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Changing Methods of NCHS Surveys: 1960--2010 and Beyond

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Introduction

The year 2011 marks the 50th anniversary of CDC's publication of *MMWR*. It also marks the 24th anniversary of the National Center for Health Statistics (NCHS) joining CDC in 1987. One of NCHS's greatest contributions to public health has been in surveys and survey methodology. Today, more than 50 years after NCHS was formed in 1960, NCHS continues to conduct some of the leading health surveys of the United States. This report describes some of the many innovations and changes in

NCHS survey methods during the past 50 years and briefly previews how the methods might change in the future.

A Brief History of NCHS and NCHS Health Surveys

NCHS is the designated federal statistical agency for compiling, analyzing, and disseminating national health and vital statistics and for monitoring the health of and health care in the nation (http://www.cdc.gov/nchs/about/mission.htm). NCHS was established in 1960 with the merger of two U.S. Public Health Service agencies, the National Office of Vital Statistics and the National Health Survey Program (NHS). The National Office of Vital Statistics, which had been part of the Public Health Service since transferring from the U.S. Bureau of the Census in 1946, was responsible for producing national vital statistics on births, deaths, fetal deaths, marriages, and divorces. NHS had been created in 1956 after passage of the Public Health Service Act. Section 306 of the Act authorizes NCHS to collect national statistics on 1) the extent of illness and disability; 2) the impact of illness and disability on the economy; 3) environmental, social, and other health hazards; 4) determinants of health; 5) health resources; 6) use of health-care resources; 7) health-care costs and financing; and 8) family formation, growth, and dissolution. The Act also directs NCHS to conduct research to develop and improve methods of health surveys.

Since its founding in 1960, NCHS has conducted 15 distinct major surveys (http://www.cdc.gov/nchs) (Table 1). The National Health Interview Survey (NHIS) and the National Health Examination Survey (NHES) were started as part of NHS in 1957 and 1959, respectively, and continued after NCHS was established in 1960. The National Health and Nutrition Examination Survey (NHANES) replaced the NHES in 1971. The National Survey of Family Growth (NSFG) was started in 1973, and the first of eight components of the National Health Care Surveys (NHCS) was started in 1965. The vital records follow-back surveys linked to national samples of birth and death records have been discontinued and two random digit-dialed telephone surveys---the National Immunization Survey and the State and Local Area Integrated Telephone Survey---have been introduced.

Examples of Major Innovations in NCHS Survey Methods

Innovations in NCHS survey methods during the past 50 years have been driven largely by advances in information technology and in the statistical, behavioral, and cognitive sciences. One way to examine these innovations is to categorize them by the six stages of the survey measurement process to which they apply: sample design, questionnaire design, data collection, data processing, data dissemination, and data analysis. Six examples of innovations in NCHS surveys are presented, one innovation for each measurement stage.

Stage 1. Sample Design: Network Sampling

Network sampling was introduced by NCHS staff during the 1970s to improve the precision of sample surveys of rare and elusive populations (*2*). Network sampling also was applied in the 1977 NHIS to estimate the national prevalence of diabetes (*3*). Subsequently, it was used in the National Ambulatory Medical Care Survey (NAMCS) to transform estimates of the numbers of physician office visits into estimates of the number of persons who visited physicians' offices (*4*) and to transform estimates of the number of practicing physicians into estimates of the numbers of physician practices (*5*).

Stage 2. Questionnaire Design: The Cognitive Research Laboratory

A cognitive research laboratory is a workplace for designing and testing survey questionnaires. Cognitive interviewing methods are used to detect and eliminate cognitive problems that respondents have in answering survey questions (*6*). The NCHS Questionnaire Design Research Laboratory (QDRL) was established in 1985. It was the first permanent cognitive research laboratory in a statistical agency or elsewhere, and it served as a model for cognitively testing survey questionnaires that has been adapted by many survey research organizations in the government and private sectors in this country or elsewhere. In 2002, the QDRL initiated the development of Q-Bank, a computerized database of cognitively tested questions. Under the QDRL's management, the Q-Bank serves as the federal interagency repository of cognitively tested survey questions (http://www.cdc.gov/qbank/home.aspx).

Stage 3. Data Collection: Administrative Record Linkage

Formally established in the late 1990s, the NCHS Administrative Record Linkage Program links NCHS data files with administrative record files (http://www.cdc.gov/nchs/data_access/data_linkage_activities.htm). However, some NCHS data files have been linked to some administrative record files since the early and mid-1980s. The Program expanded the scope of NCHS surveys and increased their analytic power to examine factors affecting disability, chronic diseases, health-care use, and illnesses and death (http://www.cdc.nchs/data_access/data_linkage_activities.htm). The program links NCHS survey files with death records from the National Death Index; air monitoring data from the U.S. Environmental Protection Agency; Medicare enrollment and claims data from the Centers for Medicare and Medicaid Services; and Retirement, Survivor, and Disability Insurance and Supplemental Social Security Income benefit data from the Social Security Administration. A pilot study is under way to link NHANES data to state administrative records for Supplemental Nutrition Assistance Program (formerly called the Food Stamp Program) and Temporary Assistance for Needy Families.

Stage 4. Data Processing: Multiple Imputation for Missing Data

Multiple imputation is a model-based technique for imputing values of missing data in which missing values are independently imputed two or more times (*7*). Thus, multiple imputation retains the advantages of single imputation by decreasing bias due to missing data (if the imputation model is valid) and allowing data analysts to obtain valid assessments of variability due to imputation. NHANES III (1988--1994) became one of the first large-scale multiple imputation applications to impute values of missing data on several variables in a large public-use data file. NHIS has used multiple imputation annually since 1997 to impute missing values of personal earnings and family income.

Stage 5. Data Dissemination by Remote Access: The Research Data Center

In 1988, NCHS established the Research Data Center (RDC) (http://www.cdc.gov/rdc) to provide off-site researchers access to NCHS restricted data files while maintaining data confidentiality. The Research Data Center was modeled after the Census Bureau's research data centers. Remote access allows a researcher to run statistical programs against an analytic data set created specifically for the approved use. After the output has been checked for disclosure risk by an NCHS automated system, it

is sent to the researcher. This automated tool for remote access is unique in the federal statistical system and is a key element in expanding access to data for the public health research community.

Stage 6. Data Analysis: Secondary Analyses of Survey Data

During the 1960s, analyses of NCHS survey data were limited largely to descriptive statistics. However, recent advances in statistical methods and computer software appropriate for secondary analyses of data collected in complex sample surveys has greatly expanded the use of NCHS survey data for research purposes. For example, NCHS staff pooled 3 NHIS data years, 1998--2000, to bridge the changes in the classification of race from single-race reporting to multiple-race reporting before and after the 2000 population census (*8*). Advances in statistical methods and computer software have provided analysts of NCHS public-use data files with capabilities to address important issues in cancer research (*9*).

Examples of Survey-Specific Methodology Changes

The founders of NCHS introduced four complementary surveys, NHIS, NHANES, NHCS, and NSFG. They viewed these four surveys as collectively capable of producing the wide range of national health statistics authorized by NCHS' legislation. The examples discussed below illustrate how methods of these surveys have changed during the past 50 years in response to the evolving needs for health statistics.

The National Health Interview Survey

NHIS, the principal source of national information about the health of the U.S. civilian population living in households (*10*), annually collects information through personal interviews on the reported incidence of acute illness and injuries, prevalence of chronic conditions and impairments, extent of disability, use of health services, and in-depth demographic and socioeconomic data. Collection of these data allows continuing monitoring of the nation's health (http://www.cdc.gov/nchs/nhis.htm).

Questionnaire Revisions

The NHIS household questionnaire has undergone revision approximately every 10 years, reflecting changes in health measurements, new concepts of health and disease, and evolving factors associated with illness and health. Comparisons of early with later NHIS questionnaires demonstrate an evolution of perspectives, including 1) shifting from an emphasis on detailed medical-care use to general access to and use of health-care services, health behaviors, and perceived health status; 2) changing from focusing exclusively on the family unit to including questions about both family and randomly selected sample persons' (adults and children) health characteristics, along with requiring self-response from the selected adult; 3) moving from a paradigm of individual body systems to a more holistic health approach; and 4) recognizing the need to address health disparities by collecting information for as many minority populations as possible within the constraints of the sample size.

Changes in survey questions have reflected societal changes in the understanding of health and methodologic refinements in ways to address issues of importance, such as proxy responses, recall periods, and definitions of health concepts. In addition to the evolution in concepts and the refinement of key measurements, the NHIS has adapted to changing methods, moving from pencil and paper administration of the survey to Computer Assisted Personal Interviewing, which when adopted in 1997, increased the flexibility of the instrument and the quality of the resulting data.

Decennial Sample Redesigns

The NHIS household sample has been redesigned after each Population Census to reflect changes in the size and distribution of the national population. The redesign after the 1980 Census also included an important change in the household sampling frame. This change enabled NCHS to analyze data in greater geographic detail; link NHIS files with administrative records; and use NHIS address listings as sampling frames for population surveys, including the NCHS's NSFG, and the Medical Expenditure Panel Survey conducted by the Agency for Health Care Research and Quality (*11*).

The National Health and Nutrition Examination Survey

NHANES collects data on the health and nutritional status of the civilian noninstitutionalized U.S. population through physical examinations and laboratory tests conducted by trained medical personnel in mobile medical centers. NHANES enables assessment of diagnosed and undiagnosed health conditions (*12--14*). Chronic disease, health and risk factor status, infectious disease, oral health, nutrition, environmental health, and genetic data are collected (http://www.cdc.gov/nchs/nhanes.htm).

NHANES Web Tutorial

After NHANES data were made accessible on the NCHS website in 1998 and personal computer--based statistical software became available, the NHANES user base dramatically increased and diversified. In 2005, the NHANES Web Tutorial (NWT) was developed to overcome analytic barriers and promote broader and more proficient use of NHANES data (http://www.cdc.gov/nchs/tutorials/). It was the first NCHS Web tutorial developed and was a collaboration among research analysts, statisticians and programmers, information technology specialists, instructional designers, and science writers.

NWT is a self-guided, distance-based, multimedia interactive learning tool instructing NHANES users how to 1) efficiently locate pertinent information on the NCHS website; 2) quickly retrieve NHANES data files and variables to prepare an analytic dataset; and 3) correctly conduct statistical analyses with appropriate attention to the nuances of NHANES data, given its complex sample design, weighting requirements, and data structure. The tutorial offers analysis tracks in SAS Survey Procedures, SUDAAN, and Stata. It is a textbook of best practices for analyzing NHANES data. It is part of the accredited CDC online learning courses and has been used in several graduate-level university programs. The NWT allows 24/7 data and analysis assistance and has reduced the timeframe for NHANES analysis proficiency from 3--4 months to 3--4 weeks for new staff. Because of the success of the initial NWT, five additional tutorials (environmental health; NHANES I, II, and III supplemental tutorials; and a full dietary tutorial) have been developed, and a sixth (physical activity) is being developed.

Community-Level Health Examination Statistics

Although NHANES serves the health examination data needs on a national level, no comparable program is available for states, local communities, or special populations. To address these gaps, NHANES provides local areas with technical expertise to conduct their own health examination surveys. For example, two projects funded by interested subnational communities have been undertaken. In 2003--2004, NHANES helped the New York City Department of Health and Mental Hygiene successfully conduct the first New York City HANES by using comparable NHANES data

collection and information technology methods for selected conditions, such as diabetes, high blood pressure, high cholesterol, and depression (*15,16*). During 2008--2009, NHANES helped Oregon prepare for a landmark, statewide study of health and access to care using similar measures.

These projects stimulated another initiative currently in the evaluation stage that, if successful, might offer a way to obtain community-level estimates nested within future NHANES redesigns for large counties such as Los Angeles County, California, that are part of NHANES sample every year. A special dataset comprising information collected from NHANES participants in Los Angeles County during 1999--2004 was created for this evaluation study (*17*).

The National Survey of Family Growth

NSFG is based on in-person interviews with national samples of men and women 15--44 years of age in the household population of the United States. NSFG collects data on marriage and divorce, sexual activity, infertility, pregnancy outcomes, contraceptive use, and reproductive health (*18,19*). These data help to explain trends and differences in birth and pregnancy rates, reproductive health, and family formation (http://www.cdc.gov/nchs/nsfg.htm).

Audio Computer Assisted Interviewing

When NSFG began during the 1970s, it focused on contraceptive use, infertility, and pregnancy among ever-married women because a relatively small percentage of births were to unmarried women (*20)***.** However, as the percentage of births to unmarried women increased (to 18% in 1980 and 39% in 2006 [*20*]), collecting a wider range of sensitive data became more important. To do this, in 1993, NCHS began to collect part of the NSFG interview using Audio Computer Assisted Survey Interviewing (ACASI). ACASI is a means of collecting sensitive information in face-to-face interviews in a way that respects the privacy of respondents and encourages complete and accurate reporting of sensitive behaviors. In ACASI, the respondent uses a laptop computer to read the questions while listening to them through headphones and then enters his or her responses directly into the computer. The interviewer does not see or hear the questions or the answers. This method gives the respondent greater privacy, and it yields more complete reporting of sensitive behaviors than does a paper and pencil questionnaire (*21)*. In the 1995 NSFG, ACASI was used primarily to collect data on pregnancy outcomes, but in 2002, the ACASI section of the questionnaire was expanded to collect data on behaviors that increase the risk for HIV and other sexually transmitted infections, including male--male sex, numbers of sex partners, and drug use (*22--24*).

When NSFG changed from periodic to continuous data collection in 2006, collecting real-time administrative data about the survey data collection process became increasingly important to manage the survey. Hence, NSFG began to routinely collect data about the data collection process, called paradata, including the times of day interviews were conducted, length of interviews, and number of attempts to complete interviews. The availability and use of paradata with a 1-day lag between field actions and receipt of the paradata are helping NSFG control both the costs and quality of data collection (*18,25*)**.** The use of paradata for survey management and cost control is in its early developmental stages, and much more remains to be learned about using the paradata to control survey costs, improve data quality, and maximize response rates (*18,25*).

The National Health Care Surveys

The National Health Care Surveys, a family of national surveys of patient encounters with health-care providers in different settings (Table), collects data directly from health-care providers on patients' diagnoses and treatments and on services provided to patients. These surveys also collect information about the health providers. The data are used to assess national patterns in the use, payment, organization, quality, and delivery of health-care services (http://www.cdc.gov/nchs/nhcs.htm).

Survey Integration

As a consequence of introducing new surveys whenever new settings for delivering health services emerge, NHCS has conducted eight distinct and independent provider surveys since 2004. Reducing the number of distinct surveys while retaining the capability of surveying all providers is simplifying planning, making the surveys easier to conduct, and potentially lowering survey costs.

For example, the National Hospital Ambulatory Medical Care Survey (NHAMCS) was initially fielded in 1992 and collects information about patients seen in emergency and outpatient departments of hospitals. The National Survey of Ambulatory Surgery (NSAS) was initially fielded in 1994--1996 and collects information about surgical procedures performed in freestanding and hospital-based ambulatory surgery centers. Initially, NHAMCS and NSAS were independently designed. After a feasibility study demonstrated a cost-effective way to integrate the NSAS and NHAMCS sample designs and data collection methods without loss of data quality, NSAS was combined with the NHAMCS beginning in 2009. The vast majority of freestanding surgery centers were selected from within the NHAMCS primary sampling units, and hospital-based ambulatory surgery centers were selected from hospitals already included in NHAMCS. Information about surgical encounters and patients' procedures was collected by using the same data collection form in both freestanding and ambulatory settings, and data collection forms and methods were standardized with NHAMCS's outpatient department patient record forms.

The increasing use of the electronic medical record system will be a key issue in designing NHCS in the future as increasingly more health-care providers adopt this technology. NHCS has been collecting information about the use of electronic medical records in virtually all of its health-care provider surveys (http://www.cdc.gov/nchs/data/hestat/emr_ehr/emr_ehr.htm). At the present time, gathering national data solely from electronic sources would yield highly unrepresentative estimates. NCHS, however, recognizes that it must prepare for a future in which data may be gathered mainly from electronic systems. Many methodologic problems remain to be addressed. These include identifying the range of data available electronically, defining the items of interest, defining the properties of these data (including their levels of completeness and accuracy compared with conventional paper medical records), developing methods to securely transfer large volumes of confidential data electronically in a manner acceptable to health-care providers surveyed, and developing methods to combine data from disparate noninteroperable systems to produce usable data files.

Future Directions of NCHS' Survey Methods Research Program

Changes in NCHS survey methods will depend on the vigor, rigor and imagination of its survey methods research program in maintaining the statistical standards of the Center's surveys, while also developing and applying innovative survey methods to meet the ever changing needs for health statistics. The survey methods research program is an NCHS-wide effort but is one of the primary

missions of the Office of Research and Methodology (ORM). The principal domains of the NCHS program are as follows: short-term and long-term research oriented to NCHS' mission and basic survey research oriented to the future data needs of the Federal Statistical System. However, the boundaries between domains are porous, and the findings of research projects in one domain often lead to new research projects in other domains.

Mission-Oriented Survey Research

Short-term mission-oriented research responds to the ongoing programming needs of an NCHS survey, whether it is NHIS, NHANES, NSFG, or NHCS, and it is usually conducted by the Survey Division's staff and often with ORM support. Examples of ongoing short-term mission-oriented survey research projects are as follows: NHIS post 2010 Census sample redesign, NHANES Web tutorials, NSFG's ACASI, and NHCS's integration of the sample designs of NHAMCS, NSAS, and other health-provider surveys.

Long-term mission-oriented research anticipates the future programmatic needs of NCHS surveys. Examples of possible future long-term mission-oriented survey research projects are as follows: integrating the sample designs of NCHS population and provider surveys, developing analytic methods to assess the health effects of social networks in NCHS population surveys, and assessing the World-Wide Web and the Internet as potential sampling frames and data-collection modes for NCHS surveys.

Basic Survey Research

NCHS collaborates with other federal agencies in conducting basic interdisciplinary surveys oriented to the future data needs of the Federal Statistical System. For example, NCHS was instrumental in establishing the Funding Opportunity in Survey and Statistical Research (FOSSR), a grants program that annually supports investigator-initiated basic survey research projects related to future needs of federal statistical agencies (*26*). Examples of FOSSR-funded research projects are as follows: cognitive and visual issues in Web survey designs, model-based replication variance estimators for sample surveys, and adaptive sample designs in network and spatial settings. FOSSR is jointly funded by NSF and a consortium of about a dozen federal statistical agencies, including NCHS, and is jointly administered by NSF and the Office of Management and Budget's Federal Committee on Statistical Methodology.

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TABLE. Principal surveys conducted by the National Center for Health Statistics

Survey*	Periodicity	Year established	Most recent active year
Household and examination surveys			
National Health Interview Survey (NHIS)	Annually	1957	2011
National Health Examination Survey (NHES)	Periodically	1959	1970
National Health and Nutrition Examination Survey (NHANES)	Annually since 1999	1971	2011
National Survey of Family Growth (NSFG)	Annually since 2006	1973	2011
Vital record--linked surveys			
National Mortality Follow-back Survey (NMFS)	Periodically	1961	1995
National Natality Follow-back Survey (NNFS)	Periodically	1963	1988
Health-care surveys			
National Hospital Discharge Survey (NHDS)	Annually	1965	2010
National Ambulatory Medical Care Survey (NAMCS)	Annually since 1989	1973	2011
National Nursing Home Survey (NNHS)	Periodically	1973	2004
National Home and Hospice Care Survey (NHHCS)	Periodically	1992	2007
National Hospital Ambulatory Medical Care Survey (NHAMCS)	Annually	1992	2011
National Survey of Ambulatory Surgery (NSAS)	Periodically	1994	2006
National Survey of Residential Care Facilities (NSRCF)	Periodically	1989	2010

National Hospital Care Survey	Annually	2011	2011
Random-digit dialed telephone surveys			
National Immunization Survey (NIS)†	Annually	1994	2011
State and Local Area Integrated Telephone Survey (SLAITS)	Annually	1997	2011

* See Reference 1 for survey descriptions.

† Conducted with the National Center for Immunizations and Respiratory Diseases.

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