

# Utilization of the National Health and Nutrition Examination (NHANES) Survey for Symptoms, Tests, and Diagnosis of Chronic Respiratory Diseases and Assessment of Second hand Smoke Exposure

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## Abstract

**Background:** Respiratory diseases encompass a number of complex disorders that constitute a major cause of both morbidity and mortality worldwide with a major burden to the afflicted as well as the health care systems that care for them. Although the prevalence of chronic respiratory diseases (CRDs) has been decreasing in industrialized countries due to a decreasing number of smokers and stricter laws aimed at reducing exposure to secondhand smoke (SHS), the burden of CRDs in developing world populations is expected to worsen due to communicable disease prevention programs, aging populations, environmental air pollution, and continued tobacco smoke exposure. Although tobacco smoking has been shown to be significantly associated with many CRDs, evidence linking SHS exposure to different CRDs is mixed, especially with low levels of SHS exposure.

**Methods:** The National Health and Nutrition Examination Survey (NHANES) is a series of studies designed to assess the health and nutritional status of non-institutionalized adults and children in the United States (U.S.). In addition to being used to monitor the health of the U.S. population, NHANES data allow for research into prevalent health problems and their risk factors in the population, such with CRDs and SHS exposure. NHANES data can be utilized to explore a variety of issues related to the assessment of SHS exposure and its association to respiratory symptoms and illnesses.

**Results:** First, we provide a brief review of NHANES including its strengths and limitations. We then provide a summary of the variables and publically available population based data that can be used to study associations between SHS exposure and CRD symptoms, testing and diagnoses.

**Conclusion:** Rich and cost effective, NHANES data provide a unique opportunity for research into the risk factors for CRDs in the U.S. population, particularly into the possible health effects of low levels of SHS exposure.

**Keywords:** NHANES; Chronic respiratory disease; Second hand smoke exposure; Cotinine; NNAL; Biomarker

## Introduction

Respiratory diseases are complex disorders that constitute a major cause of both morbidity and mortality worldwide. For example, the top five respiratory diseases account for 17.4% of all deaths and 13.3% of all Disability-Adjusted Life Years according to the World Health Organization [1]. Additionally, respiratory diseases are a major burden to the health care system; in 2006, respiratory diseases were the third most common diagnosis for emergency department visits in the United States (U.S.) and a major cause of hospital admissions in the USA [2,3]. The burden of chronic respiratory diseases (CRDs), such as asthma, chronic bronchitis, emphysema, allergic rhinitis, and chronic sinusitis, has been decreasing in industrialized countries due to decreasing numbers of smokers and the passage of laws aimed at reducing exposure to secondhand smoke (SHS) [4-6]. However, in developing world populations, the burden of CRDs is expected to worsen due to aging populations, environmental air pollution, continued tobacco smoke exposure, and communicable disease prevention programs [4-6].

Although tobacco smoking has been shown to be significantly associated with many CRDs, evidence linking secondhand tobacco smoke exposure to different CRDs is inconsistent, especially with low levels of SHS exposure [4,6-10]. Research on the health effects of SHS

exposure pose a particular challenge due to the tools used to measure SHS exposure. For example, it has been shown that self-report of SHS exposure can be inaccurate, frequently underestimating SHS exposure [11]. One type of measurement tool designed to increase the accuracy of a subject's SHS exposure, particularly at low levels of SHS exposure, are biomarkers of tobacco smoke exposure. Thus, robust studies investigating associations between SHS exposure and CRDs frequently include both self-report as well as objective biomarker measurements to verify or quantify such exposures.

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The National Health and Nutrition Examination Survey (NHANES) is a series of studies designed to assess the health and nutritional status of non-institutionalized adults and children in the United States. Conducted by the National Center for Health Statistics (NCHS), the program of studies has focused both on different populations as well as a variety of health measurements to meet emerging needs. In addition to being used to monitor the health of the U.S. population, NHANES data provides a unique opportunity for research into prevalent health problems and their risk factors in the population, such with CRDs and SHS exposure. NHANES data can be utilized to explore a variety of issues related to the assessment of SHS exposure and its relation to health outcomes.

The objective of this review is to provide a general description of currently accessible and future datasets regarding assessment of SHS exposure and the symptoms, tests, and diagnoses of CRDs as part of NHANES III and the continuous NHANES 1999-2010. After a brief description of the NHANES, we will provide summaries of the data and the variables that can be used to study symptoms, diagnoses and tests of CRDs and assessment of SHS exposure.

## Materials and Methods

Use of large-scale population based surveys is a common practice for epidemiologic investigation. In these surveys, demographic characteristics, self-report survey questions, physical examination characteristics, as well as laboratory measurements are frequently used to investigate the complex relationships that affect the development of disease in both individuals and populations. The NHANES is a widely used resource that combines a wide array of such variables that are available for analysis, with many variables that are publically accessible. We provide a general review of NHANES, summaries of NHANES data and the variables that can be used to investigate relationships between SHS exposure and variables regarding CRDs in the U.S. population.

### The National Health and Nutrition Examination Surveys (NHANES)

The National Health and Nutrition Examination Survey (NHANES) is a program of studies designed to assess the health and nutritional status of adults and children in the United States. The NHANES program began in the early 1960s. The program has been conducted as a series of surveys on different health topics and population groups. In 1999, the survey became a continuous program with a changing focus on a variety of health and nutrition measurements. Each year a nationally representative sample of about 5,000 persons who are located in counties across the country are interviewed for demographic, socioeconomic, dietary, and health-related questions.

The studies originally included a limited array of survey questions and physical examination variables. After much iteration, the study has expanded to include a plethora of demographic, survey, physical examination, and laboratory variables allowing for comprehensive analyses of cross-sectional data. Highly trained medical personnel administer the examination component which consists of medical, dental, and physiological measurements, as well as laboratory tests.

The two most recent incarnations of the NHANES series, the NHANES III and the continuous NHANES, include serum biomarker data of tobacco smoke exposure which create both significant advantages as well as complications for research using data from this study. We review both NHANES studies regarding survey design and data available.

The NHANES III employed a complex sampling strategy to obtain a representative sample of African-Americans, non-Hispanic whites, and Mexican-Americans ages two months and older. Household interviews were obtained on nearly 34,000 family members from approximately 20,000 randomly selected households in 81 U.S. counties. Physical examinations were conducted at mobile examination centers where blood samples were obtained. The 1999-2010 NHANES also employs a complex sampling strategy to obtain a representative sample of the U.S. civilian, non-institutionalized population ages two months and older. African-Americans and Mexican-Americans are over-sampled. Response rates for the household interview ranged from 81.9% to 85.6% in the NHANES III and the 1999-2008 NHANES. Data from NHANES 2009-2010 are projected to be publically available for analysis and inclusion into future studies in 2012. Upon release of these data, which will include serum cotinine, total urinary NNAL measurements, and chronic respiratory disease measures, they can be included in research for addressing symptoms, diagnoses and tests of CRDs and assessment of SHS exposure resulting in further increase in the sample size. The NHANES survey combines interviews and physical examinations across multiple years. Anonymous survey data and related documents can be obtained from <http://www.cdc.gov/nchs/nhanes.htm>.

### Tobacco-related measurements

Assessment of tobacco smoking status and tobacco smoke exposure can be assessed in both NHANES III and the continuous NHANES. Survey participants are asked about current and past tobacco use as well as exposure to second hand smoke exposure at home or at the workplace. The self-report variables of tobacco smoke exposure can be used independently or in combination with objective measures of recent tobacco smoke exposure with serum cotinine and NNAL measurements.

Serum cotinine is available for NHANES III participants aged 4 years old and above. The NHANES 1999-2010 contain serum cotinine measurements for participants aged 3 years old and above. In both surveys, serum cotinine was assessed using an isotope dilution, high performance liquid chromatography/atmospheric pressure chemical ionization tandem mass spectrometric method. The laboratory test detection limit for serum cotinine was 0.05ng/mL for NHANES III, NHANES 1999-2000, and part of NHANES 2001-2002. Improvements in the laboratory testing methods reduced the limit of detection (LOD) to 0.015ng/mL and this lower detection limit was used for NHANES 2001-2010. Urinary total NNAL testing was added to the series of laboratory tests in NHANES 2007-2008 and is also being collected in NHANES 2009-2010. NNAL is measured by using liquid chromatography linked to tandem mass spectroscopy. The laboratory test detection limit for urinary NNAL was 0.0006ng/mL. In all studies, survey questions assessed for participant's current or former use of all tobacco products as well as workplace and household SHS exposure.

### Respiratory disease measurements

Similarly to the assessment of tobacco smoke exposure, NHANES III and the continuous NHANES include self-report and more objective measures of CRDs. Survey questions regarding current and past diagnosis of asthma, chronic bronchitis, emphysema, and hay fever were included in both NHANES III and NHANES 1999-2008. Survey questions about sinusitis were asked in NHANES III, as well as in a battery of questions within a special NHANES 2005-2006 study on allergies. Respiratory outcome definitions requires consultation with respiratory disease experts and an updated review of any published NHANES studies which have used the respiratory-

related data in this survey. For example, acute sinusitis can be defined as anyone who reports having 1 to 3 episodes of sinusitis or sinus problems over the past 12 months and chronic sinusitis is anyone who had at least 4 episodes of continuous sinus problems during the past 12 months, as used elsewhere. In other cases the questions of doctor-defined respiratory conditions such as bronchitis can be used. Physical examination and laboratory variables for this analysis include spirometry, as well as serum total and allergen-specific IgE testing. Spirometry was performed on 20,627 survey participants aged 8 years and older as part of NHANES III using equipment and procedures that met the 1987 American Thoracic Society's recommendations using a minimum of five maneuvers. Analyses involving pulmonary function can be performed in participants with asthma or COPD. As part of the NHANES 2005-2006 special study, laboratory testing of total and allergen-specific serum IgE was performed on participants aged one year and older using the Pharmacia Diagnostics ImmunoCAP 1000 system (Kalamazoo, Michigan); these measures can also be evaluated.

## Results

This study provides a general review of already-released and

soon-to-be released data from the NHANES for symptoms, diagnoses and tests of CRDs and assessment of SHS exposure. We provided summaries of the data including the number of responders and the variables that can be used to study symptoms, diagnoses and tests of CRD and assessment of SHS exposure.

The current availability of reported SHS exposures, serum cotinine, total urinary NNAL, and corresponding LOD were provided for NHANES III and NHANES 1999-2008. [Table 1](#) provides a matrix of currently available NHANES biomarker and self-reported SHS data; in total, there are 61,261 serum cotinine measurements, 7,170 urinary NNAL measurements, and 85,617 survey responses regarding SHS exposure in all NHANES excluding NHANES 2009-2010 which are projected to be publically available for analysis and inclusion into future studies in 2012. Of note, the percentages of serum cotinine values below the LOD range from 12.3% to 37.7%. The lowest percentage (12.3%) was seen between 1988-1994 from NHANES III i.e. 2,751 out of 22,377 participants with serum cotinine values below 0.005 ng/ml. On the other hand, the highest percentage (37.7%) was seen in the NHANES 1999-2000 (i.e. 2,743 out of 7,284 participants with serum cotinine values below 0.05ng/ml). This low percentage of undetectable

Study Characteristics	NHANES III 1988-1994	NHANES 1999-2000	NHANES 2001-2002	NHANES 2003-2004	NHANES 2005-2006	NHANES 2007-2008
Serum cotinine limit of detection (ng/mL)	0.050	0.050	0.050 or 0.015	0.015	0.015	0.015
# of participants with serum cotinine values	22,377	7,284	8,299	7,792	7,761	7,748
Serum cotinine values below the LOD (%)	2,751 (12.3%)	2,743 (37.7%)	1,872 (22.6%)	1,314 (16.9%)	1,368 (17.6%)	1,352 (17.5%)
Total Urine NNAL limit of detection (ng/mL)	-	-	-	-	-	0.0006
# of participants with total urine NNAL values	-	-	-	-	-	7,170
Total urine NNAL values below the LOD (%)	-	-	-	-	-	3172 (44.2%)
# of participants asked about workplace & household SHS smoke exposures	33,994	9,965	11,039	10,122	10,348	10,149

Total Urinary NNAL, and corresponding Limits of Detection (LOD)

**Table 1:** Current availability of Reported Second Hand Smoke (SHS) exposures, Serum Cotinine,

Symptoms, diagnoses and tests of CRDs	Number of respondents		
	NHANES III 1988-1994 Adults	NHANES 1999-2008	NHANES 2005-2006 Special Study
Subjects with pulmonary function tests/Spirometry (including subjects with asthma and COPD)	20,627	-	-
<b>Asthma</b>			
Subjects asked if ever been told you have asthma?	20,050	49,096	-
Subjects asked if still have asthma?	1,377	4,664	-
Subject asked if had asthma attack in past year?	-	4,276	-
Emergency care visit for asthma/past year?	-	2,198	-
<b>Chronic Obstructive Pulmonary Disease</b>			
Subjects asked if a doctor ever told you that you have chronic bronchitis?	20,050	26,249	-
Subject asked if still have chronic bronchitis?	-	1,211	-
Subjects asked if still have bronchitis?	1,134	-	-
Subjects asked if a doctor ever told you that you have emphysema?	20,050	26,243	-
<b>Allergic Rhinitis</b>			
Serum Total IgE and allergen specific IgE	-	-	8,336
Subject asked if a doctor every told you that you have allergies?	-	-	9,822
Subjects asked it a doctor ever told you that you have hay fever?	20,050	-	9,822
Subjects asked if still have hay fever?	1,501	-	-
Subject asked if had hay fever in past year?	-	14,920	-
<b>Chronic Sinusitis</b>			
During the past 12 months, have you had sinusitis or sinus problems?	5,848	-	-
Number of episodes of sinusitis in the past 12 months?	4,526	-	-
Subject asked if during last 12 months a doctor told you that you have sinus infection?	-	-	9,822
Subject asked if currently has flu, pneumonia, ear infection?	-	45,061	-

**Table 2:** Symptoms, diagnoses and tests of chronic respiratory diseases (CRDs) currently available in the National Health and Nutrition Examination Survey (NHANES). Note that the NHANES 2005-2006 survey cycle conducted special testing regarding allergies and survey questions regarding allergic rhinitis and sinusitis.

cotinine levels in the USA population in past years is likely due to implementation of stricter SHS exposure laws.

Symptoms, diagnoses and tests of CRDs such as asthma, chronic obstructive pulmonary diseases (bronchitis, chronic bronchitis, and emphysema), allergic rhinitis, hay fever and chronic sinusitis currently available in NHANES. Note that the NHANES 2005-2006 survey cycle conducted special testing regarding allergies and survey questions regarding allergic rhinitis and sinusitis. [Table 2](#) presents a summary of the number of participants who were administered questions or laboratory testing involving CRD variables. Survey participants were asked whether they have ever been told by a doctor about having a current or past diagnosis of asthma, chronic bronchitis, emphysema, hay fever, and chronic sinusitis.

NHANES data (NHANES III 1988-1994, 1999-2010) can be utilized to explore a variety of issues related to the assessment of SHS and its relation to health outcomes for symptoms, diagnoses and tests of CRDs. NHANES provides population based data that is rich and cost effective in availability of the variables for studying SHS and CRD.

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