Journal of Family Violence, Vol. 17, No. 3, September 2002 (© 2002)

Age Adjustment and Recall Bias in the Analysis of Domestic Violence Data: Methodological Improvements Through the Application of Survival Analysis Methods

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This methodological paper presents the utility of survival analysis methods to provide age adjustment in the analysis of domestic violence data. These methods improve the estimation of lifetime probability of domestic violence, improve identification of patterns of first victimization over the lifespan, and provide methods of testing risk factors for first victimization while adjusting for the respondents' age. Most importantly, these methods allow a new investigation of recall bias. Results suggest that lifetime probability of abuse may have been substantially underestimated in previous studies because of problems in recall/disclosure encountered by middle-aged women.

KEY WORDS: domestic violence; abuse; age adjustment; recall bias; lifetime prevalence; survival analysis.

INTRODUCTION

Domestic violence (here defined as violence against women by male intimate partners) is a serious social and health problem affecting women's well-being worldwide (Heise, 1994; Straus & Gelles, 1986, 1988; United Nations, 1989). Studies that document prevalence play a crucial role in developing effective prevention and intervention policies and services. Epidemiological

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studies of domestic violence have focused on estimating two quantities: the past-year prevalence and the lifetime prevalence among women. This paper addresses the analytic methodology for the latter of these quantities.

The concept of lifetime prevalence of domestic violence has not been well defined in previous research. Previous studies of the lifetime prevalence of domestic violence have typically examined whether the respondent ever reported any victimization. As women age, however, they may be exposed to new incidences of domestic violence, that is, the older the women, the more exposure they accrue, so "lifetime prevalence" estimates will depend on the age distribution of women in the study. By definition, the lifetime probability of domestic violence victimization increases with age, and theoretically, a "true lifetime prevalence" could only be obtained by questioning each woman just prior to death. Because such a study would hardly be feasible, any measure of lifetime prevalence must take the age of the respondents into account.

There are two major approaches to adjusting for age: age stratification or age adjustment, and the use of survival analysis. In the next section, we review previous studies that used age stratification or age adjustment. In the subsequent section, we discuss methods of survival analysis to estimate both the lifetime probability of abuse and the distribution of age at first abuse. We then present an example illustrating that survival analysis methods provide an improvement over age adjustment in several respects.

Age Stratification or Age Adjustment

Age stratification involves grouping women by age and calculating the proportion of those ever having experienced domestic violence in each age group. Age effects may be tested using either chi-square tests or logistic regression analysis (Agresti, 1990). A literature search using multiple sources, including the Psycholit and Social Science Citation Index databases and professional contacts, found 13 studies that examined the lifetime prevalence of domestic violence among community-based samples in the United States and Canada (Table I). These studies varied in the population of women studied with respect to socioeconomic status (SES) and type of relationship (married, cohabiting, and dating) and also differed in the types of violence measured (e.g., physical only or physical and sexual). These differences may have led to the observed variation in rates of victimization across studies. However, we are most interested in patterns in the risk of abuse by age within each study, rather than comparing the results across studies.

Only one published study (Smith, 1990) reported lifetime prevalence rates of domestic violence stratified by age groups. Two additional published

studies reported logistic regression analyses of abuse status controlling for age, dichotomized into two groups (Browne & Bassuk, 1997; Sorenson & Telles, 1991). Two studies (Neff *et al.*, 1995; Nisonoff & Bitman, 1979) tested the effects of age with the use of a chi-square test and found no significant difference in the lifetime prevalence of domestic violence between two age groups; age-stratified rates, however, were not reported. (The latter four studies used dichotomous age groups, most spanning more than two decades; such broad groupings are not as informative as age stratification by increments of 5–10 years.) The remaining eight studies did not use age stratification or adjustment in the analysis of the lifetime prevalence rates, although some of them used age stratification in the past-year prevalence rates (Colten *et al.*, 1996; Dutton, 1995; Lloyd, 1996; Rodgers, 1994; Schulman, 1979; Straus *et al.*, 1980; Teske & Parker, 1983; Tjaden & Thoennes, 1998). Among them, personal communication with the researchers has allowed the analysis of age-stratified lifetime rates of domestic violence in two cases (Colten, 1998; Lloyd & Taluc, 1997).

Assuming no cohort effects, one would expect the proportion of women with a history of abuse to increase with age because older women have had more exposure to the risk of abuse. However, except in two studies (Browne & Bassuk, 1997; Sorenson & Telles, 1991), the proportion of women experiencing domestic violence did not necessarily increase with the respondents' age. In fact, the proportion of women who had ever experienced domestic violence was often higher in the youngest age group (Smith, 1990), or it was fairly constant across age groups (Colten, 1998; Lloyd & Taluc, 1997; Neff *et al.*, 1995; Nisonoff & Bitman, 1979).

A number of factors may account for these seemingly inconsistent observations. Cohort effects are possible, that is, older women may have experienced less abuse than younger women today. Changes in dating patterns (e.g., having a larger number of boyfriends and/or increase in cohabitation without marrying), which began around the early 1970s (Glick, 1984), may have resulted in increased abuse among women currently under 50. Indeed, a significantly higher rate of domestic violence has been observed in cohabiting couples compared to married or dating (noncohabiting) couples during the previous year (Stets & Straus, 1989). However, cohort effects are not supported by analyses of U.S. national surveys, which found no increase in the proportion of women experiencing violence by partners from 1975 to 1985 or 1992 (Egley, 1991; Straus & Kaufman Kantor, 1994; Suitor *et al.*, 1990). Some studies have found a significant relationship between men's alcohol use and perpetration of violence against women (Kaufman & Straus, 1987; Leonard & Senchak, 1996). Alcohol consumption among adolescents, however, steadily decreased between 1976 and 1989 (Bachman *et al.*, 1991). These findings collectively do not support a significant cohort effect that

Table I. Age Adjustment Used in Previous Studies of the Lifetime Experience of Domestic Violence

Authors	Interview[a]	Type of violence[b]	Relationships[c]	*N*	Age stratification (proportion of women reporting abuse[d])	Age adjustment	
						Method[e]	Significance of age effects
Nisonoff and Bitman (1979)[f]	T	P-h	MCD	169	16–39 (17.6%)	Ch	No (<40 vs. ≥40)
				119	40+ (8.7%)		
Smith (1990)[g]	T	P-CTS	MCD	168	19–30 (29%)	LR	No[h]
				201	31–40 (23%)		
				227	41–50 (23%)		
		P-CTS/S		168	19–30 (8%)	LR	No[h]
				201	31–40 (7%)		
				227	41–50 (7%)		
Sorenson and Telles (1991)[i]	F	P-h/t	MCD	1,243	18+ (20.0%)	LR	Yes. Respondents aged ≥45 were more likely than those aged <45 to perpetrate violence,[j] $\chi^2 = 21.63$, $p < .0001$
Neff *et al.* (1995)[k]	F	P-s/h/k/p	M	772	20–60 (30.9%)	Ch	No (<40 vs. ≥40)
Lloyd and Taluc (1997)[l]	F	Sy/D	MCD	134	16–24 (38.1%)	t-2	Yes, $t = 2.77$, $p = .006$
				239	25–34 (42.7%)		
				198	35–44 (46.5%)		
				107	45–54 (37.4%)		
				74	55–64 (37.8%)		
				46	65+ (17.4%)		
		P/S & S		134	16–24 (23.9%)	t-2	No, $t = 0.26$, $p = .79$.
				239	25–34 (27.6%)		
				198	35–44 (32.8%)		
				107	45–54 (28.0%)		
				74	55–64 (33.8%)		
				46	65+ (17.4%)		

Browne and Bassuk (1997)[m]	F	P-CTS/S	MCD	436	15+ (60.7%)	LR	Yes, odds ratios for ages (<20 vs. ≥20) of .27
Colton (1998)[n]	F	P-h/s/k/t/etc. & S	MCD	173 195 259 106	20–24 (63.0%) 25–29 (67.7%) 30–39 (64.9%) 40+ (62.3%)	Ch	No

[a] F = face-to-face interviews; T = telephone interviews.
[b] P = physical violence; P-CTS = Conflict Tactics Scale physical violence; P-CTS/S = Conflict Tactics Scale severe physical violence; P-h = hitting; P-h/t = hitting and throwing things; P-s/h/k/p = slapping, hitting, kicking, and pushing; P-h/s/k/t/etc. & S = hitting, slapping, kicking, throwing, shoving, hurting badly, using a gun/knife, forcing to have sex, and making her think she would be hurt; P/S & S = severe physical and/or sexual violence; Sy/D = symbolic and physical violence (pushing, grabbing, and slapping).
[c] M = married; C = cohabiting; D = dating.
[d] All studies investigated proportions of respondents ever victimized, except for Sorenson and Telles (1991) who examined the proportion of the respondents who perpetrated violence.
[e] Ch = chi-square; LR = logistic regression; *t*-2 = 2-tailed *t* test.
[f] Respondents were female residents of Suffolk County, Long Island, NY, randomly drawn using RDD.
[g] Respondents were a random sample of women in Toronto who were currently or formerly married (within 2 years) or cohabiting with a male partner.
[h] Controlling for family income, marital status, education, employment, and religion.
[i] Respondents were males and females of Mexican descent in Los Angeles County, a subsample of the Epidemiologic Catchment Area study.
[j] Controlling for gender, marital status, country of birth, education, number of children, and mental disorder.
[k] Respondents were regular drinkers and nondrinkers who were married, separated, or divorced, randomly selected by a multistage area probability sample of households in urban San Antonio, TX, stratified by median household income and by percent Black/Hispanic origin.
[l] Respondents were women randomly selected from Humboldt Park, Chicago (predominantly African American 55% and Latina 39%).
[m] Respondents were homeless women and low-income women who have never been homeless in Worcester, MA.
[n] Respondents were a representative sample of women who were receiving Transitional Aid to Families with Dependent Children between January and June, 1996, in Massachusetts.

might explain higher rates of lifetime violence reported by younger women, although such effects cannot be entirely ruled out.

A second explanation for the higher observed rate of domestic violence among younger women is that older women may be less likely to consider a partner's acts as domestic violence. However, most studies use behavior-specific questions which, unlike broad screening questions, do not heavily rely on the respondent's perception of what constitutes domestic violence. A third possibility is that older women may be less willing to disclose their victimization experiences than are younger women, or may not remember these experiences, more distant or less severe violent episodes in particular. We find this explanation to be the most plausible. Such disclosure and recall bias cannot be disentangled from cohort effects with cross-sectional (synthetic cohort) data, but the combined effect can be assessed.

Survival Analysis Approach

Methods of survival analysis, also known as event-history analysis, offer an alternative way to estimate the probability of first abuse by age (Allison, 1995). Methods of survival analysis arose from studies of mortality (time to death). In this paper, we have adapted the language to time to first abuse. Survival analysis has been applied by other authors to social science data (Petersen, 1991; Singer & Willett, 1991; Teachman & Hayward, 1993; Yamaguchi, 1991). Traditionally, survival analysis methods have used prospective data from the time origin (e.g., birth) to first event (e.g., abuse), although retrospective lifetime data can also be used if problems of recall are minimal. With some modification, survival analysis can also be used with past-year or other short-term recall data, as illustrated later.

At the time of interview (or last interview in a longitudinal study), some women, younger women in particular, may not ever have been abused. These women are considered "not abused" in many analyses presented in the literature, despite the possibility that some of them may be abused at a later point. These observations are referred to as "censored" cases in the context of survival analysis, meaning that the event has not yet occurred during the period of observation. When censored cases are considered "not abused," the lifetime probability of abuse will be underestimated. Survival analysis correctly accounts for censored cases in estimating the probability of abuse by age, while allowing for the possibility that some women will never be abused.

General Survival Analysis Methodologies

Methods of survival analysis parallel analysis methods for uncensored continuous data (e.g., histograms, *t* tests, and regression analysis); however,

special modifications have been developed to handle censored data (Allison, 1995; Kleinbaum, 1996; Marubini & Valsecchi, 1995). For example, comparisons between two groups with censored data can be made using the logrank test, and the effects of covariates on age at first abuse can be tested using Cox regression. With ordinary continuous data, distribution of data values is often plotted as a histogram. With censored data, a histogram cannot be constructed, but the Kaplan–Meier (KM) estimator, the estimated cumulative probability of abuse by a certain age, can be calculated and plotted. Finally, the hazard function, a function unique to survival analysis methods, is often useful. This function gives the probability of abuse occurring at a certain age, given that no abuse has happened previously.

Statistical software to perform survival analysis is commonly available. All packages require data for the event time (e.g., age of abuse) or censoring time (e.g., age at interview if not abused) and the "censor code," which indicates whether or not the event has happened.

Advantages of Applying Survival Analysis to Domestic Violence Data

Application of survival analysis to domestic violence data has several advantages. One advantage of using the KM estimator over age stratification is that the former provides continuous age adjustment, allowing estimates of the probability of abuse by a specific age rather than only in age ranges. The KM estimator can provide an estimate of "lifetime prevalence" as the probability of abuse by ages 50 or 60 years, assuming the probability of first abuse at ages beyond 50 or 60 is negligible. This estimate can be calculated as long as some respondents are interviewed at older ages, even if most respondents are younger at the time of interview. Another advantage is that, using the hazard function, we can present the risk of first abuse with increasing age, illustrating changes in risk over the lifespan. Hazard rates that are constant, increasing, or declining over time can be modeled (Vuchinich *et al.*, 1991). This type of information assists in the identification of age groups that are at high risk for first abuse, to whom prevention and intervention programs can be targeted. A third advantage is that, using Cox regression analysis, we can compare the distribution of time to first abuse between two or more groups enabling the identification of risk factors, such as alcohol or drug abuse. We can also test for group differences adjusting for other factors (such as childhood socioeconomic status or parents' education) as covariates. In addition, when retrospective lifetime data are collected, we can use "left-truncation" (discussed more fully in Investigation of Recall Bias section) to selectively exclude data from the respondents' distant past and use only data from their recent past (Allison, 1995; Klein & Moeschberger, 1997). This analysis allows for the investigation of the potential problems of recall, disclosure, or cohort effects.

Despite the potential advantages of survival analysis methods in the analysis of domestic violence data, no published study in the United States to date has used these methods in estimating the lifetime prevalence of domestic violence. In fact, the age of first abuse was not measured in most previous studies; this information is required for the use of survival analysis methods in estimating lifetime probability of abuse. Recently, one Nicaraguan study (Ellsberg, 1997) used the KM estimator to estimate the cumulative probability of domestic violence by age, and one U.S. study compared event history analysis to logistic regression in estimating the risk of child sexual abuse (Bolen, 1998).

In this paper, survival analysis methods will be illustrated using data from a study of domestic violence among women of Japanese descent in Los Angeles (LA study), one of the few studies that has collected data on age of first abuse. Specifically, we will (1) compare unadjusted and age-adjusted estimates of the probability of experiencing domestic violence with estimates based on the KM estimator; (2) use the hazard function to illustrate risk of first abuse over the life course; (3) test possible risk factors for first abuse, using Cox regression; and (4) compare estimates of the lifetime probability of abuse using left-truncated data to investigate recall/disclosure bias and cohort effects.

METHODS

Sampling

The LA study employed a community-based random sample of women of Japanese descent in Los Angeles. Detailed study methodologies and respondents' characteristics have been described in Yoshihama (1999). Respondents were 211 women randomly selected from a list of households containing persons with a Japanese surname in Los Angeles County. Following an introductory letter, a screening telephone call was made to the household to identify any woman who met the following criteria: Japanese descent, born in the United States or Japan, aged between 18 and 49, and having had an intimate heterosexual relationship. Only one woman per household was selected using a random procedure. Face-to-face interviews were conducted by trained interviewers in the respondent's preferred language (English or Japanese) and lasted an average of 90 min. A written consent was obtained at the beginning of the interview. The method of sampling households with Japanese surnames was used in the absence of a list that enumerated all women of Japanese descent. Although this method excluded women whose surname had been changed because of interethnic or interracial marriage,

we found that approximately one fourth of the respondents had a partner who was not of Japanese descent. These women were identified because they either were unmarried or kept their maiden names after marriage.

Measure of Domestic Violence

Physical violence is the focus of analysis in this paper, as has been the case in most previous studies of domestic violence. This study used 31 behavior-specific questions to assess the respondent's experience of a partner's (including husband's, cohabiting partner's, or boyfriend's) physical violence. All forms of physical violence covered in the Conflict Tactics Scale (CTS; Straus, 1979; Straus & Gelles, 1986) were included with the following modifications: Original CTS items that contained different acts of violence (e.g., kicking, biting, or hitting with a fist) were separated into individual items. Attempted and completed acts of violence were also differentiated. Altogether, nine original CTS items were split into 17 items. Because domestic violence may manifest itself differently depending on the sociocultural context, additional items were drawn from a series of preliminary studies of women of Japanese descent in both Japan and the United States (Yoshihama & Sorenson, 1994). Two forms of violence identified by women in Japan—that is, a partner's throwing liquid or overturning a dining table—were added to the measure. Twelve forms of physical violence were added based on literature review and consultation with practitioners, such as pinning down, stomping on, pulling hair, dragging around, lifting up and throwing, and burning.

The respondent was asked how many times she experienced each specific type of physical violence by her current or former male intimate partner during her lifetime to date. The internal consistency Cronbach's alpha for the presence/absence of these types of violence was .82. To be consistent with other studies, the experience of physical violence was dichotomized into those who experienced at least one form and those who experienced none of them. For each type of violence experienced, the respondent was asked how old she was when she first experienced it. The "age at first abuse" that we analyze here is the minimum age at which the respondent first experienced any form of physical violence perpetrated by a husband or a boyfriend. The respondent's sociodemographic information included age, marital status, education, employment status, income, and country of birth.

Choice of Time Axis

When performing survival analysis, the time axis (exposure time) must be appropriately defined for the subject matter. A conventional approach

is to define exposure time as chronological age. An alternative is to define exposure time as starting at the first date or at the beginning of marriage. The choice of specific time axis is primarily guided by conceptualization of abuse, for example, violence in the marriage versus violence over the life course. The selection of an appropriate starting point may also depend on the pattern of courtship—a risk factor for domestic violence victimization—in a given society. For example, in Nicaragua, where premarital courtship is not widely practiced, a very small proportion of women reported having experienced a partner's violence prior to marriage (Ellsberg, 1997). In this case, the researcher's choice of using the beginning of marriage as the starting point appropriately reflects this sociocultural context. In societies where premarital courtship is widely practiced, the age of the first relationship may be an appropriate time origin to account for the relative length of exposure to a partner's violence. This adjustment may be useful in a setting where the ages of starting to date are heterogeneous in the population. Given the possible alternatives, we chose to use chronological age as the time axis because we were interested in exploring risk of abuse over the lifespan.

Statistical Analysis Software

SAS software (SAS Institute Inc., 1997) was used for all analyses. SAS Proc Lifetest was used to calculate KM estimates, and Proc Phreg was used to perform Cox regression as well as the left-truncated survival estimates and hazard functions. For left-truncated survival analysis, we used methods as described in Allison (1995). (Note that not all statistical packages with survival analysis modules can perform left-truncated analyses.)

RESULTS

Respondents' Characteristics

The 211 women who participated in this study were comparable to the general population of women of Japanese descent aged 18–49 (at the 1990 Census) in Los Angeles County, born in the United States or Japan, with respect to educational level, marital status, employment status, occupation, country of birth, and English proficiency. Women aged 40 and above and those with higher personal and household incomes, however, were overrepresented. Of the 211 respondents, 109 (52%) reported having experienced some form of a partner's physical violence during their lifetimes. As seen in Table II, women who reported partners' violence did not differ from those

Table II. The Respondents' Demographic Characteristics by Experience of Partners' Physical Violence

	Experiences of physical violence			
Demographic characteristics	Total ($N = 211$)	Yes ($n = 109$)	No ($n = 102$)	Significance test
Mean age at interview (*SD*)	37.2 (10.2)	36.2 (10.9)	38.2 (9.3)	$t = 1.43$, $p = .16$
Mean years of schooling (*SD*)	15.3 (2.0)	15.1 (2.1)	15.4 (2.0)	$t = 0.81$, $p = .42$
% employed	77.7	75.2	80.4	$\chi^2(1) = 0.81$, $p = .37$
% married or in committed relationship	76.3	75.2	77.5	$\chi^2(1) = 0.14$, $p = .71$
% with household income <$60,000	36.8	40.2	33.3	$\chi^2(1) = 1.02$, $p = .31$
% with personal income <$15,000	44.8	45.4	44.1	$\chi^2(1) = 0.03$, $p = .86$
% U.S.-born	73.0	75.2	70.6	$\chi^2(1) = 0.58$, $p = .45$

who did not with respect to age, educational level, employment status, relationship status, income, or country of birth. These tests, however, do not take into account the age of abuse and the possibility of future abuse.

Proportion of Women Abused Stratified by Age

We calculated the proportion of women ever abused, as well as of those abused during the previous year, stratified by age group. As seen in Table III, when stratified by age, we found a higher proportion of younger women reporting abuse during the previous year, consistent with other reports in the literature (Smith, 1990; Straus *et al.*, 1980). We also found the proportion of women abused during their lifetimes was highest among the youngest group (63.5%) although this proportion would be expected to increase with age in the absence of cohort effects, reluctance to disclose, or recall difficulties.

Survival Analysis of Time to First Abuse Episode

We used the KM estimator to examine the cumulative probability of abuse over the life course. Although KM estimates are usually presented as the probability of being eventfree (i.e., the probability of surviving), we present the probability of having the event (abuse) by subtracting the KM estimate from one. As seen in Fig. 1, the respondents began experiencing violence during their teenage years, with 25% of women experiencing abuse by age 21, and an additional 26% by age 35. After age 35, the rate of first abuse appeared to decline. KM estimates based on lifetime recall at the midpoints

Table III. Estimates of Domestic Violence by Age: Age-Stratified and Kaplan–Meier Estimates

Probability of abuse stratified by age						KM estimates of lifetime probability of abuse by the given age								
		Past year		Lifetime			Lifetime recall		15-year recall		10-year recall		5-year recall	
Age group	*N*	%	*SE*	%	*SE*	Age	%	*SE*	%	*SE*	%	*SE*	%	*SE*
18–29	52	34.6	6.6	63.5	6.7	24[a]	31.1	3.2	59.5	5.8	69.7	6.3	78.8	6.4
30–39	46	6.5	3.6	45.7	7.3	35[a]	51.2	3.6	70.8	4.6	80.8	4.6	86.8	4.9
40–49	113	8.8	2.7	48.7	4.7	45[a]	57.4	3.8	74.5	4.2	83.3	4.1	88.3	4.4
Total	211	14.7	2.4	51.7	3.4	49[b]	57.4	3.8	74.5	4.2	83.3	4.1	88.3	4.4

[a] Age at the midpoint of the interval for age-stratified estimates.
[b] Maximum age in dataset.

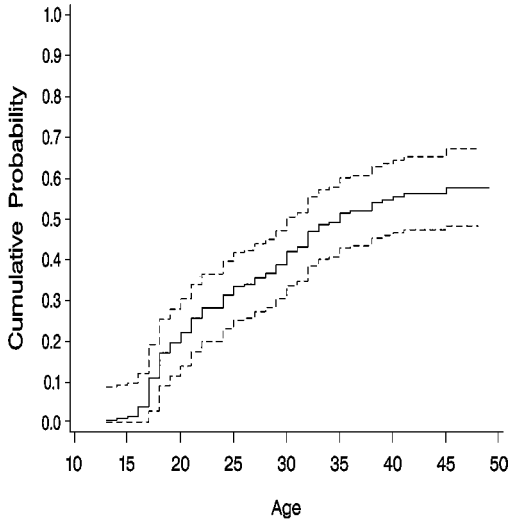

Fig. 1. Kaplan–Meier estimate of the cumulative probability of abuse by age based on lifetime recall (solid line). A 95% Hall–Wellner confidence band is given by dashed lines.

of the age intervals in Table III are in sharp contrast to the age-stratified estimates in that table. For example, the age-adjusted lifetime estimate was 64% in the age range 18–29, whereas the KM estimate for age 24 (approximate interval midpoint) was only 31%. The major difference between these two estimates is that the former is based only on data from women aged 18–29 at the time of interview, whereas the latter (KM estimate) is based on data from those women as well as middle-aged women recalling their experiences when they were 18–29 years of age. We speculate that the difference in these estimates is the result of recall or disclosure bias among middle-aged women. If middle-aged women do not recall experiences of abuse in their youth, the KM estimate of the probability of first abuse will be underestimated for younger women. Because the KM estimate is a cumulative function, this underestimation in younger ages would be carried over and lead to underestimation in older age groups. A method to improve the KM estimate in this setting using shorter recall windows will be addressed in a separate section below.

As seen in Table III, the KM estimate of the probability of abuse by age 49, which we consider to be "lifetime prevalence" (57%), is higher than the unadjusted rate of 52%. We had originally expected the lifetime KM estimate to be higher than the unadjusted estimate because of its appropriate

handling of the censored cases (i.e., allowing the possibility that women not abused may be abused later). The impact of appropriately handling censoring is larger for the KM estimates for the latter years because the number of censored cases increases as time goes on. Considering the KM underestimation in the 18–29-year range, the higher lifetime KM estimate is surprising. Although the effects of recall bias depress the KM estimate in the younger age range, it appears that accounting for the censoring effect appropriately increases the KM estimate in the middle-aged years. Thus, the unadjusted lifetime estimate (52%) is too low because of not accounting for censoring, and the lifetime KM estimate (57%) is too low because of recall bias. If a KM estimate could be corrected for recall/disclosure bias, it would be higher across all age groups (see under Investigation of Recall Bias).

The Hazard Function

We next examined the hazard function of abuse by age, which is the probability of first abuse at a given age for respondents who have not been abused before. (The hazard function was estimated using 5-year recall data, to be discussed below.) As seen in Fig. 2, which presents the hazard function

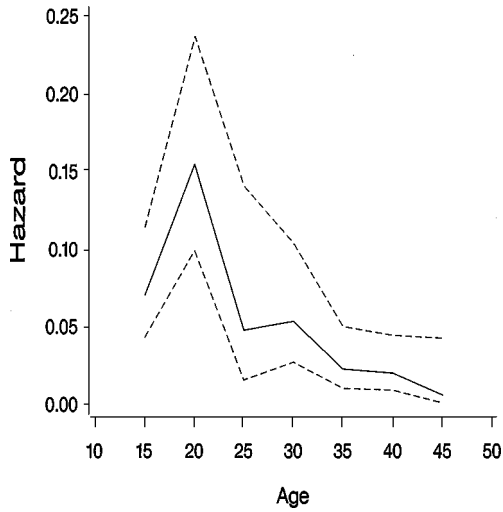

Fig. 2. Estimates of the hazard function of abuse by age based on 5-year recall (solid line). Pointwise 95% confidence intervals are given by dashed lines.

estimate with 95% pointwise confidence intervals, women were at highest risk of being abused for the first time during ages 18–22, with a probability of approximately 15% per year. The probability of first abuse decreased to approximately 5% at age 25. In the late 30s and early 40s, the risk of first abuse steadily declined. The peak in the risk of first abuse near age 20 is much clearer in the hazard function (Fig. 2) than it is in the survival function (Fig. 1). These figures illustrate the utility of calculating both the survival and hazard functions, even though similar information is presented in each graph.

Testing Risk Factors

An important goal of domestic violence research is to identify factors that affect a woman's risk of first abuse. Such factors can be tested by including them as covariates in a Cox regression model. This model assumes that the ratio of the hazard functions is constant over time for any two levels of a covariate (e.g., childhood SES), referred to as the proportional hazards assumption. (This assumption can be graphically checked by plotting the log[-log (KM estimate)] for each level of the covariate versus time and looking for parallelism of the lines. Noncrossing survival curves are necessary but not sufficient to insure proportional hazards.)

To illustrate Cox regression for a single covariate, we compared risk of abuse by the country of birth (United States vs. Japan). For this analysis, we excluded women who had been divorced or separated because the proportional hazards assumption was not met for these groups. (An analysis with time-dependent covariates could model the nonproportionality, but we chose to present a simpler analysis for illustration.) The Cox regression yielded a p value of .055, indicating a marginally significant difference in the risk of abuse between the two groups. U.S.-born women had a 59% increase in risk of abuse over Japan-born women, and this increased risk is assumed to hold over the entire lifespan (i.e., the two hazard functions are assumed to be proportional). This assumption was graphically checked and found to hold reasonably well. We note that the chi-square test comparing the proportion of U.S.-born among those abused and not abused was not significant ($p = .45$ as shown in Table II for all respondents, and $p = .36$ excluding women ever divorced or separated). Cox regression is a more appropriate way to examine the relationship between abuse and a covariate such as country of origin because it takes into account the age of respondent and detects differences in the distribution of ages of first abuse that cannot be detected by the test of proportions.

Investigation of Recall Bias

To investigate the potential problem of poor recall of distant past events, we performed survival analyses, using only data within a fixed time window prior to the interview date for each respondent. This method is called survival analysis with left-truncated data, also known as delayed entry (Allison, 1995). This method considers women to be at risk only during the recall window and excludes data from those respondents who were abused prior to the recall window. For example, using a past 5-year window, a woman's report of first abuse was included only if it occurred in the 5 years prior to her interview, and women who experienced first abuse prior to that time period were excluded. This method is easily performed using survival analysis software by specifying the woman's date of "entry" into the analysis (i.e., her age at the beginning of the time window) in addition to the usual information on age of first abuse or age at interview (if not abused).

We used 5-, 10-, and 15-year windows ending at the interview date and estimated the cumulative probability of abuse (KM estimate) by age. These KM estimates are compared to the survival estimate with the use of lifetime recall data presented in Fig. 1.

Although reflecting different recall windows, all four analyses estimate the same quantities: the cumulative probability of first abuse by age. If recall were perfect and no cohort effects were present, these estimates would only differ by random variability because of having additional data in the wider time windows. Any substantial differences in estimates across different recall windows could be due to either recall/disclosure bias or cohort effects. Although we cannot distinguish between these two causes with cross-sectional data, we suspect that differences are primarily due to recall/disclosure bias, considering inconclusive findings of cohort effects in previous studies. If recall is better for more recent time periods, we would expect increased reports of abuse in the analysis that used a narrower recall window covering the more recent past.

Results of this analysis are presented in Fig. 3. There is a pattern of increasing KM estimates as the recall window narrows. The KM estimate using lifetime recall is substantially lower than the left-truncated KM estimates for any of the three narrower recall windows. For example, the KM estimate of the probability of experiencing abuse by age 24 is 79% using 5-year recall, 70% using 10-year recall, 60% using 15-year recall, and 31% using lifetime recall (see Table III).

As seen in Table III, the younger the respondent, the closer the left-truncated estimates were to the age-stratified lifetime estimates. At age 24, the three left-truncated KM estimates range from 60 to 79%, which are

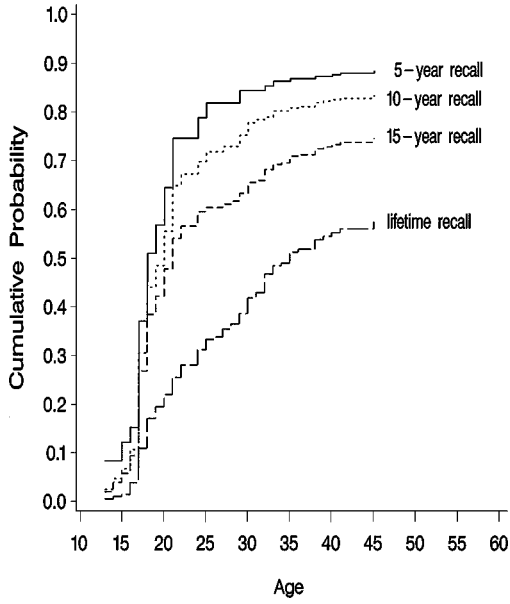

Fig. 3. Kaplan–Meier estimates of the cumulative probability of abuse by age based on 5-year (solid), 10-year (dotted), 15-year (short dashes), and lifetime (long dashes) recall. The first three are based on left-truncated data.

similar to the 64% age-stratified lifetime estimate reported by women, 18–29, but are much larger than the KM estimate using lifetime recall of 31%. We conjecture that the lower KM lifetime recall estimate is due to the large number of middle-aged women who did not recall abuse at younger ages. In contrast, for women aged 35, the left-truncated KM estimates (87, 81, and 71% for 5-, 10-, and 15-year windows, respectively) are much higher than both the lifetime estimate for age stratum 30–39 (46%) and the KM estimate using lifetime recall (51%). By age 45, the left-truncated KM estimates (88, 83, and 75% for 5-, 10-, and 15-year windows, respectively) are still higher than both the lifetime estimate for age stratum 40–49 (49%) and the KM estimate of 57% using lifetime recall. Substantial recall/disclosure bias appears to underlie significant underestimation in both the age-stratified estimates of lifetime abuse and the KM estimates based on lifetime recall. Given the similarity of 5- and 10-year estimates, we recommend using recall windows of 10 years or less to obtain more accurate estimates of lifetime abuse.

DISCUSSION

Utilities of Survival Analysis Methods

This paper highlights the usefulness of survival analysis methods in the epidemiological investigation of age at first domestic violence victimization. Survival analysis correctly accounts for the fact that women who have not yet been abused at the time of interview may still potentially be abused at a later date. Survival analysis methods provide a continuous adjustment for age, whereas age stratification presumes a constant rate of abuse within an age group. Survival analysis yields an estimate of the proportion of women ever having experienced abuse during their lifetimes (i.e., by age 50 or 60), even though few women in the sample have reached that age. Finally and most importantly, when lifetime abuse data are collected, survival analysis provides a method for investigating and correcting the effect of recall/disclosure bias with age.

Cox regression analysis facilitates the examination of risk factors for first abuse. Although we chose to use country of birth as an example, other covariates, both categorical and continuous, known prior to first exposure to risk of abuse (i.e., the start of dating) can also be tested using Cox regression. Such covariates include race, childhood SES, and educational level of parents, and are easily interpreted as risk factors for abuse. For covariates describing characteristics post-first-date such as marital status and current SES, the interpretation is less straightforward because the covariate values at the time of the interview may have been influenced by episodes of abuse. For example, women may divorce as a result of abuse, and may have lower SES as a result of divorce.

Plots of the hazard function can illustrate patterns of first abuse over the lifespan, yielding useful information regarding age groups at which prevention and intervention programs could be targeted. For example, this study identified that women were at higher risk of experiencing a partner's physical violence for the first time during the teen years. This finding is consistent with the high rate of partners' violence during teenage years found in previous studies (Bergman, 1992; Molidor & Tolman, 1998).

The findings of this study underscore the importance of adjusting for age in general, and the utility of survival analysis in particular, in studies of domestic violence. The only limitation of survival analysis is the need for data on age of first abuse, and possibly age at first date to adjust the exposure time if needed. Although the findings presented here apply to the Japanese American population in Los Angeles, the methods we present should be useful in estimating the probability of first abuse by age and exploring recall bias in other data sets.

Variation in Estimated Probabilities of Domestic Violence Among Studies

If we consider our 5-year-recall KM estimate at age 49 (88%) to approximate "lifetime" probability of abuse, this estimate is much higher than any previously reported in the literature. One explanation for this high estimate may be the broad definition of domestic violence used in this study compared to other studies (e.g., Neff *et al.*, 1995; Nisonoff & Bitman, 1979; Smith, 1990; Sorenson & Telles, 1991), as well as the inclusion of dating relationships. Using the modified CTS (a narrower definition of abuse) and the conventional (age-unadjusted) method of calculating the probability of lifetime victimization (proportion of women reporting any violence in their lifetimes), the probability of lifetime CTS-equivalent violence was 34% in the LA study (Yoshihama, 1999). (This result is comparable to the 27% found by Smith [1990] using a modified CTS in a different population.) The age-unadjusted probability of lifetime victimization in the LA study using the broader definition of violence was 52%. Thus, the wider definition led to an increase of 18% in the proportion of women categorized as experiencing violence (34% vs. 52%), suggesting that the definition of domestic violence is crucial to consider when comparing study results. We recommend designing questionnaires to allow estimation of domestic violence by different definitions (e.g., CTS-equivalent, physical and sexual violence separately) to facilitate comparisons across studies.

In addition, use of survival analysis methods to correctly adjust for the different ages of women at the time of interview increased our estimate of lifetime domestic violence from 52 to 57%. Finally, we conjecture that the difference between the estimates 57% (lifetime recall) and 88% (5-year recall) is due to recall/disclosure bias, as discussed previously. Thus, the statistical methods also have a major impact on estimates of the lifetime probability of domestic violence.

Addressing Problems of Recall

One of the most striking findings of this study is the substantially lower proportion of middle-aged women reporting abuse that occurred during their younger years compared to the proportion of younger women reporting abuse. Although cohort effects cannot be ruled out, we suspected that middle-aged respondents encountered increased difficulty or reluctance in recalling events that took place during their teenage and young adult years. Analysis using KM estimators for left-truncated data found evidence for substantial recall/disclosure bias.

Cohort effects and recall/disclosure bias limit the interpretation of study findings, regardless of whether survival analysis or any other analysis method is used. With cross-sectional data, women of different ages are from different birth cohorts, referred to as a "synthetic cohort" in demography (Keyfitz, 1985). If cohort effects are present (i.e., if the age-specific probability of abuse is changing over time), estimates from this synthetic cohort will not reflect the abuse experience of any single birth cohort of women. The estimates will, however, reflect the abuse experience of women during the time period for which the data are collected. Alternatively, if recall bias is present, one possible consequence on the KM estimate of probability of abuse by age is error introduced when older women reporting no previous violence are erroneously included among the women at risk for first abuse later in life. If early abuse increases the risk of subsequent abuse, including these women in the analysis using a 5-year window would slightly overestimate the probability of abuse at the older ages.

The finding that the longer the recall period, the lower the estimates of probability of abuse corroborates similar findings in the fields of cognitive psychology and survey methodologies (Bradburn *et al.*, 1987; Jobe *et al.*, 1993; Thompson *et al.*, 1988). On the basis of our finding that recall beyond 10 years is probably not reliable with the current questionnaire format, we suggest some approaches to address this problem. Although lifetime data can always be analyzed using left-truncated survival analyses as illustrated, for new studies we recommend a recall window of no more than 10 years prior to the interview. Although using a longer recall period obtains more data per respondent, and thus appears to be more cost-effective, our finding advises against this approach if standard questionnaires are used. We were not able to investigate recall for shorter windows (less than 5 years) because of the limited sample size.

Another approach to address the problem of memory is to use a data collection format that would encourage better recall. Currently available measures of domestic violence do not incorporate specific strategies to improve respondents' recall. Clearly, systematic and focused efforts are needed to enhance respondents' recall of their experiences of domestic violence occurring in their remote past. Some alternative questionnaire approaches are currently under investigation (Caspi *et al.*, 1996; Magdol *et al.*, 1998; Yoshihama *et al.*, 2002; Yoshihama *et al.*, under review). Whether these approaches are effective in improving recall of past events can be investigated using the methods presented in this paper (e.g., the left-truncated KM estimator).

The methods of survival analysis provide substantial improvements for estimating the probability of first domestic violence over the lifespan, provide better methods of identifying patterns of risk of first victimization by age, and give methods of testing risk factors for victimization while adjusting

for respondents' age. Most importantly, these methods demonstrate the major impact of recall bias on previous estimates of domestic violence and suggest improved methods for addressing this problem.

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