A Survival Analysis of Hospitalization among Patients with Acquired Immunodeficiency Syndrome

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Abstract: Survival analysis techniques were used in estimating lifetime inpatient utilization among patients diagnosed with acquired immunodeficiency syndrome (AIDS) using data on 863 members of the Kaiser Permanente Medical Care Program in the Northern California Region diagnosed with AIDS between January 1, 1981 and June 30, 1987. Using information on both deceased and living patients, we estimated means of 40.3 lifetime inpatient days and 3.3 hospitalizations among all AIDS patients. Those presenting with Kaposi's sarcoma experienced a mean of 7.6 fewer lifetime inpatient days than those presenting with *Pneumocystis carinii* pneumonia (95% confidence interval = .61, 14.6) and a mean of 11.0 (3.9, 18.6) fewer inpatient days than all other AIDS patients. Older patients had fewer hospital admissions than younger ones. Year of diagnosis does not appear to be related to lifetime utilization, and there is an indication that increased survival has been accompanied by decreased inpatient utilization intensity as measured on a per person-year basis. We recommend the use of survival analysis methods in the study of utilization among groups of patients with incomplete follow-up. (*Am J Public Health* 1989; 79:1643–1647.)

Introduction

The cost of providing health care for patients with acquired immunodeficiency syndrome (AIDS) continues to be of national concern. Recent research on the economic impact of the epidemic has provided different estimates of the mean lifetime cost per AIDS patient, ranging from $23,000 to $168,000.[1–6] Much of the variability can be attributed to differences in estimates of the mean lifetime inpatient days accrued by AIDS patients.[1] The disparity in these estimates of inpatient utilization is due in part to true differences across the populations from which the samples of patients were drawn but also in part to the different sampling and estimation techniques. Some investigators have restricted the sample to patients who have died during a given time period, which generally results in a sample biased toward shorter lived individuals. Using survival analysis techniques, we provide estimates of the distribution of lifetime hospitalizations and inpatient days in a large well-defined sample of both deceased and living patients with AIDS.

Methods

Data Collection

We identified 863 cases of AIDS diagnosed between January 1, 1981 and June 30, 1987 who were members of the Kaiser Permanente Medical Care Program in the Northern California Region (KPNCR), a private nonprofit prepaid group practice program with over two million members receiving care in 11 counties; these include the San Francisco Bay Area, a region which has experienced a relatively high incidence of AIDS. According to the California State Health Department, as of June 30, 1987, 4,251 cases were reported in the geographic area served by the Health Plan; we estimate that over 20 percent of these cases were members of the Kaiser Permanente Medical Care Program.

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AIDS cases were identified retrospectively by obtaining reports from infection control nurses, and by examining three computerized datasets:

- the Inpatient Utilization System file which contains a record for each hospitalization at any Kaiser Foundation hospital including up to 13 diagnostic codes (*International Classification of Diseases, 9th Revision, Clinical Modification* (ICD-9)) per admission;
- pathology files containing biopsy reports from five major KPNCR hospital pathology departments; and
- a file maintained by the Health Plan's regional pharmacy administration containing all patients who had received zidovudine (AZT).

Each hospital admission from January 1, 1981 through June 30, 1987 was scanned for ICD-9 codes used specifically for AIDS: 279.10 and 279.19, which were used prior to October 1986, and 042.0, 042.1, 042.2, and 042.9 which were used subsequently. In addition, possible cases were identified by searching the hospitalization file diagnosis codes for AIDS-related conditions included in the Centers for Disease Control (CDC) case definition of AIDS.[7] Possible cases were also identified by searching the pathology files for diagnoses of Kaposi's sarcoma, *Pneumocystis carinii* pneumonia, candidiasis, and certain non-Hodgkin's lymphomas indicative of AIDS. For cases identified through the pathology file only or the AZT file only, the medical records were reviewed to verify the presence of AIDS. The medical records of those on the hospitalization file with a possible AIDS diagnosis were also reviewed. Patients were removed from the sample if the CDC criteria were not met.

Analyses are based on the 863 AIDS cases confirmed by chart review (N = 166), infection control nurse reports (N = 171), hospitalization records with diagnosis codes for AIDS (N = 506), and those on the AZT file with an additional record of an AIDS-related infection or neoplasm on the hospitalization or pathology files (N = 5). Males less than 60 years old with a biopsy report of Kaposi's sarcoma and no other source of confirmation were also included (N = 15).

For each case, date of diagnosis and diseases present on that date were obtained from the source of diagnosis confirmation. For those not confirmed either by chart review or nurse report, the earliest biopsy report or hospitalization record with an AIDS-related ICD-9 code was used. Sex and date of birth were obtained from computerized Health Plan

membership files. It is unlikely that there are patients in this case file who do not have AIDS, but it is possible that some Health Plan members diagnosed with AIDS are not included. Given the variety of sources used to identify AIDS patients, however, the number of unidentified cases is probably small.

The hospitalization file was used to obtain for each of the 863 cases the number of hospitalizations and total inpatient days from date of diagnosis to either date of death, date of leaving the Health Plan, or June 30, 1987, the end of this study. Date of death was obtained by a linkage to death records using the California Automated Mortality Linkage System.[8] Health Plan membership files were used to identify either date of leaving the plan or continued membership in the plan until death or June 30, 1987.

Data Analysis

While survival analysis techniques are often used to study time to an event such as death or onset of disease, these statistical methods are also appropriate for analyzing other random variables.[9,10] One of the main features of these methods is that the random variable of interest can be censored, which occurs when follow-up is incomplete. Information is provided by a censored observation because the final outcome will be at least as great as the measurement taken when follow-up is halted. In this study, a patient's lifetime number of hospitalizations and inpatient days were censored by leaving the Health Plan (N = 13) or by surviving through June 1987 and remaining in the plan (N = 348). We considered a patient's complete lifetime utilization to be measured only if death in the health plan occurred prior to June 30, 1987. The application of these statistical methods to the analysis of inpatient utilization is analogous to the analysis of survival time; we are treating inpatient utilization just as one would treat survival time or any other random variable subject to censoring.

The distributions of survival time, lifetime hospitalizations, and inpatient days were estimated by using the product-limit (Kaplan-Meier) method[11]; associated 95% confidence intervals were formed using Greenwood's estimation method.[12] This method provided estimates of the mean, median, and other percentiles of the distributions of inpatient utilization and survival time. Because lifetime hospitalizations as opposed to lifetime hospital days takes one of a very limited number of values, the sample median and other percentiles are less informative than the proportion of patients attaining selected values, and we present product-limit estimates of the latter. The log rank test[13] was used to assess differences in inpatient utilization distributions across subgroups defined by age, diagnosis at presentation and diagnosis date.

As an alternative to measuring hospital utilization from diagnosis to death of an AIDS patient, utilization rates on a per person-year basis and average length of stay estimates are also presented. Hospitalization and inpatient day rates are calculated for each time period as the observed number of events among AIDS patients divided by the total follow-up time for the cohort in that period. When study subjects enter and exit at any point during the year, this rate is a more appropriate measure of annual utilization intensity than statistics based on annualized data (e.g., multiplying by 12 the utilization by a patient observed for one month). Average length of stay is calculated as the mean number of inpatient days among all admissions during the given time period.

SAS was used for all data analyses[14]; the LIFETEST procedure was used to obtain product-limit estimates of distribution functions, means and percentiles, and to perform log rank tests.

Results

Patient characteristics are listed in Table 1. The mean age at diagnosis was 39.3 years; 98.7 percent were male. Fifty percent of the cases presented with *P. carinii* pneumonia only, and 16.1 percent presented with Kaposi's sarcoma only. Other opportunistic infections accounted for 17.7 percent of the cases. The sex and diagnosis at distributions are similar to those for cases in the same geographic area reported to the California State Health Department except there appears to be a somewhat smaller proportion of KPNCR patients presenting with Kaposi's sarcoma.[6] This may be an artifact due to our reliance on inpatient discharge data for diagnosis information for the majority of cases. In addition, our cases were slightly older than the AIDS patients reported to the State, whose mean age was 38.1 years.[6]

Among all 863 cases of AIDS, the median survival time was 309 days; the 25th and 75th percentiles were 103 and 552 days, respectively. The estimated probabilities of surviving one and two years (and associated standard errors) were .44 (.020) and .20 (.020). The product-limit estimates of the survival distributions for those with an initial diagnosis of Kaposi's sarcoma only, *P. carinii* only, and all others are presented in Figure 1. Diagnosis at presentation was strongly related to survival time (P = .0001). The median time to death for patients with Kaposi's sarcoma was 531 days as compared to 331 days for those with *P. carinii*. The group of AIDS patients with other diagnoses generally had the shortest survival times with a median of 187 days.

The product-limit estimate of the distributions of lifetime hospitalizations and inpatient days are presented in Figures 2 and 3. Only .5 percent of these patients had no hospitalizations. Although the majority of patients (66 percent) were hospitalized for a total of 45 days or less, there was a subset

TABLE 1—Characteristics of 863 AIDS Patients Identified at KPNCR from January 1, 1981 through June 30, 1987

	N	%
Age at Diagnosis (years)		
0–19	4	.5
20–29	110	12.7
30–39	361	41.8
40–49	262	30.4
50–59	97	11.2
60+	29	3.4
Sex		
Male	852	98.7
Female	11	1.3
Date of Diagnosis		
1/81–12/81	3	.3
1/82–12/82	16	1.9
1/83–12/83	39	4.5
1/84–12/84	119	13.8
1/85–12/85	190	22.0
1/86–12/86	282	32.5
1/87–6/87	214	24.9
Diagnosis at Presentation		
Kaposi's sarcoma (KS)	139	16.1
Pneumocystis carinii pneumonia (PCP)	432	50.1
KS and PCP	36	4.2
Other neoplasms	11	1.3
Other infections	153	17.7
Unspecified	92	10.7
Deaths through June 1987	504	58.4

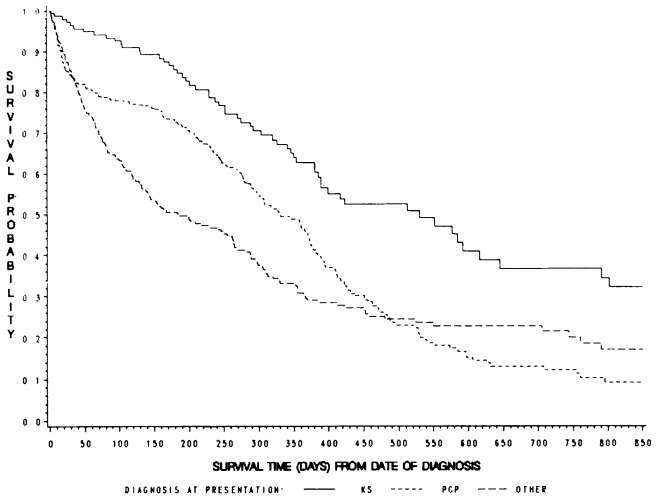

FIGURE 1—Product-Limit Estimate of the Distribution of Survival Time from Date of Diagnosis Among 863 KPNCR AIDS Patients, by Diagnosis (to provide greater detail where most of the sample falls, the distributions are truncated at 850 days).

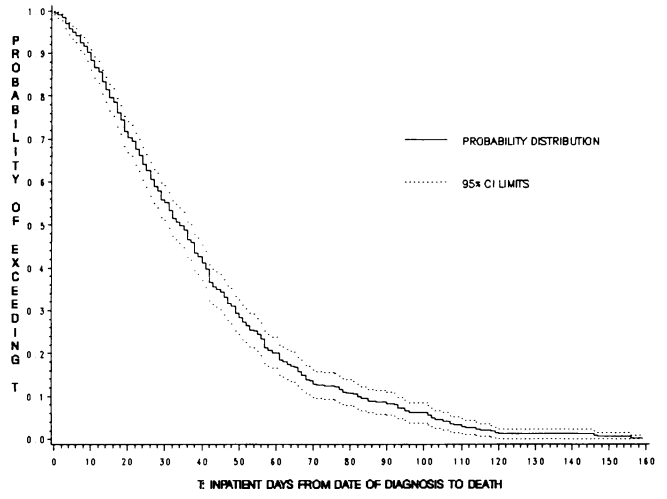

FIGURE 2—Product-Limit Estimate of the Distribution of Lifetime Inpatient Days among 863 KPNCR AIDS Patients Diagnosed between January 1981 and June 1987.

of patients that were relatively high utilizers; an estimated 8 percent were hospitalized more than 90 days. Similarly, 64 percent of the patients required three or fewer hospitalizations, but 8 percent required seven or more.

The distributions of lifetime hospital utilization for all AIDS patients by diagnosis, age, and date of diagnosis are summarized in Tables 2 and 3. The mean number of hospitalizations was 3.3, corresponding to mean and median inpatient days of 40.3 and 34. The distribution of lifetime inpatient days differed among diagnosis groups; those presenting with Kaposi's sarcoma had a lower median number of days compared to those with *P. carinii* and all others. Diagnosis at presentation, however, did not appear to be related to number of hospitalizations. Older AIDS patients experienced fewer hospitalizations but did not differ from younger patients in their inpatient days. Year of diagnosis was not related to either lifetime number of hospitalizations or days hospitalized.

Average length of stay and utilization rates are presented

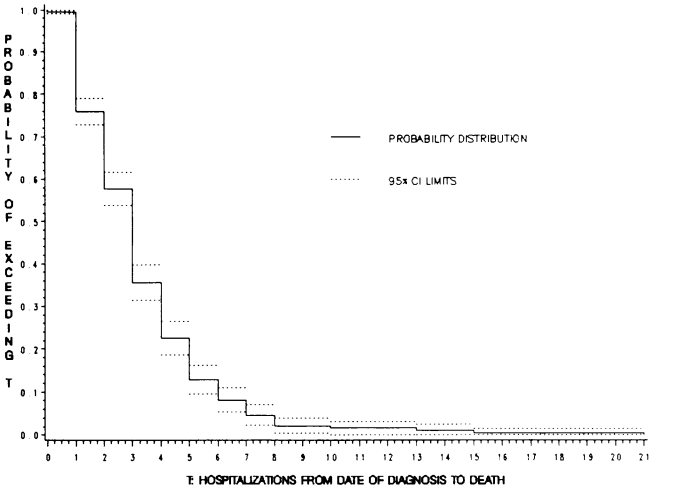

FIGURE 3—Product-Limit Estimate of the Distribution of Lifetime Hospitalizations among 863 KPNCR AIDS Patients Diagnosed between January 1981 and June 1987.

in Table 4. During 1981 through 1983, we observed 105 hospitalizations and 1,767 inpatient days in 32.9 person-years of follow-up on 58 cases, corresponding to utilization rates of 3.2 hospitalizations and 53.7 inpatient days per person-year. Based on 150.1 person-years of follow-up in the first six months of 1987, the hospitalization and inpatient day rates had declined during 1984 through 1986 to 2.6 and 31.1 per person-year, respectively. Similarly, the average length of stay per AIDS-related admission declined from 17.23 days for admissions in 1981, 1982, and 1983 to 10.69 days during the first six months of 1987.

Discussion

Our estimate of mean lifetime inpatient days is substantially lower than the 168 days reported by Hardy, *et al,*[4] and in fact is among the lowest of current estimates as summarized by Bloom and Carliner.[1] Our estimates, however, confirm the finding of other researchers that AIDS patients are hospitalized less often in the San Francisco Bay Area than in other regions of the United States. Scitovsky, *et al,*[3] suggested that strong community-based social support services in San Francisco tend to prevent or shorten hospital stays. They also suggested that in other regions there may be a larger proportion of intravenous drug users, who lack the social support network that other patients with AIDS have developed.

Diagnostic information was obtained from inpatient discharge data for 59 percent of the cases, and thus, there is some misclassification with respect to both date of diagnosis and diseases at presentation. Our estimate of the distribution of survival time from date of diagnosis to death and our utilization analysis by diagnosis subgroup are therefore less reliable than estimates obtained using complete diagnostic information from medical records on all patients. Nevertheless, our survival estimates are in general agreement with other reports from San Francisco.[15] Since it is likely that AIDS patients would generally not be hospitalized without an AIDS-related diagnosis, our primary analyses of inpatient utilization are probably minimally biased by this diagnosis date misclassification.

We examined lifetime hospital utilization among AIDS patients with well-known statistical methods usually used to

TABLE 2—Distribution of Lifetime Inpatient Days among 863 KPNCR AIDS Patients, by Diagnosis at Presentation, Age, and Year of Diagnosis

	N	Median (25th, 75th Percentile)	Mean (S.E.)
Diagnosis			
PCP only	432	35 (17, 56)	39.93 (1.78)
KS only	139	26 (15, 43)	32.33 (3.09)
Other	292	38 (19, 57)	43.38 (2.34)
χ^2 = 8.36, d.f. = 2, P = .015**			
Age at Diagnosis (years)			
0–29	114	38 (16, 68)	47.37 (4.75)
30–39	361	33 (18, 53)	38.83 (1.96)
40–49	262	36 (19, 56)	42.60 (2.59)
50+	126	31 (17, 51)	35.82 (2.54)
χ^2 = 6.18, d.f. = 3, P = .10**			
Date of Diagnosis			
1/81–12/83	58	36 (24, 61)	46.08 (4.76)
1/84–12/84	119	36 (19, 57)	42.71 (2.88)
1/85–12/85	190	36 (19, 53)	39.38 (2.30)
1/86–12/86	282	31 (17, 49)	38.12 (2.48)
1/87–6/87	214	35 (18, 53)	37.73 (4.21)*
χ^2 = 3.85, d.f. = 4, P = .43**			
All cases	863	34 (18, 55)	40.32 (1.32)

*Because the patient with the largest observed number of inpatient days was alive, the product-limit estimate of the mean could not be calculated. The estimate presented is calculated after "uncensoring" this observation and is therefore slightly biased.
**Log rank test for association; d.f. = degrees of freedom.

TABLE 3—Percent Distribution of Lifetime Hospitalizations among 863 KPNCR AIDS Patients by Diagnosis at Presentation, Age, and Year of Diagnosis

		Number of Hospitalizations					
	N	0	1	2	3–4	5+	Mean (S.E.)
Diagnosis							
PCP only	432	0.0	22.8	18.7	32.7	25.8	3.37 (.143)
KS only	139	1.4	21.8	18.8	41.9	16.1	3.11 (.278)
Other	292	0.7	25.2	17.4	36.4	20.3	3.32 (.264)
χ^2 = 1.68, d.f. = 2, P = .43**							
Age at Diagnosis (years)							
0–29	114	0.9	21.6	14.4	35.2	28.0	4.34 (.564)
30–39	361	0.3	22.8	19.2	30.2	27.4	3.26 (.131)
40–49	262	0.0	22.9	18.2	39.9	19.0	3.12 (.152)
50+	126	1.6	28.5	18.6	37.5	13.8	2.93 (.339)
χ^2 = 9.46, d.f. = 3, P = .024**							
Date of Diagnosis							
1/81–12/83	58	1.7	21.8	22.7	37.1	16.6	2.97 (.246)
1/84–12/84	119	0.0	16.5	26.9	34.4	22.2	3.27 (.218)
1/85–12/85	190	1.1	25.9	19.0	32.7	21.3	3.06 (.153)*
1/86–12/86	282	0.4	28.3	11.1	35.3	25.0	3.85 (.455)
1/87–6/87	214	0.0	19.0	17.6	35.2	28.2	3.15 (.221)
χ^2 = 3.40, d.f. = 4, P = .41**							
All Cases	863	0.5	23.6	18.2	35.1	22.6	3.32 (.127)

*Because the patient with the largest observed number of hospitalizations was alive, the product-limit estimate of the mean could not be calculated. The estimate presented is calculated after "uncensoring" this observation and is therefore slightly biased.
**Log rank test for association; d.f. = degrees of freedom.

analyze time to an event. These estimation procedures properly account for the problem of not observing all patients to their deaths. Excluding patients who have not died results in a sample that is biased toward the utilization levels of shorter-lived individuals. Among the patients who died as KPNCR members, the mean number of hospitalizations and inpatient days are 2.6 and 34.6, compared to the product-limit estimates of 3.3 and 40.3; restriction of our sample to the deceased results in a 21 percent reduction in the estimate of mean lifetime number of hospitalizations and a 14 percent reduction in estimated mean inpatient days. Our estimate of the mean lifetime hospital days based on the deceased is extremely close to Scitovsky's[3] estimate of 34.7, which is obtained from a sample of deceased AIDS patients receiving care at San Francisco General Hospital, indicating that the inpatient utilization of the KPNCR patients is similar to that of other AIDS patients in the region.

Our estimates are based on utilization patterns observed only through June 30, 1987. As new therapies are introduced or as patient population characteristics change, our estimates of lifetime utilization may need to be revised. For example, improving survival rates may lead to a change in the inpatient utilization distribution. In this study, there was no evidence of a change in lifetime utilization by year of diagnosis (Tables 2 and 3), although there was a fairly strong downward trend across calendar time in utilization intensity as measured on a person-year basis (Table 4). There was a general increase in survival rates through calendar time. For those with Kaposi's sarcoma, the one year survival rate increased from .60 for those diagnosed in 1981 through 1983 to .65 for those

TABLE 4—Average Length of Stay and Inpatient Utilization Rates among 863 KPNCR AIDS Patients

Admission Date	Average Length of Stay	Observed Person-Years	Number of Hospitalizations* (per person-year)	Inpatient Days** (per person-year)
1/81–12/83	17.23	32.91	3.19	53.69
1/84–12/84	13.78	60.96	3.58	47.68
1/85–12/85	13.56	133.96	3.13	42.67
1/86–12/86	11.72	216.88	2.82	31.43
1/87–6/87	10.69	150.15	2.62	31.10

*Classified according to the date of admission.
**Classified according to the year in which the day occurred.

diagnosed in 1986. For those without Kaposi's sarcoma, the one year survival rate increased from .37 for those diagnosed in 1981 through 1983 to .43 for those diagnosed in 1986. This suggests that the constancy in lifetime utilization while utilization intensity decreased can be explained in part by an increase in survival rates in recent years, i.e., as a group, the same amount of utilization was spread over a longer time period. Also, there appears to be a shift in inpatient utilization from the time near date of diagnosis toward the time of death. Given no change in lifetime utilization, this would result in declining measures of annual utilization intensity during years with less follow-up time close to death than to diagnosis.

Although not presented here, the dependence of utilization on treatment modalities, diagnostic category, and other factors could be examined using methods for regression analysis of survival data.[9,10] In summary, survival analysis methods are appropriate for examining health services utilization in groups of patients with incomplete follow-up. These methods are also useful in estimating the monetary cost of illness with censored data,[6] and an ongoing study of a random sample of KPNCR AIDS patients will examine costs associated with both inpatient and outpatient care.

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Family Access to Health Care: Report Available

Family access to health care is discussed in the report of a conference held in May 1988 at the University of South Carolina and sponsored by the Health Resources and Services Administration.

Single copies of the 136-page report, *Empowering Families for Better Health,* are available from the National Maternal and Child Health Clearinghouse, 38th and R Streets, NW, Washington, DC 20057; tel: 202/625-8410.