, "Because elderly residents often expend a significant portion of their savings in order to purchase care in the retirement community and, thereby, expect to receive care at the retirement community for the rest of their lives, tragic consequences can result from a continuing care provider becoming insolvent or unable to provide responsible care." To detect financial problems before they emerge and to assure the financial viability of each continuing care retirement community in the state of California, the statutes require annual reporting and maintenance of certain reserves.

Figure 1 illustrates a hypothetical resident's fee structure compared to a life care community's cost of services on behalf of that resident. The

FIGURE 1

COMPARISON OF REVENUE AND EXPENSE STREAMS FOR A LIFE CARE RESIDENT



gap between fees and costs after the first year graphically portrays the reason reserves are required from CCRC entry fees.

The statutory method of estimating the reserves is based on the life expectancy of each resident. In Section 1792.2 (b)(1) of the Code, a "Table of Mortality" is presented that is actually a table of life expectancies. These life expectancies are developed from the experience of residents of CCRCs and are intended to reflect life expectancies of people residing in such communities. CCRC residents' life expectancies are not necessarily the same as those of people who do not reside in retirement communities.

The life expectancies currently contained in the statute were developed in 1980 by Teknekron, Inc., based on the mortality experience of continuing care contractholders residing in 47 California communities between 1970 and 1977. The statute provides that the California Department of Social Services (CDSS) adopt regulations to update this "Table of Mortality" by January 1, 1996.

Actuarial Forecasting & Research (AF&R) together with their prime subcontractors, Oliver & Shostak, were retained by the California Department of Social Services, Continuing Care Contracts Branch, under Contract #C34061, to update the life expectancy table contained in the statutes. The Department has maintained data on continuing care contractholders from 83 CCRCs since 1970. Utilizing records for 29,251 different residents who lived in the facilities at some time during the 1980–93 time period, AF&R developed the new table of life expectancies shown in Table 1. A description of the methodologies used, analyses of the data, and explanations of differences between the current table and the new table are contained in this report.

TABLE 1

LIFE EXPECTANCIES (IN YEARS)

Age	Females	Males	Age	Females	Males
55	26.323	23.635	85	6.956	5.475
56	25.526	22.863	86	6.494	5.124
57	24.740	22.101	87	6.054	4.806
58	23.964	21.350	88	5.613	4.513
59	23.199	20.609	89	5.200	4.236
60	22.446	19.880	90	4.838	3.957
61	21.703	19.163	91	4.501	3.670
62	20.972	18.457	92	4.175	3.388
63	20.253	17.764	93	3.862	3.129
64	19.545	17.083	94	3.579	2.903
65	18.849	16.414	95	3.329	2.705
66	18.165	15.759	96	3.109	2.533
67	17.493	15.116	97	2.914	2.384
68	16.832	14.486	98	2.741	2.254
69	16.182	13.869	99	2.584	2.137
70	15.553	13.268	100	2.433	2.026
71	14.965	12.676	101	2.289	1.919
72	14.367	12.073	102	2.152	1.818
73	13.761	11.445	103	2.022	1.723
74	13.189	10.830	104	1.899	1.637
75	12.607	10.243	105	1.784	1.563
76	12.011	9.673	106	1.679	1.510
77	11.394	9.139	107	1.588	1.500
78	10.779	8.641	108	1.522	1.500
79	10.184	8.159	109	1.500	1.500
80	9.620	7.672	110	1.500	1.500
81	9.060	7.188			
82	8.501	6.719			
83	7.952	6.269			
84	7.438	5.854			

Based on this study, these new life expectancy tables were enacted by statute to update and replace those found in Section 1792.2(b)(1) of the State of California Health and Safety Code, Division II, Chapter 10.

Cautions Regarding Use of Proposed Tables

The reader should be aware that these life expectancies, usable for calculating statutory reserves for CCRCs in the state of California, may not be appropriate for other uses such as pricing CCRC contracts, developing fee structures for new communities, or estimating future cash flows for any particular community. These estimates are based on aggregate statistics of residents across all durations and all types of communities. Different communities will exhibit different mortality patterns as evidenced by the range of expected to actual deaths among communities contributing to this study (from a low of 53% to a high of 213%). Life care communities averaged 11% lower mortality than nonlife care communities. Even within life care communities, mortality ratios varied from a low of 74.7% to a high of 127%. Also, newer communities averaged lower rates of mortality than older communities.

Another reason these statutory life expectancies should not be used to establish community fees or to predict future cash flows is that life expectancies generally fail to properly recognize that almost 1/3 to 1/2 of a cohort of individuals will live beyond their life expectancies. Only through the use of actuarial techniques, discounting each year's probability of survivorship times the cost of services should the resident survive to that year, can one accurately set adequate pricing structures. Thus, the use of these life expectancies for any purpose other than calculating statutory operating and refund reserves is strongly discouraged.

Finally, these life expectancies are measured from community reporting dates, not from resident entry dates. They do not take into account the period of residency between entry and the first community reporting date after a resident's date of entry.

Acknowledgments

In addition to the principal investigator, Hal Barney of Actuarial Forecasting & Research, the actuarial research team was led by co-investigator Marilyn Oliver and included Nan Shostak of Oliver & Shostak and Paul Weinberg and Heather Barbá of Actuarial Forecasting & Research. Significant contributions to this study were also made by Lidicker Consulting, SDV/ACCI, and Buckingham Impressions. We wish to express our appreciation to all those who supported this effort. In particular, we are indebted to the administrative staffs at the retirement communities themselves, whose data contributions and responsiveness to our questions throughout this process made this new table possible. We especially wish to thank the California Continuing Contracts Branch, headed by Mr. King Gee, for their patience, guidance, and informative assistance throughout this process. We also thank the Department of Social Services, Systems Group for their assistance. In the course of our data review, significant interchange between the actuaries, the individual facilities, and the California Continuing Care Contracts Branch was necessary. The results presented in this paper are made possible only through this teamwork of providers, agencies, actuaries, and systems people.

II. STATE CONTINUING CARE RETIREMENT COMMUNITY MORTALITY DATA

Overview of Data

The foundation for the updated life expectancies contained in this report is the CCRC resident data provided by the communities to the state of California as a part of their annual reporting process. This resident information is maintained by the Continuing Care Contracts Branch of the California Department of Social Services on an automated data collection system. That database contains the ages, sexes, dates of entry, and dates of death or withdrawal needed for the mortality rate development process described in the next section.

The current resident data reporting process has provided the state of California, the CCRC industry, and regulators with the country's largest database for estimating CCRC resident mortality. It fulfills this function with the cooperation of over 80 community administrations. This large, critical database is maintained by a small dedicated staff at the state level.

Goals of the Data Preparation

The validity of any mortality table is only as good as the data used to construct the table. Therefore, extensive data analysis, reconciliation, verification, and audit efforts were undertaken with respect to the state database to assure the accuracy, completeness, and appropriateness of the data used to develop the mortality rates. The goal was to make use of as many of the individual records as possible in the mortality table construction. The research team eliminated only those records for which they absolutely could not obtain complete data. Every effort was made to fill in missing dates or termination codes; to eliminate duplicate records; to insure that only continuing care contractholder data were included; to exclude non-CCRC residents such as "direct admits" to the nursing component of the community; to capture all deaths; and to determine for which periods of time at each community complete resident records were available. Extensive efforts were made to minimize introduction of any biases in the final data set due to the data correction process. Another objective was to keep track of all data corrections in order to enable the state's database to be corrected upon conclusion of this project.

The Data Validation and Correction Process

The data preparation began with the state's database and included screening for blank fields, matching potential duplicates and eliminating all but one record per individual residence at a community, performing reasonableness checks regarding dates of entry relative to dates of death or birth and analyzing patterns within each community of the number of new entrants, deaths, withdrawals, and residents from year to year. The second step involved contacting communities with questionable records or patterns for clarification or validation by reference to their original residents' files. Using the responses from the communities, data corrections were made to the researchers' copy of the state's CCRC database. Finally, the researchers set beginning and ending report dates for each community to define the period for which each community's data were considered complete and reliable enough to be included in the mortality study.

Data Audit

To determine if there were systematic data errors entering the database, the research team conducted a scientific test of the clean, post-1980 data against community-maintained records. Using statistical techniques for sampling (Cochran, W.G., 1977), the researchers selected a random sample of 500 records from ten homes to yield an acceptably small standard error. Every record in the database had an equal chance of being selected for an audit except that homes with fewer than 100 records were not included in the sample frame.

The following data items were tested:

- Date of Entry
- Date of Withdrawal
- Date of Birth
- Withdrawal Code
- Sex Code
- Name

A letter from the Continuing Care Contracts Branch informed the communities of the audit and listed records to be reviewed. Subsequently, researchers visited the ten communities. Community management provided the researchers with the requested records as well as office space in which to review them. These ten communities put extra effort into this study, and the research team wishes to acknowledge their outstanding cooperation and hospitality.

The results of the audit proved that the data were quite good and well within tolerance limits for accuracy. No systematic pattern of misreporting or understatement/overstatement of deaths was found in the audit.

Results of Data Preparation

This data verification, correction, and audit process began in July 1994 and continued into January of 1995. The end result was 29,251 useable records covering 138,019 years of exposure to the risk of death and 12,084 deaths. These records formed the basis for the mortality rates described in the next section of this report. Further details of the data preparation that took place prior to calculating life expectancies can be found in Appendix I, Data Preparation.

Demographic Shifts of CCRC Residents in the Database

The average age for female CCRC residents in the database increased from 83.3 in 1980 to 84.3 by the end of 1992 while the average age of male residents decreased slightly from 82.7 to 82.5 over the same period. At the same time, the average duration since entry to the community for males dropped from 5.6 years to 4.8 years and from 6.9 to 6.7 for females over the same period. This drop in duration since entry may be the result of recent expansions in facilities or the addition to the state's database of whole new facilities in the latter part of the study period.

Figures 2 through 5 illustrate the shifts in the distributions of residents in the database by age and by duration between 1980 and 1993. In calculating

FIGURE 2
CALIFORNIA CCRC POPULATION FEMALES AGE DISTRIBUTION

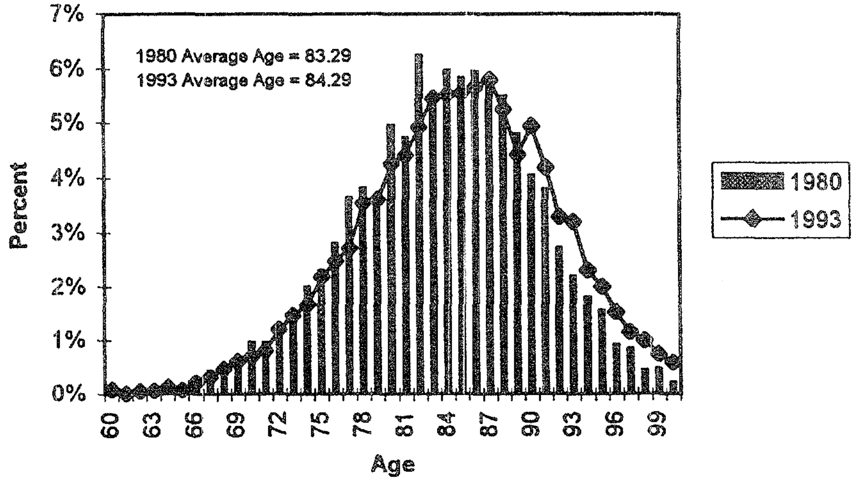


FIGURE 3
CALIFORNIA CCRC POPULATION MALES AGE DISTRIBUTION

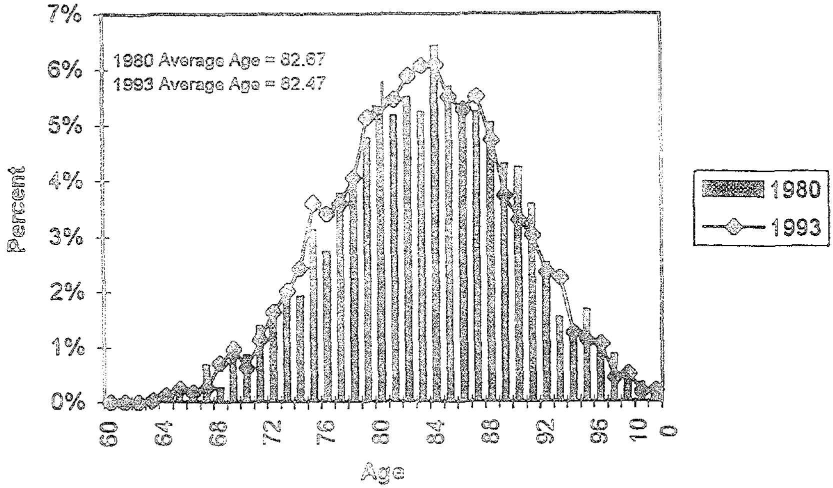


FIGURE 4
CALIFORNIA CCRC POPULATION FEMALES DURATION DISTRIBUTION

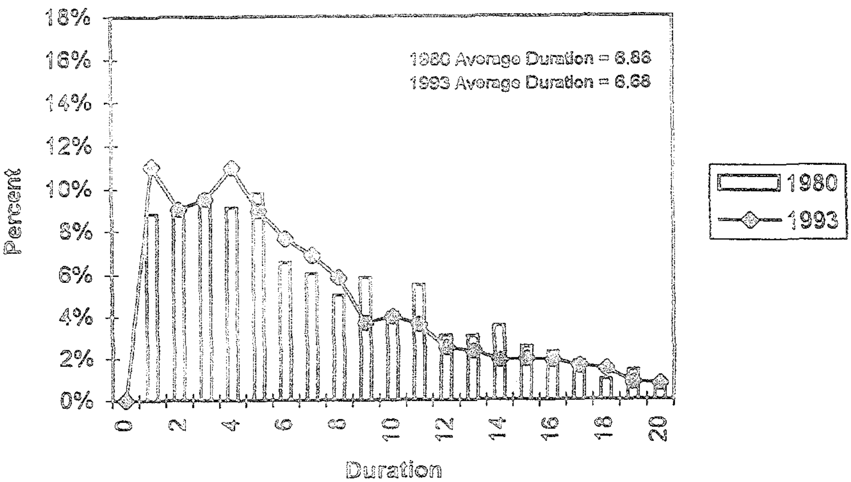
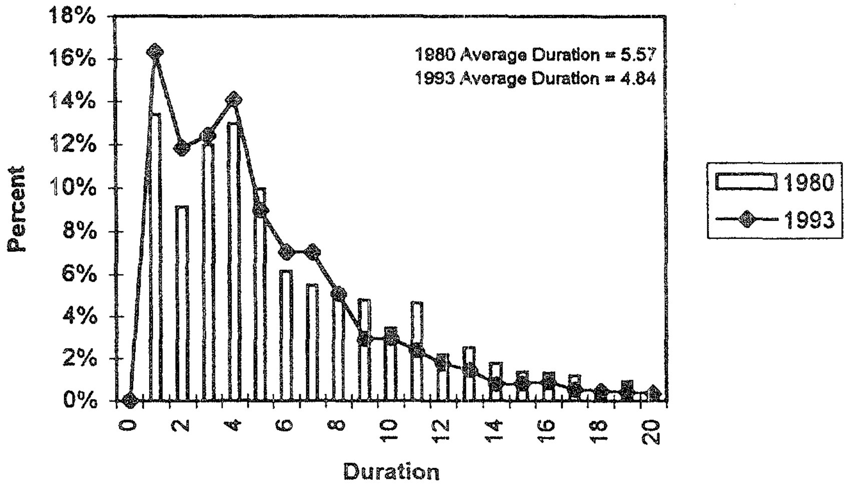


FIGURE 5
CALIFORNIA CCRC POPULATION MALES DURATION DISTRIBUTION



duration, periods of residency have been bridged when a participant either transferred between affiliated facilities (within 3 months) or left and reentered the same facility.

III. DEVELOPMENT OF MORTALITY RATES (q_x)

In order to create the new table of life expectancies for statutory reserving, it is first necessary to calculate rates of mortality based on the CCRC resident data. Mortality rates, expressed generally as the probabilities of dying in the next year, vary by numerous factors, most significantly: age, sex, and health condition. In this study, the researchers developed mortality rates for each sex and age. Since health condition data were not available, health was not considered.

Three steps were involved to develop the mortality rates underlying the life expectancy tables recommended in this study:

1. Calculation of initial (raw) mortality rates based on the corrected database
2. Analyses of the raw mortality rates
3. Smoothing of the raw mortality rates to eliminate random fluctuations.

Calculation of Raw Mortality Rates

The following formula was used to develop mortality rates separately for males and females.

Mortality Rate at Age x = (Number of Deaths at Age x)/(Exposure at Age x)

where "exposure" means the period of time between report dates during which residents age x as of the last report date could have died.

A "report-year" is the fiscal year used by each community for reporting data to the state. The exposure calculated for the report year is attributed to the age at the beginning of the report year.

Special rules were applied to report years that contained the study start date (1/1/80) or the study end date (12/31/93). No exposure was counted for any period of residency prior to the study start date nor after the study end date. In addition, exposures were not included prior to the first valid report date for each community nor after the last report date applicable to each specific community, that is, their last valid report date.

Two special considerations applied to exposure counts for this particular mortality study. First, because some residents both enter and die between two consecutive reporting dates and are therefore never reported, no deaths or exposures were counted from a resident's date of entry to the first reporting date following entry. To have done otherwise would have led to understated mortality rates. Second, because the reserve calculations are based on resident ages attained as of the reporting date, deaths and exposures were counted by age-last-birthday on the report date. These special considerations are described in greater detail in Appendix II.

The resulting "raw" mortality rates for males and females are graphed in Figures 6 and 7. Deaths, exposures and raw mortality rates (q_x's) are shown by age and sex in Appendix II.

Analyses of the Raw Mortality Rates

The statutory life expectancies vary only by sex and age. However, other factors influence CCRC resident mortality such as:

- Duration (elapsed time from entrance into a facility)
- Level of care (independent, assisted living, or nursing care)
- Type of contract (life care, fee-for-service,)
- Year of data.

FIGURE 6
RAW MORTALITY RATES—MALES

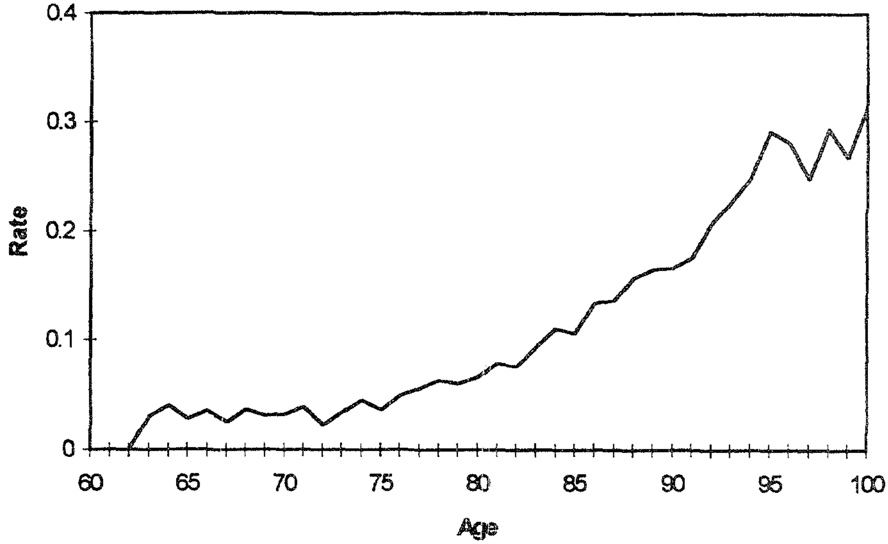
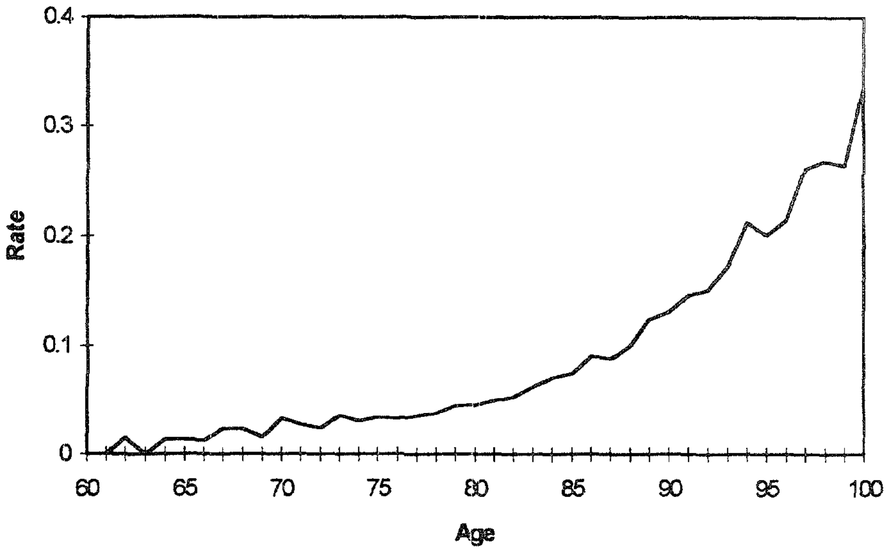


FIGURE 7
RAW MORTALITY RATES—FEMALES



To the extent possible, the researchers analyzed the impacts of these factors on the study results and made the following observations.

Duration

Because of the medical screening that occurs during the resident's application process and self-selection by those who choose to enter communities, new residents are, on average, healthier than individuals of the same age and sex who have been in the community for some time. Thus, resident mortality rates for new entrants are significantly lower than those of residents of the same age and sex who have been in the community longer. This duration effect, referred to as "selection" effect was noticeable in the 1980–1993 CCRC data and is illustrated in Table 2 for females by comparing the average mortality rates for those in a community four years or longer to the average mortality rates for residents in the same age group who have been in a community three years or less. Note the significantly lower mortality rates (21% to 35% lower) experienced by newer residents.

TABLE 2

MORTALITY RATES BY AGE AND DURATION GROUPINGS
FEMALES—1980–1993 DATA

Age Group	Average Mortality Rate for Durations 4 Years and Over (A)	Average Mortality Rate for Durations under 4 Years (B)	Ratio (B)/(A)
70–74	3.4%	2.7%	79%
75–79	4.1	3.2	78
80–84	6.2	4.4	71
85–89	10.1	6.8	67
90–94	16.3	10.6	65

The state's life expectancy tables and reserve process do not explicitly recognize this effect since duration in the community is not taken into account when looking up life expectancies for residents. Rather, life expectancies are developed on an aggregate basis, combining all duration exposures and deaths into a single mortality rate for a given age and sex. Recognition of duration, in addition to age and sex, would have the advantage of automatically adjusting reserve levels as average durations of CCRC contractholders residing in communities changed from those experienced during the 1980–93 period. However, to reflect duration as well as age and sex in the life expectancies has not been practical to date because:

1. There were not sufficient data to construct a table based on age, sex, and duration since entry into the community.
2. Use of a duration-based table would complicate the reserve calculation procedure, requiring more complex software on the state's part and more complicated lookup procedures for facilities to enter reserve factors for new entrants.

Level of Care

Continuing care retirement communities generally provide three levels of care: independent living, assisted living (personal care), and skilled nursing care. Since residence in the higher levels of care generally indicates poorer health, mortality rates tend to be higher at the higher health care levels. In fact, proprietary databases including Actuarial Forecasting & Research's (AF&R) CCRC resident database, indicate that health status, as measured by level of care, is probably the most significant determinant of CCRC resident mortality, and therefore it is important to recognize the distribution by health care level when:

- Analyzing statewide data for trends over time
- Using statewide rates to compare communities' experiences
- Using statewide rates to project specific community financial results.

Because the proportion of residents at each health care level varies from community to community and within individual communities over time, actuaries typically use different mortality tables for each health care level.

The data which California has collected to date do not include level of care or other resident health-related information. Without resident health status information, the researchers were not able to determine the proportion of residents in the state's database at various levels nor to analyze the impact on the mortality rates of the change in that distribution over time. The Continuing Care Contracts Branch has, however, started to collect health care level data effective with the 1994 fiscal year. In the future, data will be available to study mortality rates by care level.

Type of Contract

Life care contracts guarantee care for life in exchange for a relatively large entry fee plus the monthly fees, which fees are guaranteed will not increase on account of changes in health care needs. Mortality rates in these types of communities may be lower than in other communities for several reasons including (1) people who perceive their health to be better are more willing to elect to make the high initial lump sum payment ("self-selection"); (2) stricter medical screening standards may be applied at life care facilities ("health underwriting selection,"); and (3) the more comprehensive care provided at these facilities may increase longevity.

The researchers compared rates of mortality for 17 life care communities to 59 other California communities that do not issue life care contracts. The results, for females, are illustrated in Table 3. The average ages and durations shown are averages over the period 1980 through 1993.

TABLE 3

MORTALITY COMPARISON BETWEEN LIFE CARE AND NONLIFE CARE COMMUNITIES (FOR FEMALES)

	Life Care Communities			Other Communities			Ratio of Rates
Age Group	Average Age	Average Duration	Death Rate	Average Age	Average Duration	Death Rate	Other/ Life Care
70–79	75.9	4.6	3.0%	75.8	4.2	3.8%	1.27
80–89	84.3	7.1	7.1	84.5	5.8	7.7	1.08
90–99	92.8	9.1	16.8	92.8	7.8	17.8	1.06

The ratio of death rates (last column) indicates that mortality rates at nonlife care communities are higher on average than at life care communities. This occurs even though the average duration is lower for the "other" communities, a fact which would be expected to have the opposite result—namely to be accompanied by lower mortality rates (see Table 4). The average ages are quite similar so the differences cannot be attributed to age differences.

An analysis of variance test across all ages showed that the mortality rates for the "other" communities are statistically significantly higher than those of the life care communities at the 99% confidence level.

The proportion of life care communities in the study data has decreased since the 1970–77 study. Fourteen of these life care facilities were present in the last study, comprising 30% of the 46 facilities included in that study. Life care communities make up only 22% of the facilities included in this new study. This change in mix would be expected to increase total observed mortality rates.

Year of Data

Numerous studies have shown improvements in mortality for both males and females over long periods of time with substantial variation in the rate of improvement from period to period (Wilken, 1981; Berin, Stolnitz and Tenenbein, 1990; inter alia). Table 4 shows annual rates of mortality improvement for several periods based on two large groups: the Civil Service Retirement System (CSRS) and the Medicare System. Although demographically different from the CCRC population, their rates of improvement are indicators of potential improvements in mortality which might have been observed between the prior mortality study and the present study were it not for the many CCRC industry-specific shifts in mix taking place at the same time (including duration, level of care, and contract type as described above).

TABLE 4

COMPARISON OF ANNUAL IMPROVEMENT IN MORTALITY

Period	CSRS	Medicare
	Males	
1975–79	1.5%	2.1%
1981–84	1.6	1.0
1985–89	0.7	0.7
	Females	
1975–79	1.8%	2.8%
1980–84	0	0.8
1985–89	0	0.2

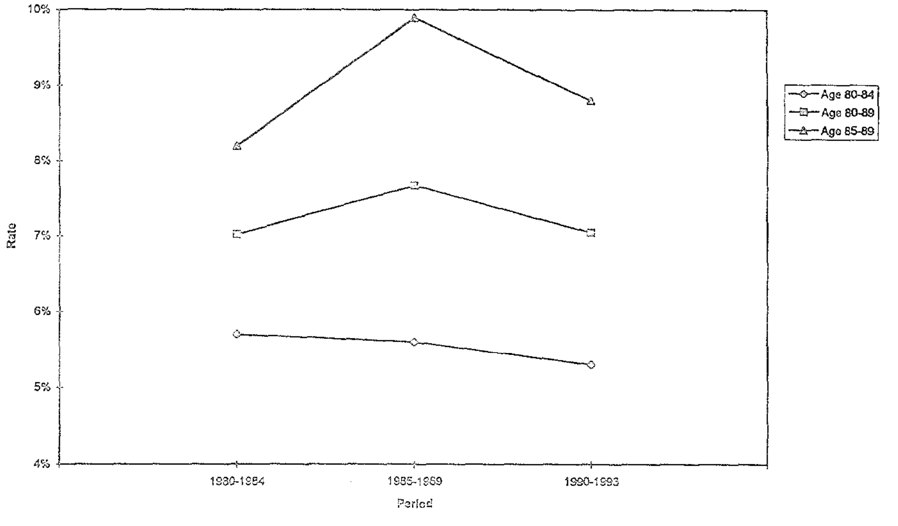
Source: *TSA 1991–92 Reports*.

Statistical tests were performed on the raw mortality rates for various time periods to determine whether mortality improvement could be detected in the California CCRC resident data. Males and females were tested separately for differences across all ages from 70 to 100 and for several specific age groupings. The results were inconclusive and conflicting.

Figure 8 uses females age 80 to 89 to illustrate theses conflicting results. Shown are average mortality rates for three time periods for females ages 80 through 84, 85 through 89, and in total (ages 80 through 90.) The results are not statistically significant based on the amount of data available.

The changes in mortality rates exhibited in Figure 8 are the result of many factors that apparently outweigh the trends in mortality rates for the population as a whole. These factors include those discussed in previous sections of this report such as the changes within the database distribution of residents by duration, health status, or contract type. The future progression of mortality rates observed among CCRC residents will be dependent on the complex interplay of the changes in these other factors over time, and, thus, does not lend itself to projection with an acceptable level of certainty. As a result, the researchers did not recommend a mortality improvement scale.

FIGURE 8
FEMALES AVERAGE MORTALITY RATES



Rather, the recommendation is to update the study in five years. At that time the state will have level-of-care data as well as five more years of resident data both of which will aid in the analysis of future trends. The use of a projection scale should be reconsidered at that time.

Smoothing of the Raw Mortality Rates

The probabilities of death (q_x's) based on the California retirement communities' raw data reflect the random effects of mortality at different ages. The result is the "peaks" and "valleys" observable in the graphs of mortality by age shown in Figures 6 and 7. Generally, mortality rates progress smoothly upward as age increases. The observed irregularities result from random variations in the sample data and are more pronounced at ages where there are less data.

The raw mortality rates were smoothed by applying the actuarial techniques described in Appendix II. The process involved different techniques at the low, high, and middle age ranges. This was because at the extremes, data were sparse while at the middle ages data were more credible. The Whittaker-Henderson method was used to smooth the mortality curve for the middle ages. At the higher ages, U.S. Life Table (for the Social Security Area) methodologies were used with a cap on mortality rates at 50%. At the lower ages, Gompertz curves were used to smooth the raw q_x's.

Results

Table 5 and Figures 9 and 10 show the results of this three-step smoothing (or, graduation) process and compare the resulting mortality rates to the raw rates of mortality based on the California resident database.

IV. LIFE EXPECTANCIES

The Recommended Life Expectancies

Based on the final (smoothed) mortality rates developed and shown in Section III, life expectancies were developed for use in setting statutory reserves under California Health and Safety Code Section 1792.2(b)(1). In actuarial notation, the formula for life expectancy (assuming a uniform distribution of deaths for each year of age) is:

$$\text{Life Expectancy at age } x = 1/2 + \Sigma_n p_x$$

where the sum starts at $n = 1$ and ${}_n p_x$ is the probability that a person age x survives to $(x + n)$.

Life expectancies based on this formula are shown in Table 6. The research team recommended that the new life expectancies replace the old life expectancies previously contained in Health and Safety Code Section 1792.2(b)(1) for use in calculating reserve requirements for continuing care retirement communities in California. The researchers also recommended that the tables in the statute include ages down to age 55 and up to age 110. Both recommendations were adopted.

These life expectancies are based on the experience of the broad range of CCRCs in the state of California. They may not be appropriate for other uses, such as pricing for individual facilities, estimating unit turnover or other projection purposes without considering attributes of the particular facility that will affect the mix of residents.

Life expectancies for females ages 109 and over and for males 107 and over are 1.5 due to the capping of the mortality rate at .5 at and above these ages. Further details on the calculation of these life expectancies can be found in Appendix III.

Comparison of New Life Expectancies to Other Tables

The research team compared the new life expectancies to life expectancies generated from other data sources and to the old life expectancy table found in the Code. Outside references included life expectancies experienced by the U.S. population as a whole, and life expectancies typical of individual insurance annuitants. The reference tables were the 1990 U.S. Life Tables

TABLE 5

FINAL MORTALITY RATES

	Male		Female	
Age	Raw	Graduated	Raw	Graduated
62	0.0000	0.0168	0.0154	0.0135
63	0.0303	0.0181	0.0000	0.0146
64	0.0401	0.0196	0.0135	0.0157
65	0.0279	0.0212	0.0131	0.0169
66	0.0356	0.0229	0.0121	0.0182
67	0.0252	0.0247	0.0231	0.0196
68	0.0373	0.0267	0.0227	0.0210
69	0.0312	0.0289	0.0153	0.0231
70	0.0322	0.0310	0.0324	0.0267
71	0.0392	0.0315	0.0267	0.0270
72	0.0224	0.0312	0.0232	0.0276
73	0.0343	0.0340	0.0354	0.0312
74	0.0449	0.0384	0.0301	0.0319
75	0.0367	0.0423	0.0331	0.0322
76	0.0488	0.0484	0.0318	0.0322
77	0.0554	0.0549	0.0344	0.0341
78	0.0630	0.0598	0.0370	0.0379
79	0.0599	0.0628	0.0443	0.0431
80	0.0656	0.0671	0.0455	0.0461
81	0.0786	0.0735	0.0494	0.0490
82	0.0754	0.0813	0.0524	0.0534
83	0.0934	0.0921	0.0618	0.0612
84	0.1104	0.1040	0.0702	0.0694
85	0.1058	0.1154	0.0742	0.0770
86	0.1338	0.1284	0.0904	0.0855
87	0.1371	0.1411	0.0878	0.0913
88	0.1576	0.1525	0.1007	0.1030
89	0.1658	0.1618	0.1244	0.1195
90	0.1669	0.1712	0.1311	0.1327
91	0.1762	0.1847	0.1463	0.1442
92	0.2070	0.2041	0.1513	0.1573
93	0.2269	0.2273	0.1734	0.1759
94	0.2500	0.2503	0.2133	0.1959
95	0.2921	0.2731	0.2009	0.2160
96	0.2816	0.2951	0.2152	0.2359
97	0.2492	0.3159	0.2617	0.2551
98	0.2940	0.3350	0.2684	0.2732
99	0.2684	0.3517	0.2645	0.2896
100	0.3136	0.3693	0.3355	0.3070
101	0.2667	0.3878	0.2569	0.3254
102	0.4338	0.4072	0.3776	0.3449
103	0.3750	0.4275	0.2169	0.3656
104	0.5000	0.4489	0.3750	0.3875
105	0.0000	0.4714	0.2727	0.4108
106	0.0000	0.4949	0.2381	0.4354
107	0.0000	0.5000	0.0000	0.4615
108	0.0000	0.5000	0.0000	0.4892
109	0.0000	0.5000	0.0000	0.5000
110	0.0000	0.5000	0.0000	0.5000

FIGURE 9
MORTALITY RATES—MALES

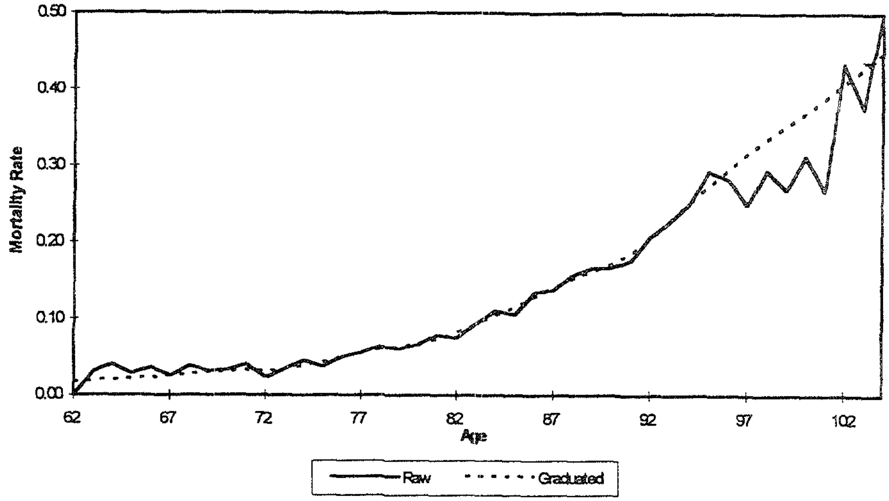


FIGURE 10
MORTALITY RATES—FEMALES

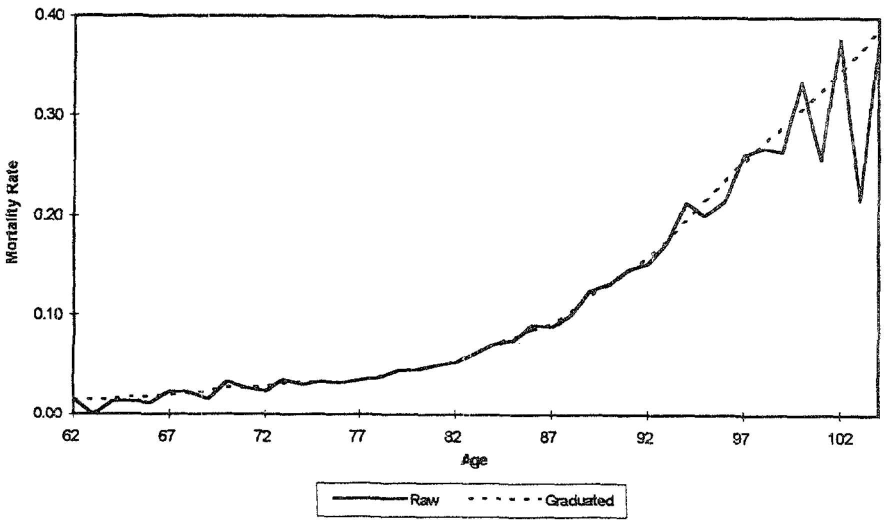


TABLE 6

CALIFORNIA CCRC LIFE EXPECTANCIES

	Males		Females	
Age	Old	New	Old	New
55		23.635		26.323
56		22.863		25.526
57		22.101		24.740
58		21.350		23.964
59		20.609		23.199
60		19.880		22.446
61		19.163		21.703
62	17.803	18.457	23.392	20.972
63	17.289	17.764	22.653	20.253
64	16.769	17.083	21.911	19.545
65	16.244	16.414	21.167	18.849
66	15.715	15.759	20.418	18.165
67	15.180	15.116	19.666	17.493
68	14.642	14.486	18.910	16.832
69	14.099	13.869	18.153	16.182
70	13.553	13.268	17.394	15.553
71	13.004	12.676	16.636	14.965
72	12.452	12.073	15.878	14.367
73	11.897	11.445	15.117	13.761
74	11.340	10.830	14.387	13.189
75	10.780	10.243	13.663	12.607
76	10.217	9.673	12.954	12.011
77	9.661	9.139	12.293	11.394
78	9.146	8.641	11.635	10.779
79	8.653	8.159	10.998	10.184
80	8.173	7.672	10.391	9.620
81	7.717	7.188	9.803	9.060
82	7.301	6.719	9.233	8.501
83	6.899	6.269	8.713	7.952
84	6.500	5.854	8.221	7.438
85	6.109	5.475	7.758	6.956
86	5.755	5.124	7.335	6.494
87	5.432	4.806	6.930	6.054
88	5.117	4.513	6.525	5.613
89	4.818	4.236	6.128	5.200
90	4.551	3.957	5.762	4.838
91	4.310	3.670	5.437	4.501
92	4.079	3.388	5.126	4.175
93	3.859	3.129	4.829	3.862
94	3.649	2.903	4.546	3.579
95	3.449	2.705	4.276	3.329
96	3.258	2.533	4.019	3.109
97	3.077	2.384	3.776	2.914
98	2.905	2.254	3.544	2.741
99	2.742	2.137	3.325	2.584
100	2.587	2.026	3.118	2.433
101		1.919		2.289
102		1.818		2.152
103		1.723		2.022
104		1.637		1.899
105		1.563		1.784
106		1.510		1.679
107		1.500		1.588
108		1.500		1.522
109		1.500		1.500
110		1.500		1.500

for the Social Security Area, and the Basic Table for the 1983 Individual Annuitant Mortality Table published by the Society of Actuaries.

The first table represents expected mortality rates in 1990 of Medicare recipients, including both healthy and disabled recipients. The second table represents expected mortality rates in 1983 among individuals holding annuity policies.

Ratios of the new California CCRC life expectancies to those in these other tables are shown in Table 7 for various ages. The new CCRC life expectancies fall between those applicable to the general population (U.S. Life Table) and those applicable to individual annuity purchasers (1983 IA Basic). The new life expectancies are longer than the U.S. Life Table life expectancies and shorter than individual annuitant tables.

TABLE 7

RATIO OF RECOMMENDED LIFE EXPECTANCIES TO LIFE EXPECTANCIES FROM OTHER MORTALITY TABLES

	Males		Females	
Age	U.S. Life Table	1983 IA Basic	U.S. Life Table	1983 IA Basic
72	1.16	0.96	1.06	0.95
77	1.14	0.95	1.09	0.98
82	1.12	0.93	1.10	1.00
87	1.07	0.89	1.09	0.99
92	1.02	0.85	1.06	0.95

Comparison to Current Statutory Table

The updated life expectancies reported in this paper are shorter than those previously used in the State Statutes, Section 1792.2 (b)(1). Statistical analyses show that the data used for this report are almost certainly drawn from a population that exhibits different mortality characteristics from those of the 1970–77 study. Figures 11 and 12 illustrate the number of deaths for males and females that would have been expected for the population in the retirement communities between 1980 and 1993 based on the state mortality rates applied to that population, compared to the actual deaths at each age that were counted for that same population. A chi-square goodness-of-fit test was conducted which indicated better than a 99.9% likelihood that the underlying mortality rates in these two studies are different.

The factors that contribute to the new life expectancies being different from the old life expectancies can be grouped into two categories: data differences and methodological differences.

FIGURE 11
EXPECTED DEATHS TO ACTUAL DEATHS—MALES 1980–93

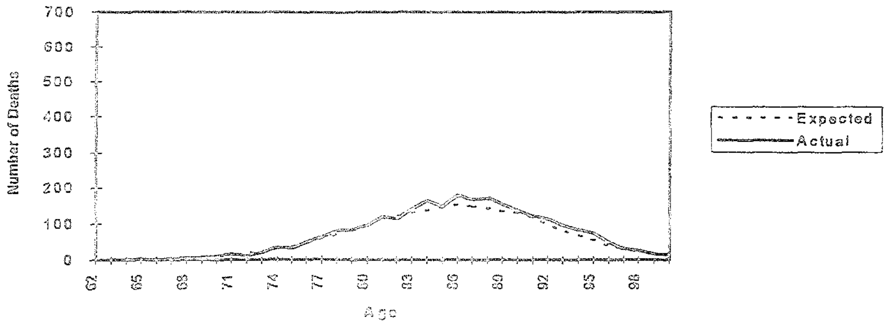
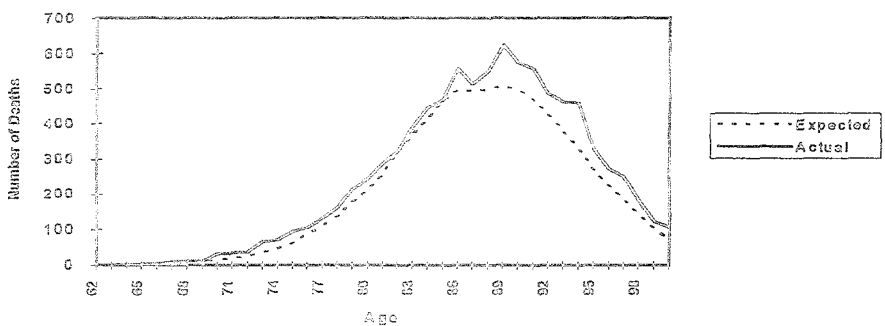


FIGURE 12
EXPECTED DEATHS TO ACTUAL DEATHS—FEMALES 1980–93



Data differences are true differences in the make-up of the populations under study in the two different time periods, including:

1. General improvements or deprovements in underlying population mortality
2. Changing mix between community types (life care versus continuing care)
3. Changing mix between healthy and unhealthy residents in communities
4. Different volume of data in the two studies.

Methodological differences include:

1. New life expectancies calculated on age-last birthday versus age-nearest birthday basis

2. Treatment of exposures and deaths prior to the first report date after entry
3. Different graduation techniques at the high and low ends of the mortality curves.

After adjusting for the methodological differences, the new life expectancies remain below those of the prior study. These differences and their relative impacts are described in greater detail in Appendix III, notes for comparing the 1970–77 study to this study.

Impact on Reserves

Statutory reserves calculated with these new life expectancies will average 9.9% less than with the old table but will more accurately reflect the future lifetime of today's average California CCRC resident.

Conclusions and Recommendations

The research team recommended adoption of these new life expectancies for calculating statutory and refund reserves for California CCRCs. The following were also recommended:

1. Extend the life expectancy table down to age 55 to provide values for younger spouses of residents who may enter communities under age 60.
2. Extend the life expectancy table to 110 as more residents are reaching the century mark than in earlier years. Zero life expectancies should not be applied at any age.

APPENDIX I
DATA PREPARATION

The California Data Collection Process

The state's automated data collection process used for CCRC reserve reporting was installed following the 1970–77 mortality study. The prior researchers (Teknekron, Inc.) had cleaned and verified data from 1970 through 1977, established a computer system for future tracking and provided the state with an up-to-date database through 1977. Information is not available to determine how records were maintained in the late 1970s but sometime in either 1980 or 1981, a computer program, based on batch processing of complete records and written in COBOL, was up and running.

The resident data are collected by the state in the annual reporting process described in detail in the Department of Social Services' booklet "Annual

Report Instructions and Forms." The Continuing Care Contracts Branch starts the process each year by mailing the annual reserve calculation booklet to communities along with a listing of current residents as of the previous fiscal year-end. This mailing takes place generally within a month of the community's year-end.

For each resident reported at the end of the previous fiscal year, the Continuing Care Contracts Branch provides the following data: resident name (last, first), sex, life expectancy, birthdate, entry code, entry date, depart code, depart date, and status. Each community is expected to update its listing and return it, along with the reserve calculation worksheets, to the Continuing Care Contracts Branch within four months after its fiscal year-end. A new community begins the data collection process by sending the Continuing Care Contracts Branch a list of new entrants still residing in the community as of its first fiscal year-end. If operations begin during the last portion of the year, the Continuing Care Contracts Branch will defer data reporting until the end of the first complete fiscal year.

The Projected Life Cost and Projected Life Revenue elements of the statutory reserve calculations are based on statutory life expectancy values, individually applied to continuing care contractholders in residence as of the end of the fiscal year. The Continuing Care Contracts Branch automatically lists the current life expectancies for all residents on the listing based on the resident's sex and attained age (that is, age as of last birthday) as of the fiscal year-end.

Communities note any changes in the resident population during the fiscal year (new entrants, deaths, withdrawals, transfers). Any change to a resident's record, such as a change in name, recording of a death or correction to a previously miscoded item, is indicated by drawing a line through the entire record and marking an "X" in the status field. The corrected record, rewritten in its entirety, is added at the bottom of the listing along with new entrant records. Beginning with mid-1994 mailings, communities are also required to indicate status (1 = independent living; 2 = assisted living; 3 = skilled nursing; and 4 = acute care). In the future, the Continuing Care Contracts Branch will track changes in this status field.

After the Continuing Care Contracts Branch staff review the listing and reconcile it to the resident totals reported in the reserve calculations, data processing staff enter changes to the listing into the mainframe database: new entrant records are added, exiting records (deaths, withdrawals) are recoded, "X" records are deleted, and change records are added. This process is an ongoing one; the batch processing takes place as data are received throughout the year.

System Enhancement Recommendations

The 15-year-old computer system could benefit from more recent technological advancements to become even more efficient while reducing the opportunities for errors to creep into the database. The researchers recommended consideration of the following enhancements to reduce staff time at both the state level and at the communities while better meeting the objectives of the database:

- Add the ability to capture changes in health care level without overwriting the original record.
- Add the ability to retain deleted ("X") files for later reconciliation.
- Enable the system user to edit a single field without deleting and reentering an entire record.
- Enhance the system to allow optional electronic transfer of data from the state to the community and back to the state.
- Assign unique identification numbers to every resident in the system.
- Add logic to the system to flag problem records immediately on entry by testing for reasonableness of dates of entry, birth, or withdrawal.

Data, Software, and Procedures

The existing state data, after verification and correction, provided the starting point for calculating CCRC resident mortality. The total number of records from the system sent to Actuarial Forecasting & Research was 41,791; the number of different community identification codes was 85. (Two codes were duplicates, leaving 83 reporting communities.) These records comprised the Continuing Care Contracts Branch's database as updated to July 18, 1994.

An alternative data approach for this mortality study would have been for the researchers to reconstruct the resident data directly from all 83 communities. This would have entailed reviewing their annual filings with the state since the last mortality study, and keypunching, verifying, and reconciling all data. If state filings were not available, individual resident files would have been reviewed. Given that copies of the state listings were unavailable for most communities back more than three to seven years and given the quality of the state data (90% of the state data was in fine shape), this alternative was ruled out in favor of using the state's data with corrections.

The researchers used Paradox database software for the data transfer, data analysis, and counting of exposures and deaths. Programming for the data verification, correction, and analysis was done in the Paradox Application Language (PAL). For mortality rate analyses, graduation of the raw mortality rates and comparisons with other mortality tables (the actual/expected ratios), the researchers used spreadsheets including Microsoft's Excel and Borland's Quattro Pro. The Whittaker-Henderson graduation program was written by Scott Dennison, FSA.

The research team devised a set of procedures for comprehensive data checking, data verification, and overall data reasonableness. Throughout the data preparation phase of the project, the aim was to create an accurate database with an audit trail from raw to final data.

The research team performed the following tasks for data preparation and analysis:

- Created unique record identification codes. This distinguished records from residents since there were multiple records for some residents.
- Performed a community-by-community test for reasonableness of recorded data which involved counting new entrants, deaths, withdrawals, and total residents for each calendar year from 1970 through 1993.
- Screened the data for missing information in certain key fields such as entry date, date of birth, date of withdrawal or type of withdrawal.
- Tested for possible data errors (for example, entry age over 90 or under 60).
- Tested for unreasonable dates such as entry or birth date after withdrawal date.
- Performed numerous field matches to identify possible duplicate transfer records.
- Developed a systematic data cleaning program.
- Produced individual resident listings by community of questionable records, sent listings to communities for correction or verification by administrative staff and input the information upon return of the listings from the communities.
- Entered data corrections and verifications received from communities and coded the source of correction for future review or audit.
- Repeated the community-based testing to identify problems specific to individual communities.
- Contacted specific communities that had unusual resident population patterns or that had not responded to previous correspondence.

Error Analysis

After initial testing for blank fields or unlikely dates, the research team ran a program to count beginning-of-year residents, new entrants, deaths, withdrawals, transfers, and end-of-year residents by calendar year for each community in the database. These histories revealed certain inconsistencies within communities such as years with no reported deaths, years with unusual increases in deaths or new entrants, or overall problematic areas within specific community data sets. The researchers found 6,470 possible problems involving 5,519 records during this initial testing.

Problems fell into two categories: possible field errors and cross-reference problems (Table I-1).

TABLE I-1

DATA PROBLEMS IN FULL DATA SET

Type	Count	Percentage
Possible Field Errors	3,972	61.4%
Cross-Reference Problems	2,498	38.6
Total Errors	6,470	100.0%

Possible field errors included blank fields, missing data, or questionable dates of birth, entry or withdrawal. Cross-reference problems included any pair of records that might be duplicate records for the same person or alternatively represent a transfer between facilities.

The state's database included residents in communities between 1970 and the last fiscal year-end report. An analysis of reported deaths revealed that, of 1,201 death records that were also missing the date of birth, 924 had 1978 or 1979 as the date of death. This odd clustering of deaths of people for whom no date of birth was available suggested that there might have been overreporting of deaths in 1978 and 1979 coupled with underreporting in previous years. Since resident records for the 1970s are no longer available, the decision was made to begin the study period no earlier than January 1, 1980. Therefore the researchers deleted all records with known (certain) dates of withdrawal before January 1, 1980, except those that might form a transfer match with other records having a withdrawal date on or after January 1, 1980. Some 30,830 records remained in the post-1980 data set.

Table I-2 shows the number and types of data problems remaining in the post-1980 data.

TABLE I-2

DATA PROBLEMS IN THE POST-1980 DATASET

Errors	For All Records		For Death Records	
	Count	Percentage	Count	Percentage
Blank date of birth	233	6.0%	159	7.7%
Blank date of entry	98	2.5	49	2.4
Withdrawal code but no withdrawal date	198	5.1	64	3.1
Blank sex code	69	1.8	30	1.5
Verify sex code and date of birth	35	0.9	20	1.0
Withdrawal date but no withdrawal code	1	0.0		0.0
Date of withdrawal before date of entry	66	1.7	59	2.9
Entry age before 60	106	2.7	33	1.6
Entry age after 90	1,163	29.8	607	29.5
Blank first name	30	0.8	20	1.0
Blank last name	1	0.0	1	0.0
Incorrect withdrawal code	42	1.1		0.0
Incorrect date of entry	16	0.4	11	0.5
Incorrect date of withdrawal	1	0.0	1	0.0
Date of entry before date of birth	8	0.2	5	0.2
Date of withdrawal before date of birth	4	0.1	4	0.2
Potential duplicates	1,235	31.6	777	37.8
Potential transfers	601	15.4	215	10.5
Total	3,907	100.0%	2,055	100.0%

Lists were prepared and mailed to each community with their data problems identified. Community administrators corrected or verified the data and returned the listings to the researchers for input into the corrected data set.

Final Data Correction and Analysis

The research team received corrected error listings from communities and entered the new information into a data correction file together with assigned "action codes" and comments. Certain action codes indicated complete verification by the community (no further action needed); others were marked for a second review at a higher level and/or follow-up for further information from the community.

The researchers combined matching records into single, continuous records for individuals who had transferred to another community in an affiliated group within three months after leaving the first community. Residency in a community either outside the affiliated group or within the group but more than three months after terminating residency in the earlier community was considered a new period of residency, not a transfer. In these situations, separate records for the same individual were kept in the database.

The researchers reran the reasonability checks on all communities to view each community's data as corrected. In a number of cases, they contacted specific communities for further information.

For the final follow-up with communities, the researchers contacted about half of the communities for more information where the recorded data indicated missing deaths or other systematic reporting/recording errors. For example, one community systematically underreported deaths to the state since its residents transfer out of the community to an off-campus skilled nursing facility or hospital before death. Another community reported deaths only upon the death of the second member of a couple (when the residential unit was resold and equity transferred).

Based on the new information provided by the communities, the research team made specific corrections to records in the database to the maximum extent possible. Even after these efforts, not all of the data from some communities were usable, and adjustments were made to define the periods for which the researchers considered the data valid for use in the mortality rate development. In Table I-3, adjusted data reporting periods are indicated for 15 communities together with the reason for the adjusted period in place of the actual reported periods.

TABLE I-3

ADJUSTED DATA REPORTING PERIODS

Home	Usable Period	Reason
1	None	Too new
2	12/31/89–12/31/92	Only valid reports
3	6/30/87–6/30/93	Only valid death reports
4	12/31/90–12/31/91	Only valid reports
5	6/30/89–6/30/90	Unverifiable reports before 1989
6	None	No on-site skilled nursing facility—Underreported deaths
7	1/31/86–1/31/94	Earlier data distorted by direct admits
8	None	Unable to contact
9	None	No deaths reported
10	12/31/79–12/31/93	Used all, but note understated deaths/no on-site skilled nursing facility until 1989
11	12/31/84–12/31/93	Deaths recorded for 1984 are understated
12	12/31/84–12/31/93	Deaths recorded for 1984 are understated
13	12/31/84–12/31/93	Deaths recorded for 1984 are understated
14	12/31/83–12/31/92	No death reports prior to 12/31/83
15	None	Deaths systematically underreported

With these final adjustments to define periods of usable data from each home, the database was ready for developing mortality rates as discussed in Section III.

APPENDIX II
TECHNICAL NOTES ON CALCULATION OF MORTALITY RATES

Calculating Raw Mortality Rates

The following formula was used to develop mortality rates separately for males and females.

q_x = Mortality Rate at Age x
= (Number of Deaths at Age x) / (Exposure at Age x)

where "Exposure" means the period of time between report dates during which residents' deaths could have been reported.

Exposures were calculated for each age and sex as outlined below. A "report year" is the fiscal year used for reporting data to the state. The exposure calculated for each report year was attributed to the age at the beginning of the report year.

Status at Beginning of Report Year	Status at End of Report Year	Exposure
Resident	Resident	1 Year
Resident	Dead	1 Year
Resident	Withdrawn	Elapsed time from beginning of year to date of withdrawal
Not resident, enter facility during year	Residing or Dead or Withdrawn	0 (zero exposure)

Special rules were applied to report years that contained the study start date (1/1/80) or the study end date (12/31/93). No exposure was counted for any period of residency prior to the study start date nor after the study end date. In addition, exposures were not included prior to the first valid report date for each community nor after the last report date applicable to each specific community, that is, their last valid report date as noted in Appendix I.

Consider the following example. Assume there are 12 female residents aged 60 at the beginning of a report year in the mortality study. If all 12 survived one year to the next report date, the exposure attributed to age 60 would be 12. The total deaths between the report dates would be divided by this exposure to calculate the mortality rate for age 60, which in this case would be 0, since no deaths occurred among those who were aged 60 at the beginning of the report year. If one of the residents died three months before the end of the report year, the exposure to death would still be one year. However, the mortality rate would now be 1/12, or 8.3%. On the other hand, if the same resident moved out of the community halfway through the year, her exposure to the risk of death while at the facility would be one-half year, and her death after that date would not be taken into consideration.

Special Considerations

Special adjustments to the exposure counting procedure were necessary due to the manner in which the data in the CCRC database is reported. The first adjustment was necessary because information contained in the database is updated at the end of each facility's fiscal year as part of the reserve calculation process. Since reserve calculations are only required for individuals in residence on that date, new residents entering during the fiscal year are often reported only if they survive to the first reporting date (end of fiscal year) after entry. Including survivors for this period (on average 1/2 year) in the exposure calculation while missing most deaths that occur during this initial exposure period would lead to an understatement in mortality rates and an overstatement of life expectancies. To alleviate this problem, exposures for new residents were counted only from the start of the first report date following entry. The resulting life tables are then consistent with the application of the rates because reserves are calculated only for those who survive to the end of the community's fiscal year.

The second adjustment was made so that the definition of age in the measurement of exposures and deaths would be consistent with the age used when the mortality rates are later applied in practice. In the mortality table construction process, the researchers calculated ages on the same basis that communities use when calculating statutory reserves. This reserve calculation is based on the resident's age as of the last birthdate prior to the facility's fiscal year-end. That is, when referring to an age 80 mortality rate one is actually referring to a mortality rate applicable to people age 80 to (but not including) age 81 at the beginning of the year. On average, these people are age 80.5. The result is mortality rates that are, on average, based on data for residents 1/2 year older than an exact (or integer) age. This 1/2 year age adjustment is important when comparing these mortality rates to other tables of mortality where the rates may be expressed for people at exact ages (i.e., 80.000).

Results

Deaths, exposures, and initial probabilities of death (raw mortality rates) are shown by age and sex in Table II-1. These raw rates fluctuate considerably below age 70 and above age 94. At the extreme ages, there are fewer exposures (i.e., less data), and the random nature of death can cause a few

TABLE II-1

INITIAL MORTALITY RATES

Age	Males			Females		
	Exposure	Deaths	Rate	Exposure	Deaths	Rate
60	5	0	0.0000	30	0	0.0000
61	8	0	0.0000	40	0	0.0000
62	22	0	0.0000	65	1	0.0154
63	33	1	0.0303	107	0	0.0000
64	50	2	0.0401	148	2	0.0135
65	72	2	0.0279	230	3	0.0131
66	112	4	0.0356	330	4	0.0121
67	159	4	0.0252	433	10	0.0231
68	187	7	0.0373	573	13	0.0227
69	257	8	0.0312	785	12	0.0153
70	341	11	0.0322	1,019	33	0.0324
71	434	17	0.0392	1,271	34	0.0267
72	536	12	0.0224	1,553	36	0.0232
73	642	22	0.0343	1,923	68	0.0354
74	780	35	0.0449	2,362	71	0.0301
75	899	33	0.0367	2,837	94	0.0331
76	1,046	51	0.0488	3,337	106	0.0318
77	1,155	64	0.0554	3,871	133	0.0344
78	1,302	82	0.0630	4,350	161	0.0370
79	1,403	84	0.0599	4,902	217	0.0443
80	1,479	97	0.0656	5,405	246	0.0455
81	1,553	122	0.0786	5,845	289	0.0494
82	1,538	116	0.0754	6,150	322	0.0524
83	1,531	143	0.0934	6,295	389	0.0618
84	1,503	166	0.1104	6,363	447	0.0702
85	1,417	150	0.1058	6,331	470	0.0742
86	1,353	181	0.1338	6,187	559	0.0904
87	1,225	168	0.1371	5,856	514	0.0878
88	1,098	173	0.1576	5,470	551	0.1007
89	941	156	0.1658	5,025	625	0.1244
90	833	139	0.1669	4,387	575	0.1311
91	698	123	0.1762	3,814	558	0.1463
92	551	114	0.2070	3,219	487	0.1513
93	423	96	0.2269	2,671	463	0.1734
94	332	83	0.2500	2,157	460	0.2133
95	250	73	0.2921	1,637	329	0.2009
96	174	49	0.2816	1,273	274	0.2152
97	124	31	0.2492	967	253	0.2617
98	88	26	0.2940	682	183	0.2684
99	63	17	0.2684	465	123	0.2645
100	48	15	0.3136	319	107	0.3355
101	30	8	0.2667	199	51	0.2569
102	21	9	0.4338	130	49	0.3776
103	8	3	0.3750	83	18	0.2169
104	4	2	0.5000	56	21	0.3750
105	2	0	0.0000	33	9	0.2727
106	2	0	0.0000	21	5	0.2381
107	2	0	0.0000	13	0	0.0000
108	1	0	0.0000	7	0	0.0000
109	1	0	0.0000	5	0	0.0000
110	1	0	0.0000	3	0	0.0000

more or less observed deaths to swing the initial rates widely even though the true rate of mortality follows a much smoother curve by age. At the middle ages, where there are more exposures, the rates follow smoother curves.

Smoothing of the Raw Mortality Rates

The research team considered several methods to smooth (graduate) the raw mortality rates including fitting mathematical mortality formulas such as Makeham or Gompertz curves to the data, using functions of existing standard mortality tables or using other smoothing techniques based on numerical analysis and finite differences. Over the age ranges where the data are credible and already fairly smooth, the Whittaker-Henderson method was chosen as the primary method for graduation. This method allows a balance between smoothness of the curves and closeness of fit to the data. Smoothness is defined in terms of rates of change in the third differences of final graduated rates. The degree of fit is defined as the sum of the squares of the differences of the original and the smoothed values. The degree of fit at each age is weighted by the standard error of the data at that age thereby assuring that the resulting curve will more closely fit the raw data at the ages with the greatest exposure counts while not being forced to pass as closely to those data points where experience is more limited. To achieve this balance between smoothness and fit, the Whittaker-Henderson method smoothes values by minimizing the function:

$$\Sigma w_t(q_t - q_t'')^2 + k\Sigma(\Delta^3 q_t)^2$$

where k is the relative importance given to smoothness and w_t is the weight (standard error) assigned at each age to the difference between the smoothed values and the raw data.

The value chosen for the smoothing parameter (k) was 10,000, producing graduated q's by age that are fairly smooth across all ages while preserving closeness of fit to the observed rates at most ages (except those with unusually low or high observed rates of mortality relative to the values at ages to either side of them.)

The researchers applied the Whittaker-Henderson method directly to ages where the raw data were credible and already fairly smooth. For males, this was between the ages of 75 and 95. For females, this was from ages 70 to 95. Below age 70 for females, below age 75 for males, and above age 95 for both males and females, other techniques were required to produce smooth curves as described below.

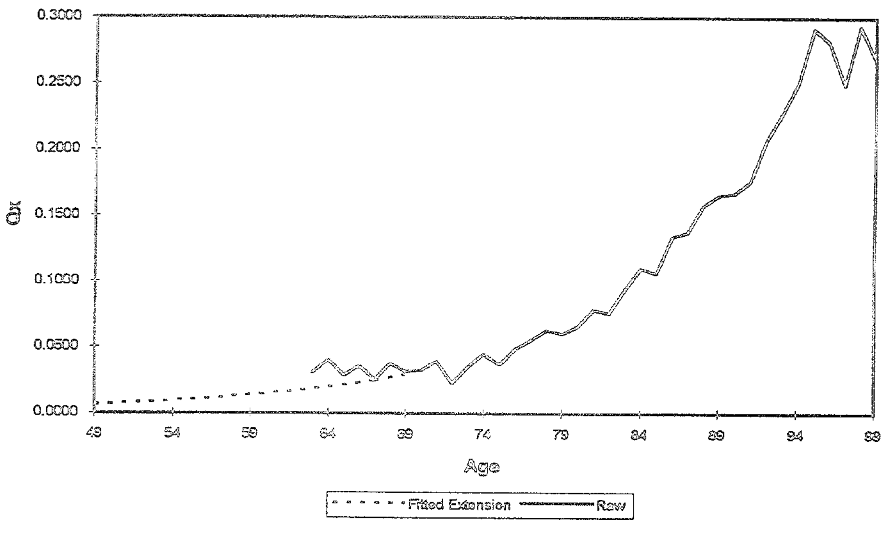
Low Ages

Due to the sparcity of data at the low end of the age range, the raw rates of mortality were smoothed by fitting Gompertz curves to the data up to age 74 for females and 79 for males. The raw mortality rates at the low ages indicated some flattening out as ages declined which could best be replicated using the Gompertz curve. This apparent flattening at the younger ages is at a higher level than found in most annuitant mortality tables. One possible explanation is that people entering retirement communities below age 70–75 do so for some health related reason. Their vital capacity may more closely match the normal vital capacity of older entrants who are normally between ages 75 and 80. The best fit for males was found using the Gompertz exponential equation for the force of mortality μ at age x,

$$\mu_x = bc^x \text{ with } b = .00013287 \text{ and } c = 1.081318.$$

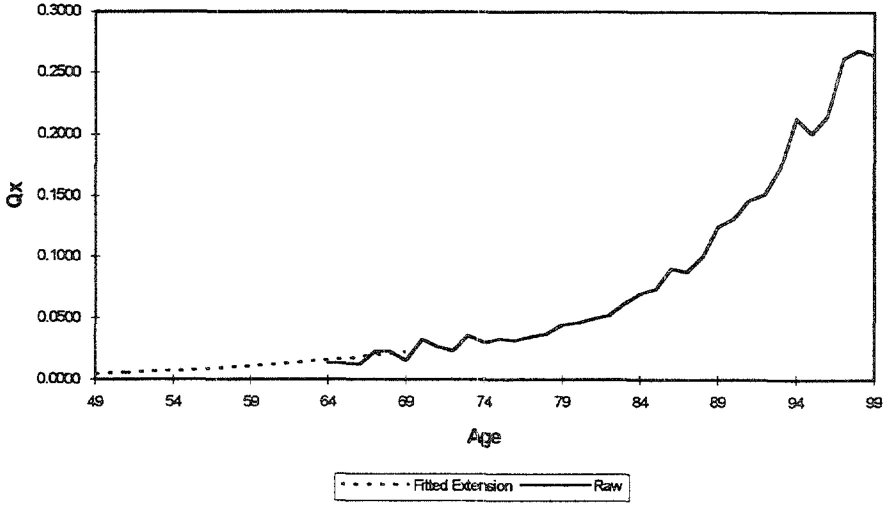
Figure II-1 shows how the raw data have been smoothed and extrapolated from age 70 down to age 49 for males.

FIGURE II-1
LOW AGE CURVE FITTING—MALES



Two separate forces appear to be at work on female mortality at the younger ages (Figure II-2). One force is the normal mortality process associated with aging. The other force creates a clear and statistically significant difference between mortality for people recently moving into retirement

FIGURE II-2
LOW AGE CURVE FITTING—FEMALES



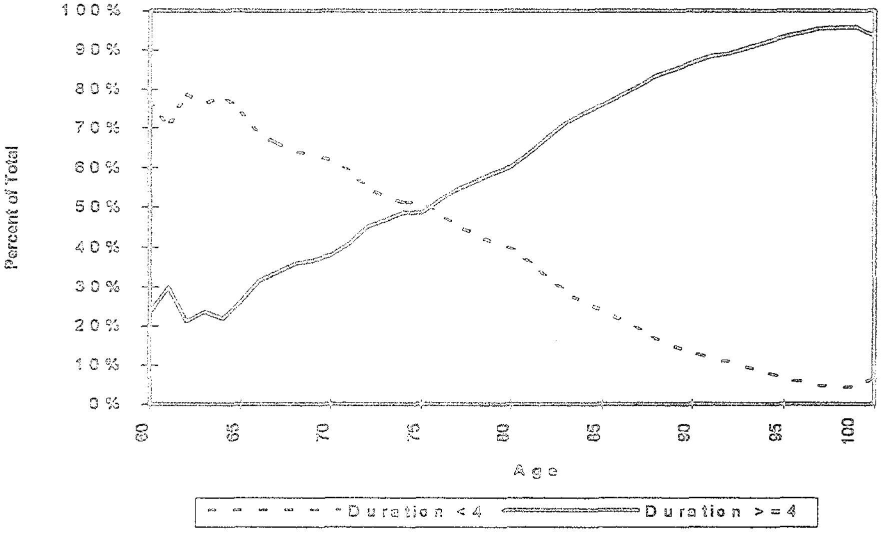
communities and those of the same age who have resided at the community longer. Single Gompertz curves did not fit the aggregate female mortality data well at the young ages where the effects of age and duration both influence the progression of rates. To reflect these two forces together, the research team fit one Gompertz curve to the data for residents with less than four years in communities between the ages of 65 and 74 and another to residents with four or more years in the community between the ages 65 and 79. The Gompertz constants for the former were $b = 0.001502$ and $c = 1.074298$ and for the latter, $b = 0.00003989$ and $c = 1.062403$. The two Gompertz curves were blended together by weighting the calculated mortality rates of each between the ages of 55 and 70 by a linear regression on the relative exposures for each of the two duration subsets by age. Figure II-3 shows the relative percentage of total exposures in each duration group by age.

The result of this dual Gompertz curve fitting is indicated in Figure II-2 showing the extended low age values for females together with the raw data.

High Ages

Recent research on America's oldest old indicates that mortality rates tend to slow from their exponential rate of increase (Bayo and Faber, 1985; Kestenbaum, 1992). There is evidence that those who are genetically strong

FIGURE II-3
LONG VERSUS SHORT DURATION—FEMALES



enough to reach the very high ages, while their weaker contemporaries have died, are such a select group that the increase in the rates of death by age for those remaining may be slower than when their cohort included the less strong (higher mortality) members.

Above age 85, where Gompertz curves do not effectively fit observed mortality rates, the research team applied techniques similar to those used in the development of the U.S. Life Tables. However, rates were ultimately capped at 50% (that is, the probability an individual age 109 on a reporting date dying in the next year was assigned a 50% probability). Each year thereafter the probability of dying in the next year, given survival of the preceding year, was set at a constant 50%.

Actuarial studies of Social Security retiree experience indicate that female mortality rates appear to increase about 6% per year beyond age 95 while male rates appear to grow more slowly at about 5% per year. For these tables, the research team blended that assumption into the rate of change appearing in male and female mortality rates between ages 93 and 94 to produce the rates of mortality for ages 95–99. Rates were then allowed to

FIGURE II-4

TEST OF FIT MALE ACTUAL AND EXPECTED DEATHS

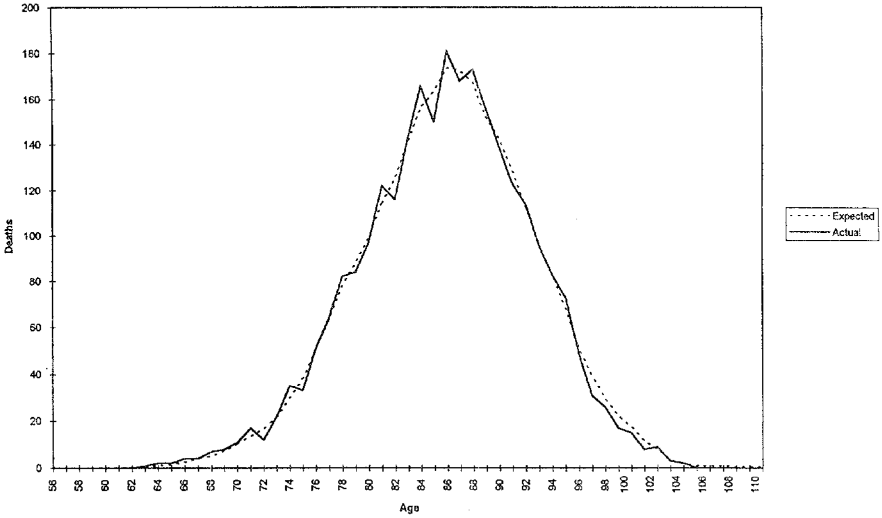
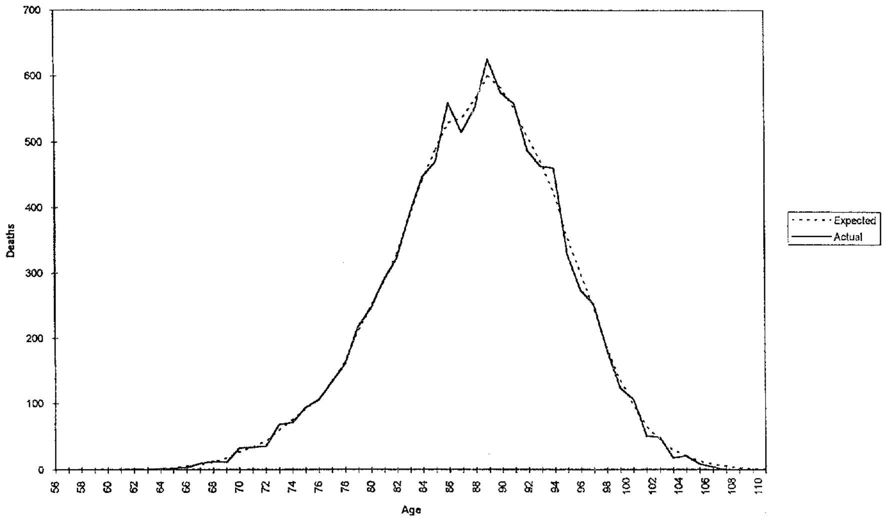


FIGURE II-5

TEST OF FIT FEMALE ACTUAL AND EXPECTED DEATHS



increase at the constant rate of 5% for males and 6% for females until reaching a rate of 50% per year at which point they were capped.

Testing Fit

Reasonableness of the final (smoothed) mortality rates was tested for each sex by multiplying the exposures at each age times the final mortality rates for the corresponding age and comparing these expected deaths to the actual deaths observed at each age. Figures II-4 and II-5 illustrate the closeness with which the final rates reproduce the actual deaths across the ages 56–110.

APPENDIX III
TECHNICAL NOTES ON LIFE EXPECTANCIES

Notes for Comparing the 1970–77 Study to this Study

1. General Improvements in Underlying Population Mortality

Numerous studies of mortality over the past two decades have indicated trends toward improved mortality at all ages (Wilken, 1981; Bayo, 1992; inter alia) as discussed in Section III of this report. Improvements in general mortality would lead one to expect lower mortality rates and longer life expectancies compared to earlier studies. However, this general trend toward mortality improvement is apparently being overshadowed by other factors in the California CCRC industry. That is, mortality is probably improving for the general population, but these mortality improvements are outweighed by the changes that are occurring in the composition or "mix" of individuals that, combined together, form the CCRC population as reported to the state.

2. Changing Mix of Contract Types Represented in the CCRC Database

Statistical tests of the resident data clearly show that life care community residents exhibit lower mortality rates and longer life expectancies than do residents of other types of continuing care retirement communities. As the mix of communities in the state of California shifts away from life care, the average mortality rates applicable to all retirement communities will likely increase. The 1970–77 study involved 47 communities of which 14 were life care communities. This new study used data from 78 communities of which only 17 were life care. With the proportion of life care communities decreasing, total life expectancy for residents of all communities is shifting toward the mortality basis applicable to nonlife care communities. Higher mortality rates and shorter life expectancies in nonlife care retirement communities may be attributed to different health requirements expected of applicants upon entry. Different fee structures and refund options on entry fees further cloud the issue. Further analysis of the state's mortality data by community fee structure and refund offerings might shed further light on these differences.

3. Different Mix of Healthy and Unhealthy Residents as Communities Age

If the mix of residents in the database were shifting from healthier residents to less healthy residents, then mortality rates would likely trend toward higher rates in the aggregate. An increase in the average duration of residents in communities would normally be accompanied by an increase in the proportion of residents in higher levels of care. However, the average resident's duration since entry to communities as recorded in the state's data actually declined between 1980 and 1992. One cannot tell from the data whether or not the proportion of residents in health care has increased as level of care data were not collected at the state level until 1994. If the ratio between independent living residents and health care residents is changing over time, the effect of different mortality rates for each level of care makes it difficult to discern underlying trends in overall mortality. With the capture of health care level data beginning in 1994, future analysts will be able to separate the effects of changing proportions of residents in each level of care from other factors influencing changes in mortality rates.

4. Volume of Exposures

Even with the volume of data available to the research team, the effects of the random nature of death can still be seen in the graphs of the raw mortality rates. This is particularly noticeable at the end points (i.e., the high ages and the low ages) where the number of people residing in retirement communities is too small to produce credible results by themselves. Because this study involved more data than the prior research, actual CCRC mortality data were usable further into the high ages before fitting different curves to extend the rates even further. The result is higher rates of mortality that more closely fit the observed mortality experience.

Methodological Differences

1. Age Nearest Birthday versus Age Last Birthday

Recognizing that life expectancies are applied in the reserve calculation process based on residents' ages as of their last birthdays, these new mortality rates were developed to be consistent with that application. The mortality rates behind the former state life expectancies were developed by measuring exposures between birthdates thereby producing age-nearest-birthday rates. Using age 80 as an example, the old rates counted as age 80 deaths, those deaths that occurred between the eightieth and eighty-first birthdays. The new mortality rate construction process counts as age 80 deaths those deaths that occurred among residents who had attained age 80 on the report date and died before the next report date. On average these latter people are 80 1/2 years old on the report date or 1/2 year older than the 80-year olds as measured in developing the old state mortality rates. The age 80 life expectancy will be applied to people between the ages of 80 and 81 on the reserve valuation date (that is, the fiscal year-end.) In essence these new life expectancies are for people 1/2 year older than the old California life expectancy tables. This methodological difference produces a life expectancy that is approximately a quarter to a third of a year shorter than shown in the old state tables and accounts for one-sixth to one-half of the differences in life expectancies between the old and new tables over the broad range of middle ages, that is, 75–90.

2. Treatment of Exposures and Deaths between Entry Date and Next Report Date

The resident data are reported to the state once a year. If an individual enters a community and survives to a reporting date, the information on that resident is forwarded to the state. However, if a resident enters the community between fiscal year-ends and dies before reaching a fiscal year-end date, that person may not be reported to the state since a reserve is reported only for individuals in the community at the fiscal year-end. Thus the database tends to have an undercount of deaths relative to exposure counts. This understatement can be significant and introduces a downward bias on mortality rates and consequently an overstatement of life expectancies. Recognizing that the reserve factors are applied only to survivors at the fiscal year-end, the life expectancies presented here were developed to be consistent with that fact by omitting both exposures and deaths between the date of entry to a community and the first fiscal year-end following entry.

Including only the reported deaths and all reported exposures between entry and the first report date would increase life expectancies by about one-tenth to two-tenths of a year.

3. Graduation Techniques

The state's old table of life expectancies and the new life expectancies were both based on mortality rates that were graduated by the Whittaker-Henderson methodology across the ages 75–90. Because the database now contains a larger volume of data, these new rates were graduated using Whittaker-Henderson methodologies over a longer age span: from age 70 to age 95. However, at the higher and lower ages, insufficient data exist to be credible, and therefore actuarial curve fitting techniques were used to extend the rates to these ages. For the younger aged end of the table, the 1970–77 study methodology merged the observed CCRC rates into an existing annuity table. Extensive analysis of the more recent data shows that, as entry age drops below age 70, mortality rates for CCRC residents level off well above annuitant mortality rates. Using annuitant mortality rates at young ages significantly overstates CCRC resident life expectancies. Unusually young entrants (ages 60–70) to CCRCs may choose to enter for some greater lack of vital capacity compared to their same age counterparts in the general population or relative to residents who enter at the more common ages of 75 to 80.

At the upper ages, the new life expectancies are substantially shorter than the old rates, reflecting the net result of two factors:

1. The use of the actual CCRC experience to a higher age offset slightly by,
2. The use of the U.S. Life Tables methodology instead of fitting a Gompertz curve to the high age experience. Gompertz curves generally fail to produce a good fit at ages above 85 (Bayo and Faber 1985; Manton, Stallard, Woodbury, and Dowd 1994).

BIBLIOGRAPHY

BAYO, F.R. "Life Tables for the United States Social Security Area 1900–2080," *Actuarial Note No. 107*, Office of the Actuary, Health Care Financing Administration, 1992:11.

BAYO, F.R., and FABER, J.F. "Mortality Rates Around Age One Hundred," *TSA*, Vol. XXXV, 1985:37–59.

BERIN, B.N., STOLNITZ, G.J., and TENEBEIN, A. "Mortality Trends of Males and Females Over the Ages," *TSA*, Vol. XLI, 1989:9–28.

COALE, A.J., and KISKER, E.E. "Mortality Crossovers: Reality or Bad Data?" *Population Studies*, 40, 1986:389–401.

COCHRAN, W.G. *Sampling Techniques*, Wiley Series in Probability and Statistics-Applied, 1977.

KALTON, G. *Introduction to Survey Samplings*, Series: Quantitative Applications in the Social Sciences; 1983.

KESTENBAUM, BERT. "A Description of the Extreme Aged Population Based on Improved Medicare Enrollment Data," *Demography*, 29, 1992:565–580.

MANTON, KENNETH G., STALLARD, ERIC, WOODBURY, MAX A., DOWD, J. EDWARD. "Time-Varying Covariates in Models of Human Mortality and Aging: Multidimensional Generalizations of the Gompertz," *Journal of Gerontology: Biological Sciences*, Vol. 49, No. 4, 1994:B169–B190.