MODELS FOR AND THE EFFECT OF NONRESPONSE IN A SURVEY OF THE NONINSTITUTIONALIZED ELDERLY

Morton B. Brown, Dan-Yu Lin, Daniel P. Normolle and A. Regula Herzog, University of Michigan
Morton Brown, Department of Biostatistics, University of Michigan, Ann Arbor, MI 48109-2029

KEY WORDS: nonresponse, categorical data, EM algorithm, urinary incontinence

Abstract

A household survey consisting of a one-seventh probability sample of the noninstitutionalized elderly was conducted in a Michigan county to estimate the prevalence and incidence of urinary incontinence in the elderly. Of the 2993 identified potential respondents, 66% completed either the entire interview or a shortened version which contained the critical questions about continence status. Those who completed the initial interview were reinterviewed after one and two years, with response rates of 69% and 72% respectively. Also, a sample of the interviewees were invited to free physical and urodynamic examinations.

Basic demographic information from the household enumeration is available for refusals at the initial interview. Responses at the first interview are available for all other respondents.

We describe models fitted to the data to characterize the refusals at each stage and the potential effect of the nonresponse on the estimates of prevalence and incidence. The effect of weighting the data to adjust for nonresponse is also discussed.

Introduction

In 1983 the National Institute of Aging funded a multi-disciplinary five-year study to estimate the prevalence and incidence of urinary incontinence in the noninstitutionalized elderly (those aged 60 and over). A second aim was to identify possible precursors, correlates and sequelae of incontinence. The field study, entitled the *M*edical, *E*pidemiological and *S*ocial aspects of *A*ging (or MESA), began with a baseline interview in the homes of the eligible elderly based on an equal probability sample of households in a Michigan county. Following the baseline interview two additional household interviews were conducted at approximately yearly intervals. At each interview (including the baseline interview), the respondents were asked about demographic and medical conditions and extensively questioned with respect to their continence status and to conditions that may be related to incontinence (potential precursors, correlates or sequelae).

Responses from the baseline interview are available to characterize nonrespondents at the subsequent interviews. Basic demographic data from the household enumeration (e.g., age, sex, number of eligible respondents in the household) are available for nonrespondents at the baseline interview.

All respondents who were characterized as incontinent at the baseline interview and the majority of those characterized as continent were invited to participate in a free physical examination at the MESA clinic. All of those participating in the physical examination were then invited to a free and extensive urodynamic examination.

Estimates of prevalence and incidence have been presented elsewhere (Diokno et al, 1986; Herzog et al, 1988). Since the prevalence of incontinence differs greatly between the two sexes and the underlying physiological dysfunctions related to the onset of incontinence also differ, estimates are obtained separately for each sex. In this paper we discuss the characteristics of the nonrespondents at each stage of the study and the effect of the nonresponse on the estimates of prevalence and incidence. Factors used to adjust for the differential invitation rates to the clinical and urodynamic examinations are also described.

Sample Design

The MESA project consisted of a baseline household interview, two reinterviews at yearly intervals, and, for a subset of the subjects, physical and urodynamic examinations. All subjects who consented to the baseline household interview were considered eligible for the additional interviews and examinations.

The sampling frame for the initial baseline interview was prepared by the Sampling Section of the Survey Research Institute at The University of Michigan. It consisted of a selection of area segments from a stratified frame based on the 1980 census of the noninstitutionalized residents in the county. Stratification was by the density of households containing one or more persons aged 60 or over in the area segment. The minimal size for a sample segment was set to 48 occupied housing units.

Based on initial estimates of drop-out at each examination, the sample size was chosen such that sufficient numbers of subjects (those incontinent, as well as continent controls) would participate in the urodynamic examination. This computation indicated that 2100 completed interviews would be necessary for the baseline sample: to achieve this, a one-seventh equal probability sample of the county was selected. [The area sampling was used for all units except for ten large facilities that were specifically designed to house older members of the population; each of these facilities was selected with certainty and a one-seventh sample of the dwelling units in the facility was selected.]

Within selected area segments, all housing units containing eligible respondents were identified and enumerated by trained staff of a survey unit in The University of Michigan School of Public Health. This enumeration provided baseline information (age, sex, location, household density, number of eligible respondents in the household) for all eligible respondents. For those refusing to be interviewed at the baseline survey, this was the total information available.

Since the baseline sample is an equal probability sample, weights to correct for disproportionate sampling are not necessary. A comparison of the study population at the baseline interview

with the census data from 1980 indicated that females greater than 75 years of age are slightly underrepresented in the sample.

Response Rates

Baseline interview: 2993 eligible respondents were identified; of these 1956 (65.9%) agreed to participate either with a complete interview or a mini-interview that contained demographic questions and the critical questions relating to continence status (Table 1). (Among these, three subjects did not provide any information about their age and/or allow their gender to be included among the responses and, therefore, they are omitted from all the analyses.) An additional 67 interviews were completed with proxies. All analyses of the baseline data are based on the 1953 interviews with respondents (excluding proxies and the three respondents described above).

Follow-up interviews: These interviews were attempted with all respondents who completed any form of interview at baseline and did not die, move out of the area or become institutionalized; a small number of 'virulent' refusals were also not recontacted. The numerator of response rate includes only those who completed either a main or mini interview. The denominator of response rate at the subsequent interviews is the number of potential interviewees at the previous interview less the number deceased and institutionalized between the two interviews; i.e., at the first follow-up the denominator is equal to 2023-62-14=1947 and at the second reinterview it is 1892-89-17=1786 (Table 1). The response rates at the two reinterviews were very similar (68.6% vs 72.2%).

Table 1
Interviews completed during the three surveys

	Baseline	1st follow	2nd follow
Interviewed			
Main interview	1,642	1,217	1,136
Mini interview	314	118	153
Proxy interview	67	60	65
Total interviews	2,023	1,395	1,354
Refusals at follow-up	--	497	387
Available for next interview	2,023	1,892	1,741
Refusals at baseline	920	--	--
Moved from region	12	51	38
Deceased	25	62	89
Institutionalized	0	14	17
Unable to interview	13	4	7
Total not recontacted	970	131	151
Total eligible at this interview	2,993	2,023	1,892
Response rate (Full + mini, excluding death and institutionalization)	65.9%	68.6%	72.2%

Clinical and urodynamic examinations: It was desired to invite sufficient continents to the clinical and urodynamic examinations in order to have approximately equal sample sizes of continents and of incontinents who underwent urodynamic evaluation. Therefore, subjects were stratified into eight groups: by sex, male or female; by self-reported continence status, continent or incontinent; and by age, < 75 or 75+. All incontinents were invited to the clinic. In order to obtain similar numbers of continents and incontinents in each age/sex grouping, all female continents and all the male continents in the younger group were invited to the clinic, but only a randomly selected 70% of the male continents in the older group were invited.

The response rates to the clinic and urodynamic invitations among the household respondents in each of the eight groups (sex by self-reported continence status by age) are presented in Table 2. As may be noted from the table, self-reported incontinent respondents were more likely to accept the invitation than self-reported continents and younger females were more likely to accept than the older ones.

Since subjects were stratified into these eight groups prior to being invited to the clinical examination and only 70% of the male continents in the older group were invited, and since there were differential rates of acceptance based on continence status, estimates of population rates or proportions are obtained by weighting estimates from the eight groups by factors that reflect the relative sizes of the groups in the original household survey. These factors

Table 2
Response Rates (in %) Of Household Respondents To Clinic And Urodynamic Invitations

		Clinic			Urodynamic	
Cont.	Age	Accepted Number	(%)	Number contacted*	Accepted** Number	(%)
				FEMALES		
Cont	<75	197	40.8	484	59	29.9
	75+	61	29.5	207	16	26.2
Incont	<75	151	52.1	290	77	51.0
	75+	47	37.0	127	17	36.2
Total		456			169	
				MALES		
Cont	<75	178	38.0	468	48	27.0
	75+	36	40.4	89	9	25.0
Incont	<75	57	56.4	101	26	45.6
	75+	27	67.5	40	11	40.7
Total		298			94	

* The number contacted for the clinic excludes those known to be deceased (14 females and 23 males), those omitted due to the sampling scheme (36 males) and those with whom contact could not be reestablished.

** The number contacted for the urodynamic examination is equal to the number of acceptances of the clinic invitation.

which are applied to the group means or proportions are presented in the first column of Table 3 (Diokno et al, in press).

In addition to the self-reported continence status, the clinician diagnosed the examinee as continent or incontinent based on the findings of the examination which included a medical history as well as a physical or urodynamic examination. To obtain estimates of population rates or proportions, an extra step is needed when defining the appropriate factors since the proportions of incontinents reported by the clinician must be converted into proportions of the original eight household groupings. These factors are also presented in Table 3 (last column).

Nonresponse

Model of Nonresponse at the Baseline Survey: Due to the short period of time between the initial enumeration and the baseline interview, almost all of the nonresponses at baseline were refusals. Out of the initial 2993 individuals, 12 (0.4%) moved and 25 (0.8%) died. 67 (2.2%) were unable to respond to the survey interview, but were represented by a proxy. The remaining 933 (31.1% of the initial enumeration) individuals did not respond or participate for other reasons (Table 1).

For nonrespondents at the baseline interview the only data available were the demographic variables: age, sex, number of eligible respondents in the household and urbanization of the community (divided into three broad categories). A dichotomous indicator variable was created to designate whether or not the subject was a respondent. Logistic regression models were fitted in a stepwise manner to relate the indicator variable to the demographic variables.

For both sexes, the number of eligible respondents in the household was a highly significant factor; when there was more than one eligible respondent in the household it was more likely that the individual would refuse to participate (Table 4). Also, older females (those 75+) were less likely to respond than younger ones (60-74).

Table 3
Factors Used To Combine Results Across Age Groupings And Continence Status

	Age	Factors used with Household* Self-Report of continence status	Clinician's** Diagnosis
		FEMALES	
Continent	<75	0.432	0.396
	75+	0.192	0.187
Incontinent	<75	0.264	0.300
	75+	0.112	0.117
Sample size		1151	456
		MALES	
Continent	<75	0.642	0.672
	75+	0.170	0.164
Incontinent	<75	0.136	0.106
	75+	0.052	0.058
Sample size		802	298

* The factors are the proportions of the strata from the household survey. The sizes of the strata (N) are used in the computations of standard errors.

** The factors are the proportions of strata from the household survey multiplied by the relative frequencies of the clinician's diagnosis.

Table 4
Explanatory Variables of Refusals

	Interview				
Factor	Baseline	1st follow	2nd follow	Clinic	Urodyn
			FEMALES		
Age linear	.016 old>	.0005 old>	NS	.0005 old>	.04 old>
Health linear	--	.04 poorer> NS|age	.09 poorer> NS|age	.0005 poorer>	NS
# Elig Respond	.004 2-3>	NS	NS	NS	NS
Marital Status	--	NS	NS	.005 wid,div>	NS
Cont. Status	--	NS	.003 cont>	.001 cont>	.0005 cont>
Severity linear	--	.004 cont,mild>	.001 cont>	--	--
			MALES		
Age linear	NS	NS	.07 old>	NS	NS
Health linear	--	.0005 poorer>	NS	.001 poorer>	NS
# Elig Respond	.0005 2-3>	.001 2-3>	.0005 2-3>	NS	NS
Marital Status	--	.06 sep,mar> .034|age	NS	NS	NS
Cont. Status	--	NS	NS	.0005 cont>	.004 cont>
Severity	--	NS	NS	--	--

Both sexes: The explanatory variables for deaths, proxies and institutionalizations are age and health.

The three lines in the table are:
(1) p-value for the marginal test of the effect.
(2) Groups for which nonresponse is increased(>).
(3) Conditional p-values, presented only when the inference may be affected.

Model of Nonresponse at the Follow-up Surveys: At the subsequent household interviews, data from the baseline interview were also available; therefore, the potential variables to explain nonresponse were augmented by marital status, self-reported continence status at the baseline interview and by self-assessed health status experessed on a 5-point scale from excellent to poor and either dichotomized (fair or poor vs good to excellent) or used as an ordinal scale (linearized). Again, stepwise logistic regression was used to identify possible factors that were related to the dichotomous variable representing whether the subject was a respondent or not.

Among females, increased age and self-reported continence (in contrast to incontinence) were important determinants of nonresponse; the factor health was not significant after adjusting for age. Among males, more than one eligible respondent in the household and poorer health status of the potential respondent were significant factors in increasing the liklihood of nonresponse.

The analysis of nonrespondents from baseline to the second follow-up survey again identifies continence as increasing nonresponse among females and more than one eligible respondent as increasing nonresponse among males.

Model of Refusals at the Clinic and Urodynamic Examinations: Using the same set of independent variables as for the follow-up surveys, stepwise logistic regressione were fitted to indicator variables describing whether the subject consented to participate in the clinic examination or in the urodynamic one.

Refusal to attend the clinical examination is associated with poorer health and self-reported continence for both sexes and with increasing age among females. Continents are less likely than incontinents to accept an invitation to the urodynamic examination (Table 4).

Estimates of prevalence, incidence and remission

Treatment of nonresponse: To understand the potential effect of nonresponse, several alternate methods were used to impute the frequencies for all the possible combinations of continence status at the three household interviews:

The initial attempt to estimate the effect of nonresponse was to assume that the baseline interview was complete and then to allocate nonrespondents at the follow-up interviews proportionately within the response categories defined at the previous interviews. For example, at the first follow-up nonrespondents who were continent at the baseline interview were divided into continent and incontinent classes to reflect the proportions of the baseline continents who so responded at the first follow-up. At the second follow-up respondents were divided into four classes depending on their responses at the previous two interviews and nonrespondents were proportionately allocated among the classes depending on their prior responses. The estimates of prevalence and incidence based on these adjusted frequencies are referred to in the tables as adjusted estimates.

For females the primary factors (in addition to continence status) that affect agreement to respond at the household interviews were identified as age and number of eligible respondents in the household (Table 4). Therefore, these two variables and the continence status at each of the three interviews (baseline and two follow-ups) were used as the indices of a five-way frequency table. Marginal subtables were formed for all the incomplete cross-classifications of these five variables. Log-linear models were fitted to the five-way table and a minimal hierarchical log-linear model was identified that fitted the data in the frequency table. This minimal model consisted of two configurations: age by number of eligible respondents and the cross-classification of the continent statuses at the three interviews. Using the algorithm of Fuchs (1982) which is based on the EM algorithm (Dempster, Laird and Rubin, 1977), the frequencies of this five-way table were estimated by maximum likelihood using first the minimal model described above and then using the saturated model which includes the highest order interaction and fits the observed values exactly. Estimates of prevalences and incidences based on these maximum likelihood estimates of the completed table frequencies are referred to as minimal model and saturated model estimates respectively.

Prevalence of incontinence: The data from the first household interview were the first to be available. Therefore, priority was given to estimating the prevalence of urinary incontinence (Diokno et al, 1986). Raw estimates of prevalence were obtained as the ratio of the number of self-reported incontinents to the total number of interviews completed (excluding proxies). (Although the cohort for the first interview was obtained by a random probability sample of the households, the same cohort was followed for subsequent interviews; therefore prevalence rates at the follow-up interviews are not community estimates.)

Estimates of prevalence from the complete data at each interview (raw estimates) and those using the above methods of adjusting for nonresponse are presented in Table 5. It may be noted that the estimates do not differ greatly.

Table 5
Estimates of Prevalence (in %)

Estimator	Baseline	1st Follow	2nd Follow
		FEMALES	
Raw estimate	37.7	48.1	53.3
Adjusted estimate	37.7	47.4	51.7
Using saturated model	37.7	47.2	51.5
Using the minimal model	37.7	47.3	51.4
Sample size	1154	786	768
		MALES	
Raw estimate	18.6	21.5	22.7
Adjusted estimate	18.6	22.0	24.5
Sample size	799	545	454

Estimates of incidence: Incidence is the probability of becoming incontinent in a twelve-month period (the time between interviews) given that the subject is continent at the beginning of the period. Therefore, the raw estimates of incidence were obtained by dividing the number of new self-reported incontinents (who were continent at the previous interview(s)) by the total number of continents at the previous interview. Other estimates of incidence (adjusted, saturated model and minimal model) were obtained in a similar manner using the completed frequency tables as described above.

For comparison, estimates were obtained by standard demographic methods (number of cases divided by years at risk) and by a modified life table method. The life table method consisted of considering each newly incontinent subject as at risk for one-half the interval between interviews. In this method all subjects were included who were continent at the baseline interview and participated in at least one other interview.

Estimates of remission: There was a large number of cases of reported continence after previously having reported incontinence (i.e., remission or transitory incontinence), especially among those who reported mild incontinence. The estimate of the rate of remission is obtained by dividing the number of subjects who are continent at an interview but incontinent at the previous interview by the number of subjects incontinent at the previous interview (Table 7). Adjusted rates are obtained as described for incidence.

Weights for nonresponse

Need for weights to adjust for nonresponse: Using the model for nonresponse at the baseline interview, weights were estimated to adjust for nonresponse. Both weighted and unweighted estimates for the percent incontinent, percent in excellent health and percent married were computed. The weights were chosen to adjust for the differential nonresponse due to the factors found to be significant in determining refusal to participate. The estimates of prevalence differ slightly from the earlier tables since the nonresponse analysis used a subset of the data; that is, homes for the elderly were sampled in a different manner than households in the community and therefore they were not included in this analysis. (However, a one-seventh sample was selected from both the homes and the community residents.)

The estimates for the baseline survey are presented in Table 8 and those for the second follow-up in Table 9. There are no major differences between the two sets of estimates of incontinence rate and of self-assessed health status. This lack of difference suggests that large biases were not introduced into these estimates by differential nonresponse.

Summary and discussion

The estimates of prevalence adjusted for nonresponse are very similar to the raw estimates at the baseline survey (37.7% for both for females and 18.5 vs 18.6% for males). The estimates differ more at the follow-up interview because continence status at the first interview is a factor in determining the willingness of the respondent to continue to participate. A higher rate would be expected because of the aging of the respondents. One may argue that the higher rate is due to the differential nonresponse of continents and incontinents. However, this differential nonresponse was nonsignificant for males (at the first follow-up there was 32% nonresponse for those who were continent at the baseline interview and 30% for those who were incontinent) and, although significant, the rates did not differ greatly for females (33% vs 30%, respectively).

The high rates of incidence found in this survey (>20% in females and 10% in males) may also be affected by the self-selection of the respondents. However, the consistency of the estimates across the two intervals (baseline to first follow-up and first follow-up to second follow-up) indicates that the incidence is not small. This pattern of high incidence is consistent with the finding of a high rate of remission; this may be indicative of a subpopulation with a transient form of incontinence. An analysis of the severity of incontinence, not presented here, indicates that the newly incident cases and those cases in which remission occurs tend to be of a mild type.

Table 6
Estimates of Incidence (in %)

Estimator	To: 1st Follow	2nd Follow
	FEMALES	
Raw estimate	22.4	18.6
Adjusted estimate	22.4	20.4
Using saturated model	22.3	20.3
Using the minimal model	22.4	20.0
Demographic estimate	21.9	19.5
Life table estimate	19.5	19.0
Sample size	482	306
	MALES	
Raw estimate	9.0	9.2
Adjusted estimate	9.6	12.0
Demographic estimate	8.2	9.6
Life table estimate	8.2	8.3
Sample size	442	338

Table 7
Estimates of Remission Rates (in %)

Estimator	To: 1st Follow	2nd Follow
	FEMALES	
Raw estimate	11.2	13.3
Adjusted estimate	11.3	13.4
Using saturated model	11.6	13.7
Using the minimal model	11.5	13.7
Sample size	304	332
	MALES	
Raw estimate	26.7	32.3
Adjusted estimate	23.3	31.0
Sample size	105	96

Acknowledgment

This research was supported by a grant award from the National Institute of Aging (1 PO1 AGO 3742).

References

1) Dempster, A.P., Laird, N.M. and Rubin, D.B.: Maximum likelihood from incomplete data via the EM algorithm. J. Royal Statist. Soc. B, 39:1-38,1977.
2) Diokno, A.C., Brock, B.M., Brown, M.B., and Herzog, A.R.: Prevalence of urinary incontinence and other urological symptoms in the non-institutionalized elderly. J. Urol., 136:1022-1025,1986.
3) Diokno, A.C., Brown, M.B., Brock, B.M., Herzog, A.R., and Normolle, D.P.: Clinical and cystometric characteristics of continent and incontinent non-institutionalized elderly. J. Urol., 1988, in press.
4) Fuchs, C. Maximum likelihood estimation and model selection in contingency tables with missing data. J. Amer. Statist. Assoc., 77: 270-278, 1982.
5) Herzog, A.R., Diokno, A.C., Brown, M.B., Normolle, D.P., and Brock, B.M.: Two-year incidence, remission and change patterns of urinary incontinence in non-institutionalized older adults. Submitted for publication.

Table 8
Effects of Nonresponse at the Baseline Survey

Factor	Sex	N	Unweighted Estimates	Weighted Estimates
% Incont	M	772	18.8% ±1.5	19.0% ±1.5
	F	1051	37.5% ±1.5	37.6% ±1.5
% Excell Health	M	769	19.5% ±1.6	20.5% ±1.6
	F	1047	14.1% ±1.3	15.2% ±1.4
% Married	M	771	82.1% ±1.5	85.2% ±1.4
	F	1049	48.7% ±1.7	51.2% ±1.7

Table 9
Effects of Nonresponse at the Second Follow-up

Factor	Sex	N	Unweighted Estimates	Weighted Estimates
% Incont	M	489	23.5% ±1.9	24.7% ±2.1
	F	717	52.4% ±2.0	52.4% ±2.0
% Excell Health	M	489	19.0% ±2.0	18.9% ±2.0
	F	717	15.9% ±1.5	15.2% ±1.5
% Married	M	435	81.6% ±2.0	85.2% ±1.7
	F	640	45.5% ±2.0	47.3% ±2.1