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## **The U.S. National Health and Nutrition Examination Survey: What Forty Years of Experience Has Taught Us**

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### **Abstract**

The National Health and Nutrition Examination Survey (NHANES) has been conducted by the National Center for Health Statistics for over forty years. The survey collects information on the health and nutritional status of the United States population using in-person interviews and standardized physical examinations conducted in mobile examination centers. During the course of these forty years, numerous lessons have been learned about the conduct of a survey using direct physical measures. Examples of these “lessons learned” are described and provide a guide for other organizations and countries as they plan similar surveys.

KEY WORDS: NHANES, direct health measures, objective health measures, health measurements

### **Introduction**

The National Health and Nutrition Examination Survey (NHANES) has been conducted by the National Center for Health Statistics, part of the U.S. Centers for Disease Control and Prevention, for nearly five decades. The primary objective of the survey is to assess the health and nutritional status of the U.S. population through personal interviews and direct physical measures (NCHS, 1965, NCHS, 1973). The initial survey was planned in 1957-1958 and fielded in October of 1959. It was known as the National Health Examination Survey (NHES). Three surveys were conducted in the 1960s with a focus on different age groups in the population (Table 1). In the 1970s, a nutrition component was added to the survey and the name changed to the National Health and Nutrition Examination Survey (NHANES). Three national surveys were conducted on a periodic basis between 1971 and 1994 as well as one survey that focused on the Hispanic population (HHANES) (Table 1). In 1999, NHANES became an ongoing and continuous survey. A representative sample of about 5,000 persons are interviewed and examined in a single year and are representative of the civilian non-institutionalized population of the United States. The continuous NHANES is conducted as two-year “cycles” where the design and content of the survey remain constant over the given time period (Table 2). Over the course of these nearly five decades, the general format and operation of the survey has remained the same but the content and complexity of the survey has changed significantly.

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**Table 1. National Health and  
Nutrition Examination Surveys  
1960-1994**

| <i>Survey</i> | <i>Dates</i> | <i>Ages</i>    |
|---------------|--------------|----------------|
| NHES I        | 1960-62      | 18-79 years    |
| NHES II       | 1963-65      | 6-11 years     |
| NHES III      | 1966-70      | 12-17 years    |
| NHANES I      | 1971-75      | 1-74 years     |
| NHANES II     | 1976-80      | 6 mo.-74 years |
| HHANES        | 1982-84      | 6 mo.-74 years |
| NHANES III    | 1988-94      | 2 mo. +        |

**Table 2. National Health and  
Nutrition Examination Surveys  
1999-2012**

| <i>Survey</i> | <i>Dates</i> | <i>Ages</i> |
|---------------|--------------|-------------|
| NHANES        | 1999-2000    | All ages    |
| NHANES        | 2001-2002    | All ages    |
| NHANES        | 2003-2004    | All ages    |
| NHANES        | 2005-2006    | All ages    |
| NHANES        | 2007-2008    | All ages    |
| NHANES        | 2009-2010    | All ages    |
| NHANES        | 2011-2012    | All ages    |

## **Lessons learned**

Over the years, many lessons have been learned about the conduct of a physical measures survey. They cover a wide array of issues and many are applicable to all comparable surveys, not just NHANES.

### **The first lesson is “don’t mess with a good idea”.**

The U.S. National Health Survey Act of 1956 led to the fielding of the National Health Interview Survey in 1957 and also authorized the conduct of “special studies” to complement the national interview survey. The purpose was “to obtain data on undiagnosed and non-manifest disease”. The founders of the National Health Survey program made the bold decision to employ a traveling staff and mobile examination units (centers) to collect this type of information. The logistical issues involved in fielding this type of survey were numerous and complex. However, they overcame them and the first National Health Examination Survey began in October 1959. These founders of NHANES had a vision that was unique and special. The core principles of the design and operation of the survey have stood the test of time and are still the same principles used in the NHANES some forty-five years later.

Over the years a number of methodological studies have been conducted to assess whether the use of “fixed sites” for survey data collection would be easier and more economical. While this approach to data collection can be less costly, the logistical complications of setting up these sites for short time periods in various locations around the country have made this alternative impractical for the national survey. It is possible that this alternative “fixed site” approach is the more appropriate option for more limited geographical versions of an examination survey. The use of new and minimally invasive data collection methods may allow the expansion of direct physical measures to other national interview surveys and surveillance systems. This will require methods comparison studies to be completed so that any differences in results due to the alternative data collection methods will be understood and accounted for in comparisons of results between two surveys. It seems unlikely that this “in-home testing and data collection” model will be satisfactory for the assessment of many health conditions that require complex, and large biomedical equipment with equally complex quality assurance procedures.

### **The second lesson learned is “be willing to change a good thing”.**

As sound as the initial health examination survey program was, there was, and still is, the opportunity to modify it to make it bigger and better. When the opportunity came, around 1970, to add a significant nutrition component to the NHES, the task was successfully implemented. This led to a change in the name of the survey (in order to acknowledge this new nutrition focus). Thus, NHES became NHANES. At the same time, the survey increased its complexity by significantly expanding the age range of the survey to cover persons ages 1-74 years. The NHES surveys had focused on specific age groups and the new NHANES focused on most of the population.

In 1999, another significant change in NHANES was implemented. Beginning that year, NHANES changed from a periodic survey covering four to six years to a continuous and ongoing survey. This change in design and operation allowed more flexibility and timeliness to address emerging public health issues, but created an extremely complex survey operation that requires planning for new survey content, collecting current survey content, processing and release of recent survey data files and analytic efforts on past data collection to all occur simultaneously.

Throughout the nearly five decades, changes in methods, equipment, protocols, and personnel have occurred in order to address new (and old) public health needs for information. So, although the NHANES survey has adhered to the mobile examination center model since 1959, it has adapted in many other ways to respond to changing technology, new survey designs and analysis methods and emerging public health needs.

### **The third lesson learned is that there is “some risk with using new cutting edge methods”.**

In order to address some emerging public health issues, one needs to use scientific methods or medical equipment that are at the “cutting edge” of science. There is some risk with using a new and less tested methodology. In NHANES, there have been many successes using such methods (especially in the context of a survey and not a clinical setting). The collection of bone mineral density data using dual energy x-ray absorptiometry in NHANES III (1988-1994) was such an example. This data ultimately became an international reference standard. On the

other hand, the addition of a new methodology in NHANES I for hand-wrist x-rays was later invalidated and the resulting data were never released because they were methodologically flawed.

A thorough review of the scientific literature is important before implementing any data collection measure, whether it is for health interview questions or physical examination measures. In the case of physical exam measures, a careful assessment of the physical and logistical constraints of the mobile examination centers is also required. The appropriate time and place to change an old methodology for a new methodology depends on many factors and may not always be an obvious decision. Sometimes the decision is made for us when the current or “old” methodology or equipment suddenly disappears and one is forced to make a change. This leads to the fourth lesson learned.

### **The fourth lesson learned is “be aware of methods and methods changes”.**

It is important to be aware of and document all the details of the methods being used to collect the data in a survey. This is important for many reasons. First, and most important, is to document for posterity the methods used to collect the information so that years later any user of the data will know exactly what procedures were used when the data were collected. Secondly, over time, methods tend to change and it is important to be able to compare methods and to understand if these changes may have influenced the “trends over time”.

In NHANES, there are numerous examples of methods issues and lessons learned. An illustrative example is provided below.

During NHANES II, mean hemoglobin levels of all population subgroups seemed to be lower than those observed in NHANES I. The question was whether these were “real” changes or changes due to methodologic differences between the two surveys. Upon further review, the change in results for mean levels actually occurred about three-fourths of the way into the NHANES I survey. A review of methods and discussions with staff never did confirm whether the differences were methodologic or not, but it was interesting to note that a change in a pipette and a lab reagent used in the field data collection instrument occurred very close to the time of the differences in mean levels observed after all the data collection was completed. This example demonstrates the difficulty that can occur when one wants to monitor trends over time. The NHANES program has worked diligently to ensure extensive quality assurance and quality control reviews of data and “cross-over” studies of lab methods are conducted whenever any change is planned. It is difficult to predict when and where these methodologic issues will arise. A constant over the nearly fifty years of NHANES is that science changes, and this leads to methods changes, and there is never a convenient time to introduce these new methods in the data collection or to prepare for all of them in advance.

It is also critical that all staff follow protocols and methods in great detail. Regular training of staff and monitoring of data collection are major efforts in NHANES and have expanded over time. It is important to find out (in a timely manner) if any staff are deviating from established measurement protocols. Procedures that have a certain “art” to the collection or are “examiner dependent” (such as blood pressure and skinfolds) require extra monitoring efforts at all times during the survey. Earlier NHANES surveys have had data release issues and data caveats on public release data sets due to problems collecting these types of data. If the problems and inconsistencies are too large, then the usefulness of the data is compromised. Again, these types of data need extra methodologic and quality assurance efforts from the planning stage through the end of data collection.

### **The fifth lesson is “you can never expend too much effort on data quality”.**

The collection of high quality data has been a major focus within NHANES since its inception. The need to collect high quality data is essential when the information is to be used for establishing program interventions or policies. The data must be scientifically and methodologically sound and data collection procedures consistent and repeatable.

In order to collect high quality data, standard protocols and procedures for collection, processing and editing of the data must be in place prior to the beginning of the survey. Having a thorough quality assurance program is an essential part of good data collection. This requires that adequate training of the staff occur prior to data collection and that retraining of staff occur on an ongoing basis through on-site visitations or at periodic retraining meetings. As with all survey data collection, the information is only as good as the field staff who collect it. Over time, the

NHANES program has added additional retraining sessions and they are critical to maintaining consistent and reliable data that follow the procedures developed for the survey data collection. They are worth all the time and resources spent to make them happen because of the increased communication with field staff who are collecting the data. This effort is in addition to periodic visits to the field operations by NHANES staff for quality assurance and direct observance of data collection. Both of the above efforts have become a routine, but critical, part of the NHANES program.

Another aspect of data quality is achieving high response rates. There is much information on this topic in the literature. It is an important part of any survey or surveillance system and, for NHANES, is a constant challenge given the complex nature of the survey and the relatively large time commitment of sample persons who are selected to participate in the survey. The primary lesson learned in this area for NHANES is that you need to have a lot of materials available for the household interviewers and examination staff to help them answer questions from sample persons and to encourage them to participate in the survey.

### **The sixth lesson is that “outreach is critical to the success of the survey”.**

Outreach efforts occur at many levels and are a critical aspect of the NHANES program. From a data collection standpoint, we have learned that you must have a variety of brochures and materials that explain the survey to persons who are selected to participate in the survey and that the interviewers and other field staff must know and understand the objectives of the survey and the uses of the data in order to explain them to survey participants. In addition, community leaders must be informed that NHANES and its mobile examination center are “coming to town”. It is not possible to quietly move the NHANES exam center into a community due to its physical presence. Thus, as much time and energy is spent on advance arrangements with the community as with the survey participants. Both are essential for NHANES to be successful and have high survey response rates.

Equally important is time spent with the collaborators who help sponsor the survey, explaining the physical and financial needs and working together to make sure the science is sound and effective. These “stakeholders” represent another critical outreach effort for the survey. In addition, there is an external “stakeholder” community of interested organizations and researchers that are important and time and materials are needed to communicate on a periodic and effective basis with them.

The amount of time spent in outreach at all of the above levels has increased dramatically over time. The importance of partnership and community outreach is likely the most significant recent lesson learned over the nearly five decades of NHANES. Another critical aspect of outreach is access to the information from the survey. This can be more timely release of data collected in the survey and more extensive information about the complexity of the data and the appropriate analytic procedures needed to analyze the data. Over time, NHANES has greatly increased the documentation associated with the survey data collection, improved the timeliness of data release, and recently provided a web-based tutorial to assist users of the survey information.

### **The seventh lesson is “you pay now or you pay later”.**

It is important to plan and develop all aspects of any direct health measures survey like NHANES taking into account new technologies that are available. When personal computers and the ability to link personal computers with biomedical equipment became possible, it made sense to spend the time and resources to convert the data collection from “paper and pencil” procedures. This allowed more timely review of data quality, fewer data recording errors, and a more timely release of information after the survey was over. While this information technology conversion took time and money “up front”, it saved more money in the long run because large staff resources were not required to code and edit the information after the data was collected.

The use of pilot tests of examination components and cognitive testing of questionnaires prior to the implementation of the survey is critical to the success of NHANES. Much is learned from these activities about whether the logistical requirements for a survey component will work in the physical setting of a mobile examination center and if the medical equipment will survive the rigors of “life on the road” as opposed to “life in a clinical setting”. Today, no new component is added to NHANES without thorough review of the science and pilot testing in the

actual NHANES data collection environment. This has resulted in higher quality data and less costly data collection in the long run.

### **The eighth lesson is “to be relevant and timely”.**

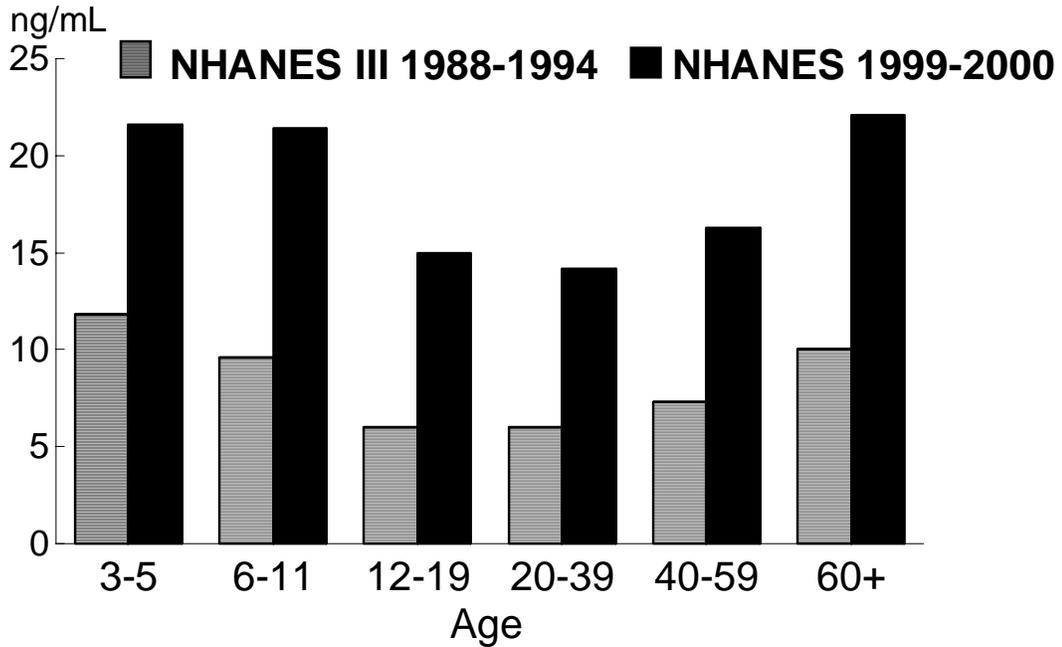
It is essential for any program to be relevant and timely in order to be useful and effective. If the data collected are relevant but not timely, then the program is not responsive to program and policy needs. Two important changes in NHANES over time have improved the timeliness of the data. Those are the introduction of an integrated automated data collection system and the change from a periodic to a continuous survey. The program is now able to respond to new and emerging public health data collection needs in a much faster way than in the past due to the continuous planning, collection and release of the data. In addition, the use of automated data collection technologies has resulted in much faster release of data and higher quality data.

Two examples of timely data from NHANES that were relevant to important intervention programs by other Federal agencies are blood folate levels and blood lead levels of the population. Blood folate levels have been measured in NHANES since NHANES II to assess the folate nutritional status of the population by providing national reference distributions for various population groups. NHANES III (1988-1994) blood folate levels were measured in all person ages one year and above. In 1997-1998, folate fortification of cereal and grain products was mandated by the Food and Drug Administration. NHANES 1999-2000 also included measure of blood folate on the general population. This provided the opportunity to compare blood folate levels in the U.S. population before and after the implementation of folic acid fortification. Figure 1 shows the mean blood folate levels of various female age groups from NHANES III and NHANES 1999-2000 (before and after fortification of the food supply). For all age groups the mean levels increased substantially, thus confirming the desired and expected outcome of folic acid fortification.

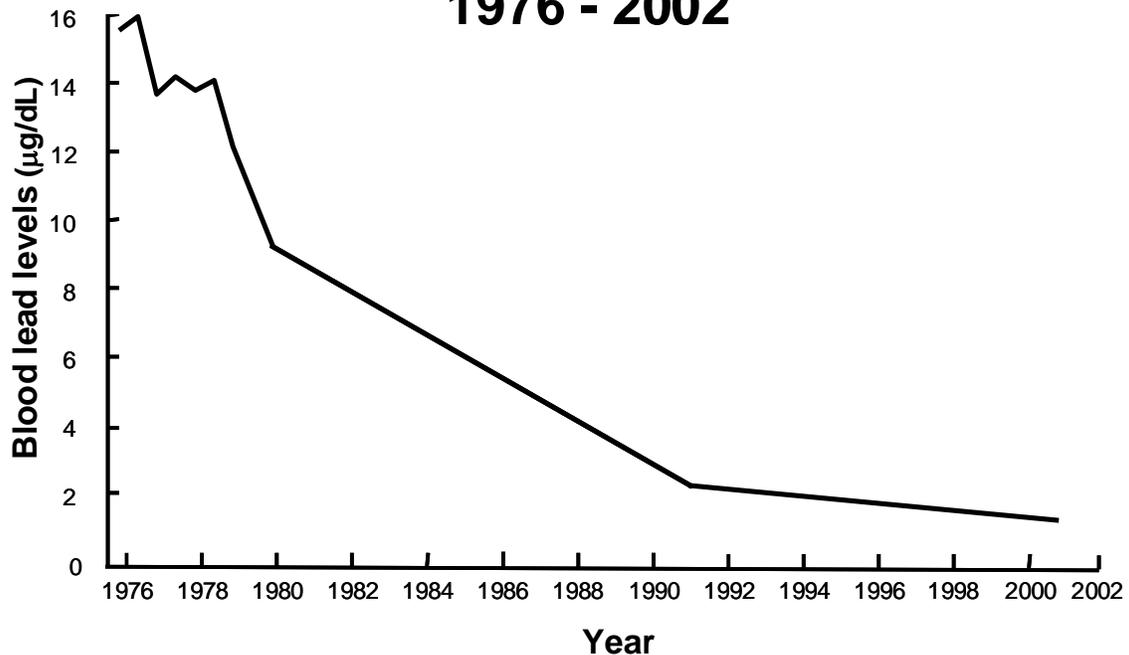
Earlier, in NHANES II, the first environmental measure assay was added to NHANES. This assay was blood lead. It was added to the survey protocol to provide the first national reference data for this environmental assessment. During the course of NHANES II, it was observed that mean blood lead levels were decreasing. Although not the original intent of the survey design, the NHANES mean blood lead levels were compared to external data on the amount of leaded gasoline being produced and used in the U.S. Both declined in a similar manner during the NHANES II data collection period (1976-1980). Figure 2 shows the observed decline of blood lead during the years 1976-1980 and also shows the continued decline in blood lead levels in subsequent years. This information, along with a variety of information from many other studies resulted in the elimination of leaded gasoline in the U.S. Subsequent NHANES data has provided an ongoing ability to monitor the declining trend in the population's blood lead levels.

In neither of these instances did the original plans for collecting these data include these eventual uses of the information. However, planning to include these types of assessments in the NHANES served both the original purpose to produce national reference data and these timely and important public health program assessments that arose later in time. For many of the NHANES topics, the original purpose for inclusion in the survey is to monitor national trends over time using the same data collection methods. This remains a core part of the NHANES and has been that way since the inception of the survey program.

**Figure 1. Mean Serum Folate Concentrations  
Females: United States**



**Figure 2. Mean Blood Lead Levels  
Children Ages 1-5 yrs, United States:  
1976 - 2002**



## **The ninth lesson is “to crawl before you walk and walk before you run”.**

The NHANES survey has evolved over time. When it began as the NHES, it covered a limited age range, used only two examination trailers and focused on a few diseases and risk factors. The initial success of the survey was likely due to the founders keeping the operation and design relatively simple (even though the concept of the survey was fairly unique and untested). The survey then became more complex with each succeeding survey. First, the nutrition component was added to turn NHES into NHANES. Then, infectious disease and environmental health assessments were added on a limited basis in NHANES II and on a much larger scale in NHANES III. Similarly, genetic testing and stored sera projects were introduced in NHANES III, and now on a broader scale in the current NHANES. Finally, exactly forty years after the inception of this national health examination survey, continuous data collection was implemented in 1999. The same approach is recommended for any organization or country attempting to conduct a similar survey based on direct physical measures. Planning and conducting smaller, more modest surveys initially will likely result in increased success and lead to future surveys that can be more extensive and complex.

## **The tenth (and ultimate) lesson is “to learn from your mistakes as well as from your successes”.**

In any survey, there will be successes and failures. Most failures can be avoided or minimized with adequate planning and pilot testing and timely and thorough monitoring of data quality during data collection. However, despite thorough and thoughtful efforts, problems will occur, especially when new procedures are implemented in a complex survey like NHANES. In the nearly five decades of conducting the NHES and NHANES surveys, there have been many successes and some failures (as described in the previous nine lessons learned). Some are with general procedures, some are with “the details”. The most important lesson of all is to learn from the mistakes and failures and to try not to repeat them. Documenting mistakes for posterity is important so that they are known to others and prevent them from making the same mistakes.

From October 1959 until the present, NCHS has been conducting an examination survey based on direct physical measures that addresses public health issues that can best, or only, be assessed using physical measures. NHANES has succeeded because the founders put in place a data collection methodology that was innovative and sound and program staff have been willing to adapt with changing scientific and operational requirements over time. Much has been learned over these nearly five decades and the survey has been modified and expanded many times to respond to changing science and technology. NHANES is a cornerstone of health and nutrition data at the national level in the United States and it serves as the model for other efforts of a similar nature around the world. The need to continue to learn lessons remains an important focus at NCHS, whether from ongoing NHANES operations or from others conducting similar surveys in other parts of the world.

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