Combining Estimates from Complementary Surveys: A Case Study Using Prevalence Estimates from National Health Surveys of Households and Nursing Homes

Nathaniel Schenker, PhD[a]
Jane F. Gentleman, PhD[b]
Deborah Rose, PhD[b]
Esther Hing, MPH[c]
Iris M. Shimizu, PhD[a]

SYNOPSIS

Objectives. When a single survey does not cover a domain of interest, estimates from two or more complementary surveys can be combined to extend coverage. The purposes of this article are to discuss and demonstrate the benefits of combining estimates from complementary surveys and to provide a catalog of the analytic issues involved.

Methods. The authors present a case study in which data from the National Health Interview Survey and the National Nursing Home Survey were combined to obtain prevalence estimates for several chronic health conditions for the years 1985, 1995, and 1997. The combined prevalences were estimated by ratio estimation, and the associated variances were estimated by Taylor linearization. The survey weights, stratification, and clustering were reflected in the estimation procedures.

Results. In the case study, for the age group of 65 and older, the combined prevalence estimates for households and nursing homes are close to those for households alone. For the age group of 85 and older, however, the combined estimates are sometimes substantially different from the household estimates. Such differences are seen both for estimates within a single year and for estimates of trends across years.

Conclusions. Several general issues regarding comparability arise when there is a goal of combining complementary survey data. As illustrated by this case study, combining estimates can be very useful for improving coverage and avoiding misleading conclusions.

[a]Office of Research and Methodology, National Center for Health Statistics, Hyattsville, MD

[b]Division of Health Interview Statistics, National Center for Health Statistics, Hyattsville, MD

[c]Division of Health Care Statistics, National Center for Health Statistics, Hyattsville, MD

Address correspondence to: Nathaniel Schenker, PhD, Office of Research and Methodology, National Center for Health Statistics, 6525 Belcrest Road, Hyattsville, MD 20782; tel. 301-458-4483; fax 301-458-4031; e-mail <nschenker@cdc.gov>.

INTRODUCTION

When a single survey does not cover a domain of interest, estimates from two or more complementary surveys can be combined to extend coverage. Ideally, the multiple surveys would cover mutually exclusive and exhaustive subsets of the domain of interest, refer to the same time period, and have data that can be combined statistically. In reality, these conditions are usually imperfectly met; a survey is designed with its own specific objectives, and being able to produce estimates that are combinable with those from another survey is not a priority. This article presents a case study that demonstrates the enhanced coverage achieved by combining estimates of the prevalence of chronic health conditions from two conceptually complementary health surveys—the National Health Interview Survey (NHIS) and the National Nursing Home Survey (NNHS), both conducted by the National Center for Health Statistics of the Centers for Disease Control and Prevention—and provides a catalog of issues to be considered in such a complex undertaking. The case study illustrates how estimates from complementary surveys can be combined, even when the surveys differ in purpose, and therefore in focus and design.

In particular, for the NHIS and the NNHS, it was believed that a more complete picture of the prevalence of chronic conditions in the elderly population in the United States would emerge from analyses of survey data that covered not only household residents, who are relatively healthy, but also nursing home residents, who have relatively poor health.

As would be expected, many of the sickest and most disabled people reside in nursing homes. Foley et al. identified differential characteristics of people remaining in households and people entering nursing homes, finding, for example, that those with cognitive impairment and limitations in activities of daily living experience a two- to three-fold increase in the risk for nursing home admission.[1] Similarly, Branch and Jette found that the elderly (80- to 99-year-olds), those living alone, those using ambulatory aids, those who are mentally disoriented, and those using assistance to perform instrumental activities of daily living have increased risk of institutionalization.[2] Furthermore, Bishop found that the types of people who reside in nursing homes have been changing over time, with such facilities focusing more on people with greater disability and postacute care needs.[3] Findings such as these support the utilization of information about nursing home residents in assessments of the overall health status of the population of the United States. For example, estimating the overall prevalence of a health condition among the elderly based on a household survey alone could yield biased results, especially if the prevalence of the condition among nursing home residents is substantially different from the prevalence of the condition among household residents. This could be an especially important issue when comparisons are being made over time. For example, suppose that the overall prevalence of a condition is increasing over time, but that people who develop the condition tend to move into nursing homes. Estimating time trends in the prevalence of the condition based on a household survey alone could lead to the erroneous conclusion that the overall prevalence is remaining constant or even decreasing over time.

An analysis of combined data from the Supplement on Aging to the 1984 NHIS and the 1985 NNHS was performed by Hing and Bloom, who estimated the prevalence of dependence in performing activities of daily living and instrumental activities of daily living in 1984 and 1985.[4] Estimates were produced for the population ages 65 and older (65+) in households, in nursing homes, and for both groups combined. The authors pointed out some of the difficulties encountered in that project, such as having to modify definitions of functional dependency to make them comparable between surveys. Hing and Bloom also estimated the prevalence of chronic health conditions, with an emphasis on comparisons by level of functional dependency.[4]

The sections that follow describe the NHIS and NNHS in more detail, and outline the estimation methods used in our case study. Estimates of prevalence of selected chronic health conditions are presented and discussed for 1985, 1995, and 1997 (the three most recent years for which NNHS data were available at the time of analysis), both for the separate household and nursing home populations and for the combined population, with an eye toward examining time trends and comparing the separate populations. We consider the age group of 65+ because it is commonly used, and the age group of 85 and older (85+) to demonstrate the benefits of combining data when analyses involve people who are more elderly. We discuss several general issues and problems regarding the combining of data from different types of surveys, and we conduct further analyses to shed light on the severity of some of these problems in the context of the NHIS and NNHS.

METHODS

The NHIS and the NNHS

The NHIS is the principal source of information on the health of the civilian noninstitutionalized population of the United States.[5,6] It is a cross-sectional household interview survey, with interviewing conducted face-to-face continuously throughout each year. The sample for each year is a stratified, multistage sample, with data collected from about 40,000 households including about 100,000 people.

Before 1997, because a large number of health conditions were covered in the NHIS, the conditions were divided among six lists. For the conditions on a given list, questions were asked about every member of one-sixth of the sampled households, with the answers for a given family provided by a "family respondent." After a major redesign of the NHIS questionnaire in 1997, the number of conditions was reduced and the format of questions about the conditions was changed. Some questions about conditions are now asked for every member of each family in the sample, with proxy responses used as before for all children and for adults not present during the interview. Most such questions, however, are asked for one adult and one child randomly chosen from each sampled family, with self-reporting required for the adult (unless the adult cannot participate because of a mental or physical incapacity, in which case a proxy can be used; however, this is done only when absolutely necessary) and reporting by a knowledgeable adult required for the child. For each health condition considered in this article, we analyzed data for the randomly sampled adult from each family.

The NNHS is a national probability sample survey of nursing homes, their expenditures, their current residents and discharges, and their staff members.[7,8] It is aimed at describing the volume and nature of nursing home stays and the characteristics of nursing home facilities nationwide. It is cross-sectional and uses a stratified, two-stage sample design, first, to select facilities (about 1,500 nursing homes are sampled in a survey year), and second, to select up to six residents and discharges from each facility. In our case study, we analyzed data on current residents.

Data for the current resident questionnaire are collected via face-to-face interviews with nursing home staff members using information from medical records. For the purpose of collecting diagnosis data, staff members are asked to provide one primary diagnosis and up to five other diagnoses (seven in 1985) for each sampled resident, both as of the time of interview and at the time of admission. For each health condition considered, we used the list of current diagnoses as a basis for determining whether a current resident had the condition.

As is evident from the previous descriptions, the information about conditions differs between the NHIS and the NNHS. For example, while the NHIS asks respondents directly about the presence of specific conditions, the NNHS collects up to a specified number of diagnoses from medical records. Furthermore, the reference period for identifying the presence of the conditions studied here is either "ever" or the last 12 months in the NHIS, whereas the corresponding information is about current conditions in the NNHS. Further information on these and other differences between the NHIS and the NNHS is given in the Discussion section.

For more information on the NHIS and the NNHS, see the website of the National Center for Health Statistics (http://www.cdc.gov/nchs/).

Estimation methods

For a given year and a given survey, the estimated prevalence rate of a condition is simply a ratio in which the numerator is an estimate of the number of people in the relevant population with the condition, and the denominator is an estimate of the total number of people in the relevant poplulation. When the NHIS and NNHS data are combined for a given year, the combined prevalence rate can be estimated by treating the two target populations (household residents and nursing home residents) as sampling strata of a single overall population and then calculating an estimated ratio. Lohr's text on sampling (Section 7.1.2) contains a discussion of estimating ratios from complex survey data.[9] We incorporated survey weights into our point estimates. In estimating variances, we used a Taylor linearization method that incorporates the survey weights, stratification, and clustering, as implemented in the SUDAAN statistical software.[10]

Criteria for selecting conditions

We present estimated prevalence rates for six chronic conditions: diabetes, essential hypertension, ischemic heart disease, cerebrovascular disease, arthritis/rheumatism, and female breast cancer. See Figure 1 for definitions of these conditions in terms of the NHIS and NNHS questions, and the codes in the International Classification of Diseases, Ninth Revision, Clinical Modification.[11] While all of the conditions mentioned in NHIS questions are of interest to the public health community, we chose six that were most amenable to demonstrating the benefits of combining es-

Figure 1. Text of NHIS and NNHS questions, and codes from the *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9), used to define the existence of chronic health conditions for 1985, 1995, and 1997

	1985	*1995*	*1997*
Diabetes (ICD-9 = 250)			
NHIS	DURING THE PAST 12 MONTHS, did anyone in the family have diabetes?	DURING THE PAST 12 MONTHS, did anyone in the family have diabetes?	[Other than during pregnancy,] Have you EVER been told by a doctor or other health professional that you had diabetes or sugar diabetes?
NNHS	According to ___'s medical record, what are ___'s current primary and other diagnoses?	According to ___'s medical record, what are ___'s current primary and other diagnoses?	According to ___'s medical record, what are ___'s current primary and other diagnoses?
Essential Hypertension (ICD-9 = 401)			
NHIS	Has anyone in the family EVER had hypertension, sometimes called high blood pressure?	Has anyone in the family EVER had hypertension, sometimes called high blood pressure?	Have you ever been told by a doctor or other health professional that you had hypertension, also called high blood pressure? [If yes] Were you told on two or more DIFFERENT visits that you had hypertension, also called high blood pressure?
NNHS	According to ___'s medical record, what are ___'s current primary and other diagnoses?	According to ___'s medical record, what are ___'s current primary and other diagnoses?	According to ___'s medical record, what are ___'s current primary and other diagnoses?

continued

Figure 1 (continued). Text of NHIS and NNHS questions, and codes from the *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9), used to define the existence of chronic health conditions for 1985, 1995, and 1997

	1985	*1995*	*1997*
Ischemic heart disease (ICD-9 = 410–414, 429.6)			
NHIS	Has anyone in the family EVER had a coronary heart disease? Has anyone in the family EVER had angina pectoris (pek'to-ris)? Has anyone in the family EVER had a myocardial infarction? Has anyone in the family EVER had any other heart attack?	Has anyone in the family EVER had a coronary heart disease? Has anyone in the family EVER had angina pectoris (pek'to-ris)? Has anyone in the family EVER had a myocardial infarction? Has anyone in the family EVER had any other heart attack?	Have you EVER been told by a doctor or other health professional that you had coronary heart disease? Have you EVER been told by a doctor or other health professional that you had angina, also called angina pectoris? Have you EVER been told by a doctor or other health professional that you had a heart attack (also called myocardial infarction)?
NNHS	According to ___'s medical record, what are ___'s current primary and other diagnoses?	According to ___'s medical record, what are ___'s current primary and other diagnoses?	According to ___'s medical record, what are ___'s current primary and other diagnoses?
Cerebrovascular disease (ICD-9 = 430–438)			
NHIS	Has anyone in the family EVER had a stroke or cerebrovascular accident? Has anyone in the family EVER had a hemorrhage of the brain?	Has anyone in the family EVER had a stroke or cerebrovascular accident? Has anyone in the family EVER had a hemorrhage of the brain?	Have you ever been told by a doctor or other health professional that you had a stroke?
NNHS	According to ___'s medical record, what are ___'s current primary and other diagnoses?	According to ___'s medical record, what are ___'s current primary and other diagnoses?	According to ___'s medical record, what are ___'s current primary and other diagnoses?

continued

Figure 1 (continued). Text of NHIS and NNHS questions, and codes from the *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9), used to define the existence of chronic health conditions for 1985, 1995, and 1997

	1985	*1995*	*1997*
Arthritis or rheumatism (ICD-9 = 710–713, 716, 729.0)			
NHIS	DURING THE PAST 12 MONTHS, did anyone in the family have arthritis of any kind or rheumatism?	DURING THE PAST 12 MONTHS, did anyone in the family have arthritis of any kind or rheumatism?	During the PAST 12 MONTHS, have you had pain, aching, stiffness, or swelling in or around a joint?
NNHS	According to ___'s medical record, what are ___'s current primary and other diagnoses?	According to ___'s medical record, what are ___'s current primary and other diagnoses?	According to ___'s medical record, what are ___'s current primary and other diagnoses?
Female Breast Cancer (ICD-9 = 174, 198.81) NHIS	DURING THE PAST 12 MONTHS, did anyone in the family have breast cancer?	DURING THE PAST 12 MONTHS, did anyone in the family have breast cancer?	Have you EVER been told by a doctor or other health professional that you had.... Cancer or a malignancy of any kind? [If yes] What kind of cancer was it? Breast?
NNHS	According to ___'s medical record, what are ___'s current primary and other diagnoses?	According to ___'s medical record, what are ___'s current primary and other diagnoses?	According to ___'s medical record, what are ___'s current primary and other diagnoses?

NOTES: The ICD codes used here are similar to, but not exactly the same as, those used in other publications on the NHIS and NNHS. For both surveys, trained NCHS personnel assigned ICD codes to condition checklists or verbatim responses. Since 1997, the NHIS has not assigned ICD codes to conditions, as a result of the questionnaire redesign.

NHIS = National Health Interview Survey

NNHS = National Nursing Home Survey

timates. Data for these conditions were available from both surveys, the conditions were defined in similar ways across the two surveys, and the conditions are considered permanent or chronic once they are diagnosed.

RESULTS

Proportions of the population in households and nursing homes

In 1985, 1995, and 1997, about 95% of the overall population ages 65+ lived in households. Of the population ages 85+, however, only about 79% lived in households. Thus, the amount of undercoverage of the combined population resulting from excluding nursing homes from an analysis for ages 65+ will be relatively small, and estimated prevalence rates for the combined population will not differ greatly from those for the household population, unless the rates for the nursing home population are vastly different from those for the household population. In contrast, for ages 85+, if the objective of an analysis is to estimate prevalence for the combined population, then excluding nursing homes from the analysis could result in substantially biased estimates.

Separate and combined estimates of prevalence

Tables 1 and 2 display estimated prevalence rates of diabetes, essential hypertension, ischemic heart disease, cerebrovascular disease, arthritis/rheumatism, and female breast cancer in 1985, 1995, and 1997 for ages 65+ and 85+. Figure 2 displays these results graphically, with the results for the two age groups presented side-by-side for comparison.

The estimated rates for the household population are sometimes larger (e.g., for essential hypertension, arthritis/rheumatism, and breast cancer) and sometimes smaller (e.g., for diabetes and cerebrovascular disease) than those for the nursing home population. In Figure 2, the separation between the combined estimates and the corresponding household estimates is much larger for ages 85+ than it is for ages 65+, which illustrates that the reductions in bias of overall prevalence estimates are potentially much greater when data are combined for the older group.

Perhaps the most striking example of the differential effect of including the nursing home data in the estimates for different age groups is for arthritis/rheumatism, in which the rates for the nursing home population are much smaller than those for the household population. Combining data for ages 85+ results in rates that are between four and seven percentage points lower than the corresponding household estimates. In contrast, the differences between the combined and household estimates for ages 65+ are all only about one percentage point.

As an example of how combining data can affect the analysis of trends, consider the changes in the prevalence of ischemic heart disease from 1985 to 1995 for ages 85+. Whereas the estimated rate for households decreased by one percentage point (from 16.1% to 15.1%), the estimate for nursing homes decreased by more than 12 percentage points (from 32.6% to 20.0%). As a consequence, the combined estimate decreased by four percentage points (from 20.2% to 16.2%), an amount substantially larger than the decrease for households.

DISCUSSION

Our results illustrate that there can be major advantages to combining estimates from complementary surveys. Specifically, for the elderly population (ages 85+), estimated prevalence rates of chronic conditions in the overall population can be improved substantially by using data from both households and nursing homes, especially if the individual prevalence rates for these two groups differ by a large amount.

Examples of other situations in which combining estimates can be beneficial

There are many surveys other than the NHIS and the NNHS that can be considered complementary, and for which combining estimates can be beneficial. We mention a few examples of health surveys here.

The National Center for Health Statistics and Statistics Canada are planning a joint binational health survey in which identical telephone survey questionnaires will be administered simultaneously in the United States and Canada. The two countries' surveys will be geographically complementary.

The National Hospital Discharge Survey and the National Survey of Ambulatory Surgery, both conducted by the National Center for Health Statistics, are complementary health care surveys that cover two disjoint sources of health care services.[12,13] The sampled units are inpatient visits to hospitals and outpatient visits to ambulatory surgery centers. Data from these surveys could be combined to provide broader coverage of surgical procedures.

The National Population Health Survey, conducted by Statistics Canada, was designed to have two complementary components: a survey of people living in households and a survey of residents in institutions providing long-term care for a period of at least six months.[14]

Table 1. Separate and combined estimates of prevalence rates (in percent) of six conditions for people ages 65+, in 1985, 1995, and 1997

Condition	1985			1995			1997		
	Households	Nursing homes	Combined	Households	Nursing homes	Combined	Households	Nursing homes	Combined
Diabetes	10.38	12.81	10.49	12.55	15.48	12.68	13.15	16.23	13.29
	(0.66)	(0.52)	(0.63)	(0.72)	(0.44)	(0.69)	(0.50)	(0.46)	(0.48)
Essential hypertension	41.28	16.42	40.13	40.01	27.24	39.46	46.75	30.75	46.05
	(1.27)	(0.59)	(1.23)	(1.15)	(0.58)	(1.10)	(0.74)	(0.62)	(0.71)
Ischemic heart disease	11.81	26.89	12.51	11.63	17.47	11.88	20.83	16.31	20.63
	(0.85)	(0.82)	(0.82)	(0.73)	(0.55)	(0.70)	(0.55)	(0.49)	(0.52)
Cerebrovascular disease	6.11	19.76	6.75	6.93	20.35	7.51	7.82	20.47	8.38
	(0.63)	(0.68)	(0.61)	(0.64)	(0.49)	(0.63)	(0.36)	(0.51)	(0.34)
Arthritis or rheumatism	40.83	20.90	39.91	40.73	21.87	39.93	51.18	20.33	49.82
	(1.26)	(0.73)	(1.20)	(1.13)	(0.54)	(1.07)	(0.72)	(0.52)	(0.69)
Female breast cancer	1.11	0.97	1.10	2.56	1.55	2.50	5.70	1.10	5.44
	(0.37)	(0.20)	(0.35)	(0.50)	(0.17)	(0.47)	(0.39)	(0.14)	(0.37)

NOTES: Estimated standard errors are in parentheses. See Figure 1 for detailed definitions of conditions.

DATA SOURCES: National Health Interview Survey and National Nursing Home Survey

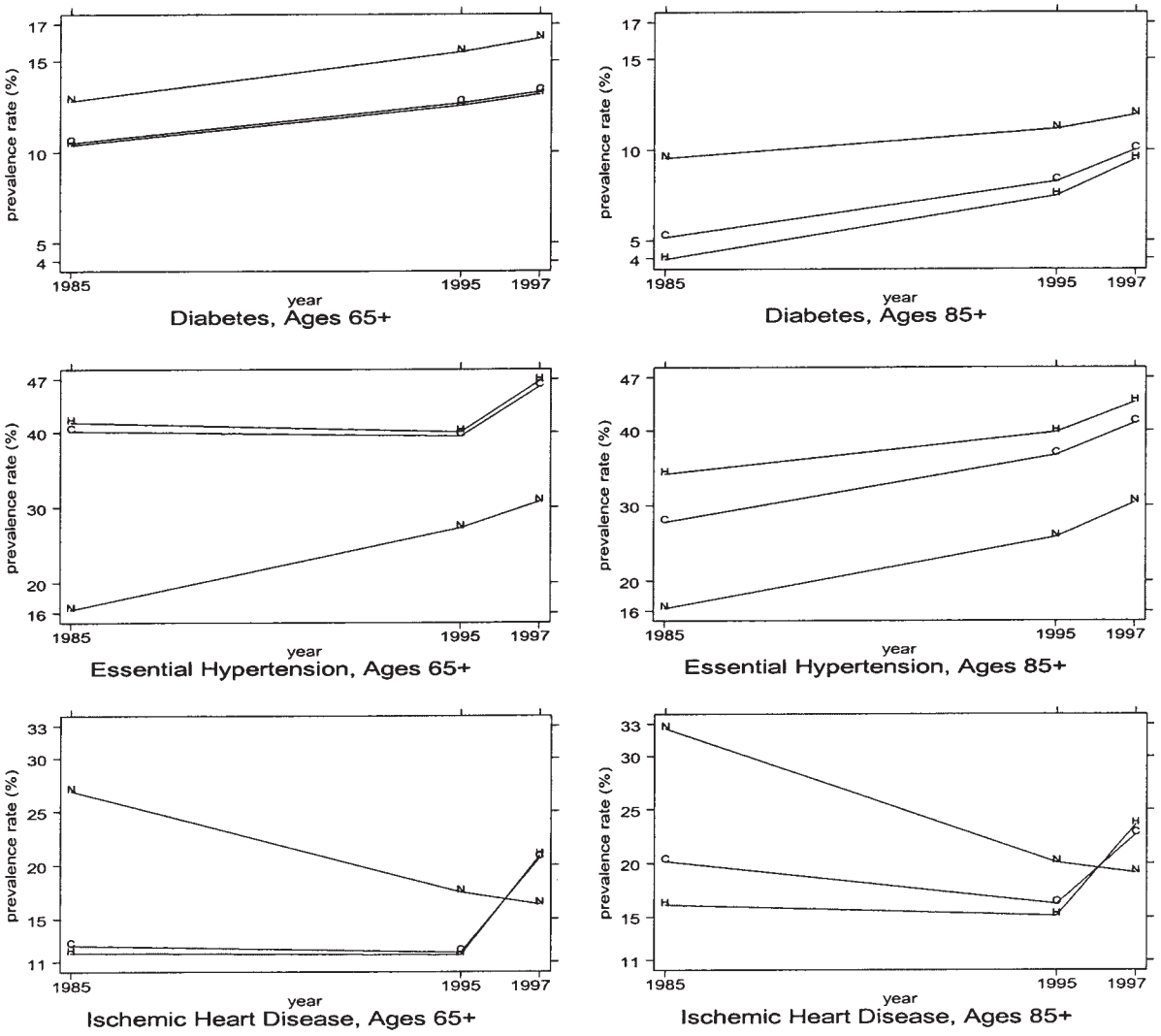
Table 2. Separate and combined estimates of prevalence rates (in percent) of six conditions for people ages 85+, in 1985, 1995, and 1997

Condition	1985			1995			1997		
	Households	Nursing homes	Combined	Households	Nursing homes	Combined	Households	Nursing homes	Combined
Diabetes	3.95	9.54	5.16	7.46	11.13	8.24	9.45	11.92	9.97
	(1.52)	(0.67)	(1.20)	(2.05)	(0.53)	(1.63)	(1.23)	(0.54)	(0.98)
Essential hypertension	34.20	16.33	29.78	39.75	25.81	36.70	43.73	30.40	40.94
	(5.19)	(0.87)	(4.03)	(4.17)	(0.78)	(3.27)	(2.08)	(0.81)	(1.65)
Ischemic heart disease	16.10	32.57	20.17	15.11	20.04	16.19	23.59	19.12	22.65
	(3.83)	(1.16)	(2.90)	(2.97)	(0.76)	(2.34)	(1.85)	(0.70)	(1.47)
Cerebrovascular disease	9.63	18.01	11.70	12.63	17.97	13.81	12.07	17.29	13.16
	(4.02)	(0.94)	(3.05)	(2.90)	(0.65)	(2.30)	(1.51)	(0.65)	(1.20)
Arthritis or rheumatism	45.14	26.26	40.76	50.37	26.55	45.89	57.56	24.45	50.61
	(4.92)	(1.02)	(3.66)	(4.00)	(0.77)	(3.17)	(2.26)	(0.76)	(1.83)
Female breast cancer	1.31	0.91	1.21	4.72	1.63	3.98	6.65	1.17	5.29
	(1.32)	(0.24)	(1.01)	(1.91)	(0.23)	(1.47)	(1.25)	(0.19)	(0.94)

NOTES: Estimated standard errors in parentheses. See Figure 1 for detailed definitions of conditions.

DATA SOURCES: National Health Interview Survey and National Nursing Home Survey

Figure 2. Separate and combined estimated prevalence rates, by age group, 1985, 1995, and 1997



continued

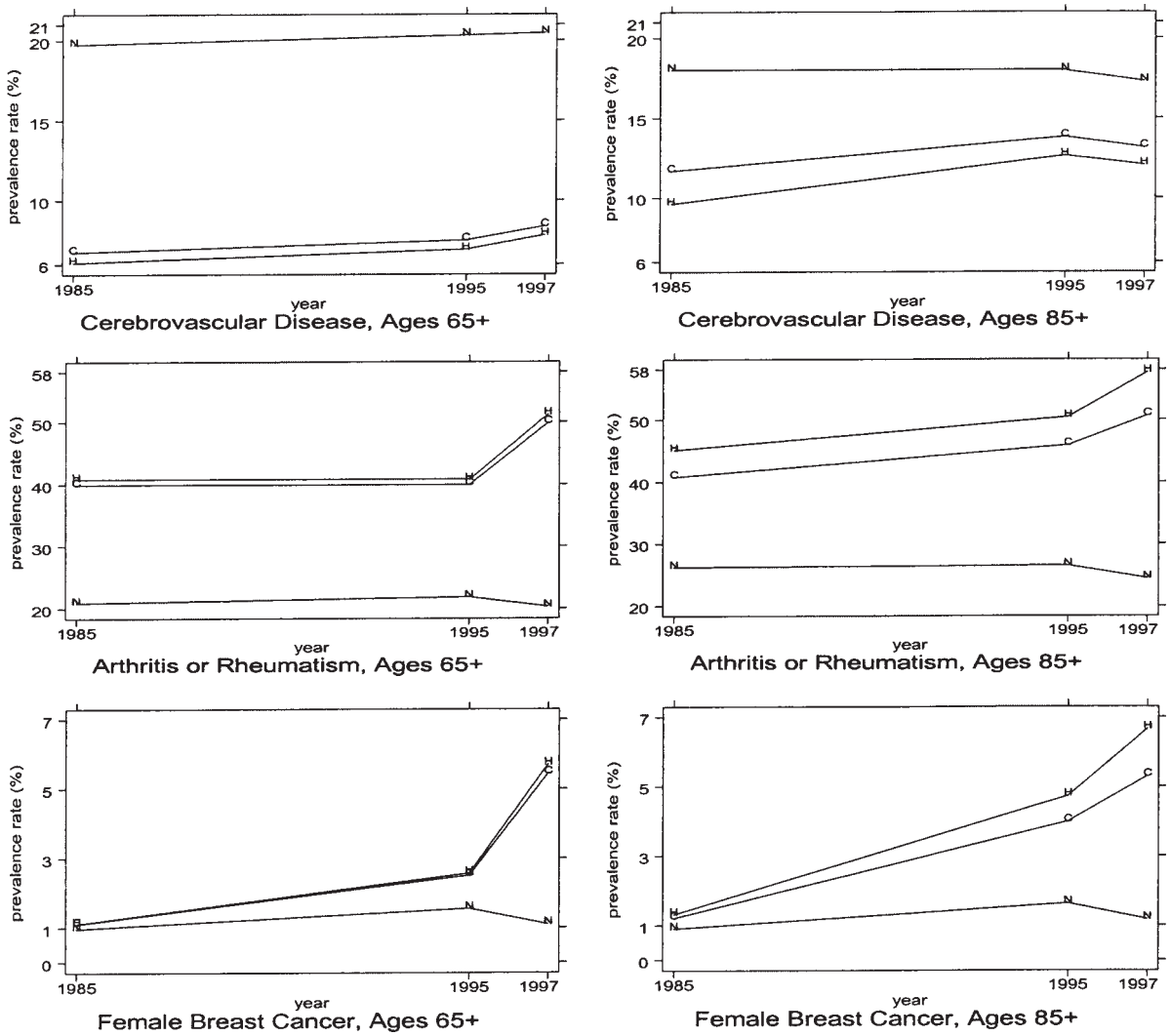
Finally, data from consecutive waves of the same survey are sometimes combined to increase the available sample size. Botman and Jack discussed issues that arise when data from several years of the NHIS are combined for analysis.[15]

Questions to consider when combining estimates

As with any analysis of real data, there are many, possibly overlapping, issues that can arise in combining estimates from complementary surveys. It is important for data analysts to recognize these issues so that remedies can be developed, if possible, and so that the results of the analysis can be interpreted properly. We pose several questions to elucidate such issues and give examples from our case study. We recommend that analysts who are considering combining estimates from complementary surveys pose these same questions.

To what extent are the target populations of the surveys mutually exclusive and exhaustive subsets of the overall domain of interest? Ideally, the target populations of the surveys being combined would not overlap and would together represent the entire domain of interest. The differing objectives of different surveys make this very unlikely to occur, however. In our case study, the com-

Figure 2 (continued). Separate and combined estimated prevalence rates, by age group, 1985, 1995, and 1997



NOTE: See Figure 1 for detailed definitions of conditions.

DATA SOURCES: National Health Interview Survey and National Nursing Home Survey.

C = combined

H = households

N = nursing homes

bined NHIS and NNHS do not represent all residents of the United States because there are some subpopulations that neither survey is designed to cover. For example, neither the NHIS nor the NNHS targets the incarcerated population.

Moreover, the target populations for surveys of households and nursing homes are changing as they are being studied, and there is potential for overlap between the surveys, because people can have one or more transitions between households and nursing homes during a given survey year. Indeed, Foley et al. found that previous use of a nursing home was one of the strongest factors contributing to an increased risk of a household resident being admitted to a nursing home.[1] Implicit in combining estimates from two or more surveys is an assumption that the net effect within the studied time period of transitions among the target populations of the surveys is small.

Do the surveys cover their target populations adequately and comparably? If one survey has better coverage of its target population than another survey, then the comparability of information from the two surveys is reduced. Moreover, if the coverage of a survey changes over time, there can be increased problems of noncomparability in studying time trends.

As an example, when the adult selected to be interviewed in an NHIS sample household is in a hospital during the allotted interview period, the interviewer is almost never able to visit the adult in the hospital to complete the interview. Estimates from the survey data are thus probably biased toward under-representing the hospitalized portion of the population. This could be true especially if the characteristics of the people in hospitals differ strongly from those not in hospitals, which is most likely the case for health data. Moreover, information about temporarily hospitalized adults collected during the portion of the NHIS that covers all family members will necessarily be collected by proxy, reducing the accuracy of data for hospitalized people.

For the present case study, we believe such biases to be very small. Kozak and Lawrence provided estimates, by age group, of the average number of days of hospital care per person in 1985, 1995, and 1997, based on the National Hospital Discharge Survey and the United States Census.[16] The implied estimates of the average daily percentages of the population in hospitals in 1985, 1995, and 1997 are 0.9%, 0.7%, and 0.6% for ages 65+; and 1.5%, 1.2%, and 1.1% for ages 85+. Because all of the estimates are 1.5% or smaller, we suspect that any biases from people being in hospitals at the times of the NHIS interviews are small.

Do the surveys ask similar questions? Differences in questions between the surveys being combined can be a primary cause of noncomparability of information. For example, it is possible to estimate the prevalence of deafness in the household population using 1997 NHIS data and the prevalence of deafness in the nursing home population using 1997 NNHS data. For a person who wears a hearing aid, however, the NHIS asks about deafness without the hearing aid, whereas the NNHS asks about deafness with the hearing aid. Thus, the two surveys differ with respect to the types of deafness that can be studied using their data. That is one reason why deafness was not included among the conditions considered here.

Another example of noncomparability of complementary surveys involves the reference time periods for questions in the surveys being combined. Table 3 displays the reference periods for the questions on conditions that we have analyzed here. The NNHS provides information about current conditions (as well as information about conditions at admission, which is not used in our prevalence estimates), whereas the reference periods for the NHIS are longer. Each survey's choice of reference periods meets that survey's objectives, but the respective estimates may not be comparable between surveys.

If a condition is chronic in the sense that it persists a long time without being cured, then differences in reference period should not matter much with regard to comparability, because there is high probability that a person who had the condition long ago will still have the condition. The NNHS has some data that might help to shed light on the chronicity of the conditions considered here, because information about diagnoses is collected based on both the time of the interview and the time of admission. Figure 3 displays estimated probabilities of a condition being reported currently, given that it was reported at admission, for various intervals of time since admission. The estimates were computed for current residents ages 85+ in the 1997 NNHS. Although data were available for residents for whom admission had occurred up to 46 years ago, we show estimates only for up to five years since admission, covering 84% of the residents ages 85+, because

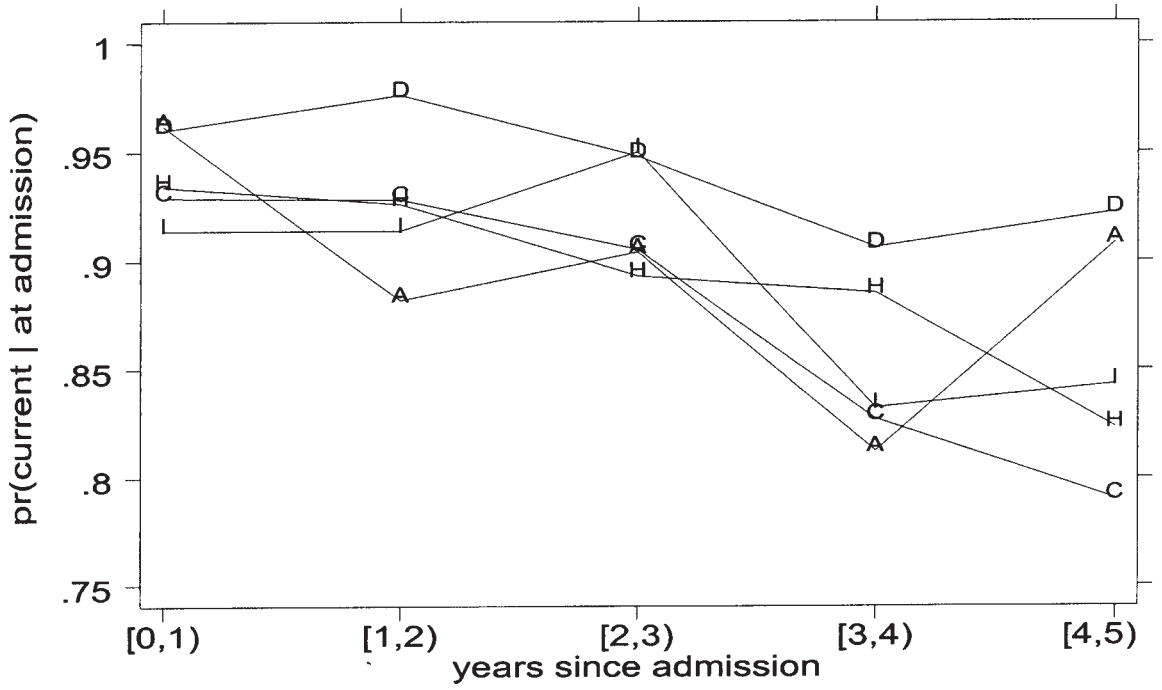
Table 3. Reference periods of survey questions analyzed

Condition	*1985 & 1995 NHIS*	*1997 NHIS*	*NNHS*
Diabetes	Past 12 months	Ever	Current
Essential hypertension	Ever	Ever	Current
Ischemic heart disease	Ever	Ever	Current
Cerebrovascular disease	Ever	Ever	Current
Arthritis or rheumatism	Past 12 months	Past 12 months	Current
Female breast cancer	Past 12 months	Ever	Current

NOTE: See Figure 1 for detailed definitions of conditions.

DATA SOURCES: National Health Interview Survey and National Nursing Home Survey.

Figure 3. Estimated probabilities of a condition being reported currently, given that it was reported at admission, based on current residents ages 85+ in the 1997 National Nursing Home Survey



NOTE: See Figure 1 for detailed definitions of conditions.

DATA SOURCE: National Nursing Home Survey.

A = arthritis or rheumatism

C = cerebrovascular disease

D = diabetes

H = essential hypertension

I = ischemic heart disease.

the sample sizes are very small for longer times since admission. We also omit estimates for female breast cancer due to small sample sizes.

Figure 3 shows that diabetes generally has the highest and most slowly decreasing estimated probabilities over time, with all of the estimates larger than 0.9. This might be expected, because diabetes is generally considered incurable. Cerebrovascular disease has perhaps the most steadily and sharply decreasing estimated probabilities, which also might be expected, because some of the effects of stroke may be reversed over time in stroke patients who do not die. All of the conditions appear to display a downward trend in the estimated probabilities over time. Nevertheless, all of the estimates are larger than 0.79. If the probabilities of conditions persisting were at the levels shown in Figure 3, then the reference periods used in the NHIS could lead to moderate overestimates of current prevalences of conditions, because use of a longer reference period could result in classifying some people who no longer have a condition as having it currently.

The estimated probabilities in Figure 3 are likely underestimates, however, of the true chronicities of the conditions. Shimizu reported that, in a pilot study for the NNHS in 1975, nursing home staff members were asked to give the primary diagnosis at admission for residents in two surveys conducted about eight weeks apart.[17] Although, in principle, the primary diagnosis at admission should not change, for the 152 residents for whom answers were given in both surveys, the second reported diagnosis disagreed with the first in 37% of the cases. That the NNHS asks for up to five (seven in 1985) diagnoses in addition to the primary one should decrease the effects of such prob-

lems on determining whether a condition exists at admission, currently, or both. Nevertheless, some errors or inconsistencies might remain. Even without any errors in the collected list of diagnoses, if a resident has increasing numbers of medical problems or changing primary problems as time progresses, even truly chronic conditions recorded by the NNHS as existing at admission might not be recorded by the NNHS as existing later, especially when there is a limit on the number of conditions that can be recorded, as is the case with the NNHS. Based on these considerations, we might expect the estimated probabilities in Figure 3 to decrease over time, even for truly chronic conditions such as diabetes.

Are the sources of information similar between the surveys? Even if the questions asked were identical across the surveys, differing sources of information might introduce noncomparability. One example in our context is that the NNHS condition information is diagnosis data provided by nursing home staff members using medical records for the nursing home residents in question. These diagnoses had been based on physician assessments. In contrast, the respondents in the NHIS generally do not have access to such records during the interview. Edwards et al. reported that household interviews and medical records often yield different estimates of prevalence for chronic conditions.[18]

Have the surveys changed over time? When aspects of survey designs and procedures are changed, the goal is usually to enhance the accuracy and relevance of current information obtained from the survey. A side effect of such changes, however, is that they can make results less comparable across time and thus create difficulties in the study of trends.

An example in our context is the redesign of the NHIS questionnaire in 1997, which appears to have enhanced the quality of NHIS information, but has also, in some cases, decreased the comparability of our 1997 results with those from 1985 and 1995. The estimated trends in household prevalence rates (and consequently, in the combined estimates) from 1995 to 1997 are often different from those for the period from 1985 to 1995. In particular, the 1997 estimates are often substantially larger than their 1995 counterparts, as illustrated in Figure 2.

A possible contributing cause of the changes in trend is that, again, the 1997 NHIS questionnaire redesign changed the way that people responded to questions about conditions. One aspect of the redesign that could be a factor is that the 1985 and 1995 NHIS information was frequently given by proxy, whereas we used 1997 NHIS information that was given by self-report, except in rare cases. An analysis by Hendershot showed that estimates based on just self-reporters in 1995 are sometimes closer to the 1997 estimates than are estimates based on both the proxy respondents and the self-reporters in 1995.[19] Another important aspect of the 1997 NHIS questionnaire redesign involved changes in question wording (see Figure 1). For example, the reference period for the question about diabetes was 12 months in 1995, whereas it was "ever" in 1997. As another example, whereas the 1995 NHIS asked specifically about arthritis or rheumatism, the 1997 NHIS asked about pain, aching, stiffness, or swelling in or around a joint, without mentioning arthritis or rheumatism.

As the previous discussion implies, estimates of trends across a period in which aspects of a survey have been substantially redesigned need to be interpreted with caution. With respect to our case study, although there is evidence to suggest that the 1997 NHIS questionnaire redesign improved the accuracy of prevalence estimates compared with those from previous years, it might be safer to concentrate more on differences between 1985 and 1995 than on differences between those years and 1997 when examining time trends.

Do the surveys ascertain the characteristics of interest accurately and comparably? Inaccurate ascertainment of characteristics of interest can cause either upward or downward biases. For example, until and unless a condition is diagnosed, its presence may be unknown. Not only can this lead to underestimates of prevalence, but it could also lead to noncomparability if, for example, the diagnosis of conditions were more complete in nursing homes than in households.

As another example, because the NNHS adheres to the common and necessary practice of imposing a limit on the number of diagnoses that can be collected, and because the order in which the diagnoses are recorded may not be meaningful or consistent, the presence of conditions could be underascertained, especially for people with a large number of medical problems. Thus, for example, there could be bias with respect to age because of increased comorbidity with age. Moreover, because a person's main medical problems can change over time, the use of a list with a limit to its length could lead to ascertainment of a condition at one time point but not at another time point, even if the condition existed at both time points. This was discussed as one possible cause of the downward trends in Figure 3.

On the other hand, the potential for underascertain-

ment or misascertainment also exists in the NHIS. A respondent may fail to report the presence of an existing condition (e.g., because of recall problems, a reluctance to report some conditions, or inaccurate medical knowledge).

As a final example, asking about the presence of a condition indirectly can yield an estimated rate that is fundamentally different from the rate obtained by asking about the condition directly. To illustrate, the NHIS has a section that asks about limitations of activity. For people with limitations, the survey asks for a list of conditions that cause the limitations. These data are not intended to assess the prevalence of a condition among those both with and without limitations.

Consider the estimation of the prevalence of diabetes using 1997 NHIS data. The estimated rate of diabetes as a cause of limitation of activity in 1997 is 3.75% for ages 65+ and 2.59% for ages 85+. These estimates are between one-third and one-fourth the size of the corresponding estimates of prevalence (13.15% for ages 65+ and 9.45% for ages 85+) in Tables 1 and 2, which were obtained by asking directly about the presence of diabetes.

Do seemingly similar questions have different meaning or applicability between surveys? Differences across surveys in the meaning or applicability of a question can result in estimates that are not comparable. For example, the 1997 NNHS questionnaire asks if the resident in question currently receives any assistance in certain activities. In some nursing homes, however, it is standard procedure to assist residents, whether the residents need such assistance or not. Therefore, information from the NHIS and NNHS about certain limitations of activity might not be comparable. This was one reason we decided not to produce combined estimates of the prevalence of limitations of activity in our case study.

Do the separate survey estimates have face validity? In any data analysis, considering the reasonableness of results is good practice. In particular, in the context of combining estimates, if the separate survey estimates display counterintuitive values and/or patterns, then the reasons should be investigated, and both the individual and combined estimates should be interpreted with caution.

In our case study, for example, although we might expect the prevalence rates for arthritis/rheumatism and hypertension to be higher in nursing homes than in households, our estimates show the opposite pattern. As discussed in general previously, this could be due in part to underascertainment of conditions because of the limit on the number of diagnoses that can be collected in the NNHS. It could also be due in part to differences between household interviews and use of medical records. For example, in an evaluation of the NHIS, Edwards et al. estimated that arthritis was reported by individuals in households at a higher rate than the rate at which it was recorded in medical records.[18] In the case of hypertension, there could also be a tendency not to diagnose hypertension when cerebrovascular disease has already been diagnosed, because the former often accompanies the latter. Note that our estimated prevalence rates for cerebrovascular disease are substantially higher for nursing homes than for households.

For comparison with our results, we analyzed data from the 1995 Medicare Current Beneficiary Survey (MCBS) to estimate prevalence rates, by age group, for arthritis and hypertension for two subsets of the Medicare population: those who lived in the community during all of 1995 and those who lived in long-term care facilities during all of 1995.[20] The MCBS, which was directed by the Health Care Financing Administration (now the Centers for Medicare & Medicaid Services), asked whether a doctor had ever told the person about whom data were being collected that the person had the condition in question. Thus, the MCBS asked directly about specific conditions rather than obtaining a list of diagnoses, and it used a common reference period ("ever") for the community and for facilities. Nevertheless, the MCBS estimates showed the same seemingly counterintuitive types of patterns that were displayed by our estimates from the NHIS and NNHS (i.e., those in the community had higher estimated prevalence rates for arthritis and hypertension than those in facilities).

There are several other possible explanations for the results regarding arthritis/rheumatism and hypertension based on the MCBS and the surveys used in this article. For example, hypertension could decrease for people in facilities due to their more sedentary life-styles and weight loss. Moreover, if people in facilities are more cognitively impaired or have more comorbidity, they might be less likely to report conditions that could be considered relatively minor, such as arthritis/rheumatism, or conditions that are not necessarily painful, such as hypertension.

Concluding remarks

The usefulness of combining estimates is not always predictable. For the two surveys used here, as an example, the bias introduced by analyzing household survey data and not nursing home data will depend on the objective of the study, the age of the subpopulation being studied, and the health status measure being

analyzed. Analyzing both separate and combined estimates will yield information on the extent of such bias and provide different and useful types of information.

A number of difficult and complex issues arise when there is a goal of combining complementary survey data, and we have cataloged many of these issues in this article. Some of these issues could be eliminated through the design of complementary surveys with an eye toward combining their data. Two examples were given previously of surveys that were deliberately designed to be complementary (i.e., the United States/Canada binational health survey and the two components of Canada's National Population Health Survey). However, because different surveys are usually designed or revised at different times, by different people, with different purposes, it is likely that much of the onus for considering these issues will continue to fall on the analyst. Despite the complexities of the task, the results of our case study involving the NHIS and the NNHS illustrate that combining estimates from complementary health surveys can be very useful for improving coverage and avoiding misleading conclusions.

The authors thank Irma Arispe, Amy Bernstein, Viona Brown, Liming Cai, Robin Cohen, Linda Demlo, Charles Dillon, John Eltinge, Trena Ezzati-Rice, Joyce Frazier, Kelly Huebert, James Lubitz, Diane Makuc, Tommy McLemore, Kathryn Porter, Deborah Poulos, Robin Remsburg, Diane Shinberg, Arlene Siller, and an anonymous referee for contributions to this research.

REFERENCES

1. Foley DJ, Ostfeld AM, Branch LG, Wallace RB, McGloin J, Cornoni-Huntley JC. The risk of nursing home admission in three communities. J Aging Health 1992;4:155-73.
2. Branch LG, Jette AM. A prospective study of long-term care institutionalization among the aged. Am J Public Health 1982;72:1373-9.
3. Bishop CE. Where are the missing elders? The decline in nursing home use, 1985 and 1995. Health Aff 1999;18:146-55.
4. Hing E, Bloom B. Long-term care for the functionally dependent elderly. Vital Health Stat 1990;13(104):1-50.
5. Adams PF, Hendershot GE, Marano MA. Current estimates from the National Health Interview Survey, 1996. Vital Health Stat 1999;10(200):1-202.
6. Botman SL, Moore TF, Moriarity CL, Parsons VL. Design and estimation for the National Health Interview Survey, 1995–2004. Vital Health Stat 2000;2(130):1-31.
7. Hing E, Sekscenski E, Strahan G. The National Nursing Home Survey: 1985 summary for the United States. Vital Health Stat 1989;13(97):1-249.
8. Gabrel C, Jones A. The National Nursing Home Survey: 1995 summary. Vital Health Stat 2000;13(146):1-83.
9. Lohr SL. Sampling: design and analysis. Pacific Grove (CA): Duxbury Press; 1999.
10. Shah BV, Barnwell BG, Bieler GS. SUDAAN user's manual: software for analysis of correlated data, release 7.00. Research Triangle Park (NC): Research Triangle Institute; 1997.
11. Department of Health and Human Services (US). International classification of diseases (ninth revision), clinical modification. Sixth ed. Publication number (PHS) 97-1260. [CD-ROM]; 1997.
12. Dennison C, Pokras R. Design and operation of the National Hospital Discharge Survey: 1988 redesign. Vital Health Stat 2000;1(39):1-42.
13. McLemore T, Lawrence L. Plan and operation of the National Survey of Ambulatory Surgery. Vital Health Stat 1997;1(37):1-124.
14. Trottier H, Martel L, Houle C, Berthelot J-M, Légaré J. Living at home or in an institution: what makes the difference for seniors? Health Rep 2000;11:49-61.
15. Botman SL, Jack SS. Combining National Health Interview Survey datasets: issues and approaches. Stat Med 1995;14:669-77.
16. Kozak LJ, Lawrence L. National Hospital Discharge Survey: annual summary, 1997. Vital Health Stat 1999; 13(144):1-46.
17. Shimizu I. Lessons learned on procedures for longitudinal study of nursing home residents. Proc Social Stat Section Am Stat Assoc 1977;589-93.
18. Edwards WS, Winn DM, Kurlantzick V, Sheridan S, Berk ML, Retchin S, et al. Evaluation of National Health Interview Survey diagnostic reporting. Vital Health Stat 1994;2(120):1-116.
19. Hendershot GE. Estimates of the prevalence of selected chronic conditions in 1995 and 1997: an analysis of differences and their possible causes. National Center for Health Statistics; 1999. Internal report.
20. Health Care Financing Administration, Office of Strategic Planning, Information and Methods Group. Medicare Current Beneficiary Survey CY 1995 cost and public use file documentation. Baltimore (MD): Health Care Financing Administration; 1998.