Technical Documentation for Health Resources Service Administration's Health Workforce Simulation Model

National Center for Health Workforce Analysis

Bureau of Health Workforce

Health Resources and Services Administration

U.S. Department of Health and Human Services

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Contents

Exhibits

Acronyms Used in This Report

ACA	Affordable Care Act
ACS	American Community Survey
ADA	American Dental Association
AHCA	American Health Care Association
AMA	American Medical Association
ACO	Accountable Care Organization
APN	Advanced Practice Nurse
BLS	Bureau of Labor Statistics
BRFSS	Behavioral Risk Factor Surveillance System
CBO	Congressional Budget Office
CDC	Centers for Disease Control and Prevention
CMS	Centers for Medicare and Medicaid Services
DHHS	U.S. Department of Health and Human Services
DHPSA	Dental Health Professional Shortage Area
ED	Emergency Department
FTE	Full Time Equivalent
HRSA	Health Resources and Services Administration
HPSA	Health Professional Shortage Areas
HWSM	Health Workforce Simulation Model
IPEDS	Integrated Postsecondary Education Data System
ISPOR	International Society for Pharmacoeconomics and Outcomes Research
LPN	Licensed Practical/Vocational Nurse
LOS	Length of Stay
MEPS	Medical Expenditure Panel Survey
NAMCS	National Ambulatory Medical Care Survey
NCCPA	National Commission on Certification of Physician Assistants
NCES	National Center for Education Statistics
NCLEX	National Council Licensure Examination
NHAMCS	National Hospital Ambulatory Medical Care Survey
NHHCS	National Home and Hospice Care Survey
NIS	Nationwide Inpatient Sample
NLN	National League for Nursing
NMW	Nurse Midwife
NNHS	National Nursing Home Survey
NP	Nurse Practitioner
NPI	National Provider Identification
NPPES	National Plan and Provider Enumeration System
NSSRN	National Sample Survey of Registered Nurses
OES	Occupational Employment Statistics
PA	Physician Assistant
RN	Registered Nurse
SNF	Skilled Nursing Facility

I. Introduction

The Health Workforce Simulation Model (HWSM) is an integrated microsimulation model that estimates the future demand for and supply of health care workers in multiple professions and care settings. It can provide state-level estimates and describe the effects of a policy option at any point in time within the projection period.

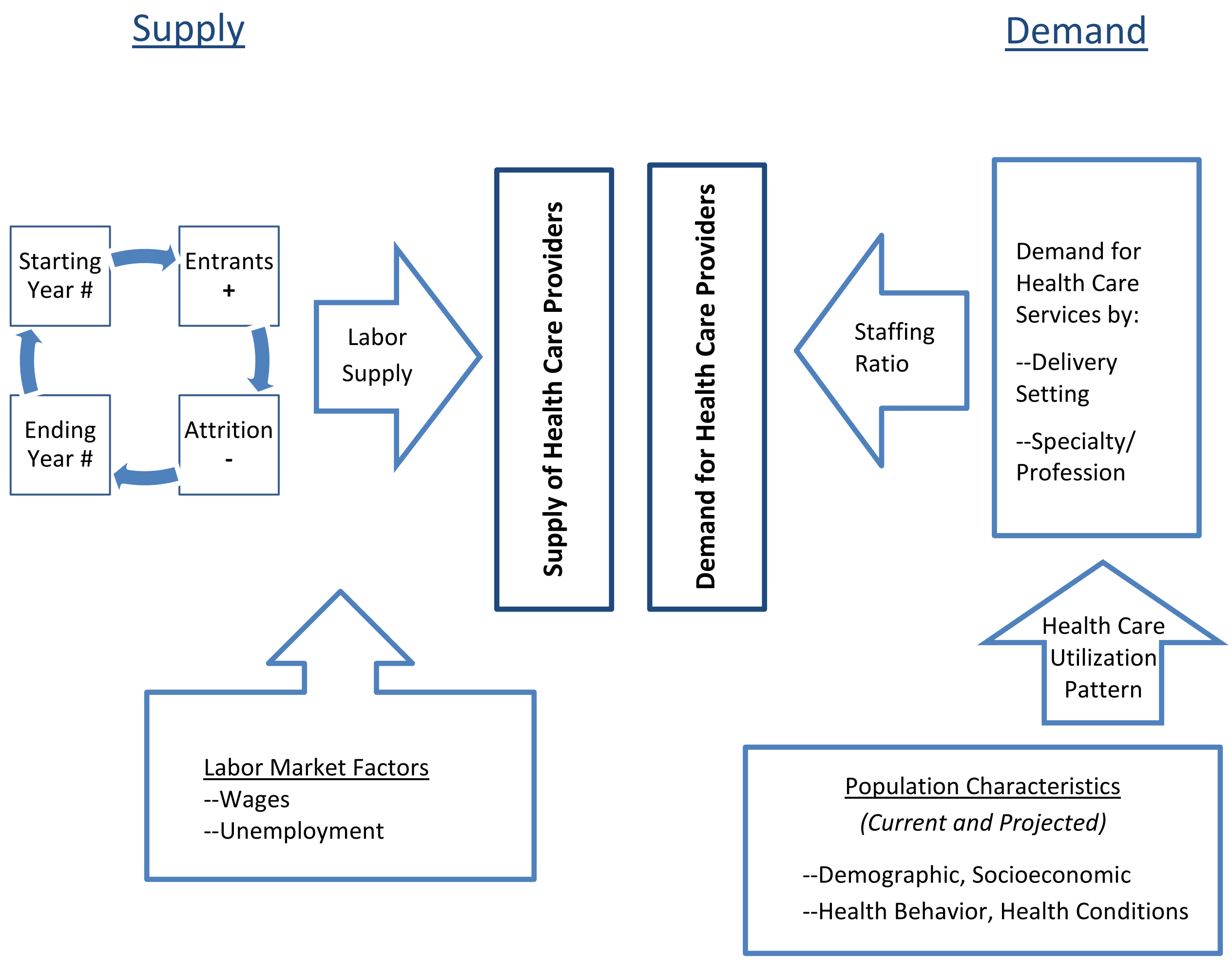
This report provides documentation on the logic, methods, data, assumptions, and validation processes for HWSM in general, and as applied to individual health professions. HWSM continues to be maintained and refined—including new professions added to the model and scenario modeling capabilities enhanced. Each year the model is updated with the most recent data for key data sources, so recently modeled professions use more current data than professions modeled in previous years.

The remainder of this chapter provides an overview of HWSM supply and demand components and the health professions modeled to date. Chapter II describes in more detail the general components of the supply model, and Chapter III describes the demand model. Chapter IV provides information specific to the health occupations that have been modeled to date. Chapter V describes the validation task undertaken to develop the model, its strengths, and limitations.

While the nuances of modeling differ for individual health professions and medical specialties, the basic framework used within HWSM remains the same and consists of three components: 1) the **model for supply of health professional**; 2) the **model for demand for health care services**; and, 3) the **staffing ratios** that convert demand for services to demand for health care workers (Exhibit 1). Consistent with prevailing practice, the model assumes that supply equals demand in the base year.[1] To project the number and characteristics of future health care workers and service users, HWSM simulated individual-level data based on predicted probabilities estimated from the current or base year data. Depending on the predicted probabilities, individual records were simulated to age forward. The aged individual-level records were then aggregated to obtain the national or state- level projections. On the service use side, the current utilization rates by individual characteristics were applied to projected populations at the national and state levels.

[1] Ono, T., Lafortune, G., Schoenstein, M. 2013. "Health workforce planning in OECD countries: a review of 26 projection models from 18 countries". *OECD Health Working Papers, No. 62*. France: OECD Publishing 2013:8-11

Exhibit 1: HRSA's Health Workforce Simulation Model



A number of elements contribute to the development of the model (Exhibit 1). To calculate supply, workforce decisions for future professionals are simulated based on provider characteristics (demographics), profession and specialty, and the features of the local or national economy (wages, unemployment rate). The major components of the **supply model** include:

1. A micro data file containing the characteristics of the current workforce in a given profession.
2. Estimates of the annual number and characteristics of newly trained workers entering a given profession.
3. Equations that describe workforce decisions, such as retirement and number of hours worked, based on current labor market factors. Predicted probabilities from these equations simulate labor supply decisions of future health care professionals.

HWSM simulates the demand for health care services based on individual characteristics of the U.S. population (demographics, socioeconomics, health behavior, and health status). Two major components of the **demand model** are:

1. A database that contains characteristics for each person in a representative sample of the current and projected population in each state through 2025.
2. Regression equations that relate health care use patterns by setting to a person's characteristics. Predicted probabilities from these equations are applied to simulate health care utilization of future populations.

The third component of HWSM is **staffing ratios**, which translate demand for health care services into projected demand for full time equivalent (FTE) providers in different care delivery settings. HWSM simulates demand for health care services in seven settings (emergency rooms, hospitals, provider offices, outpatient departments, home health, nursing homes, and residential facilities). Demands for specific services within a setting are combined with provider staffing ratios in that setting to estimate the demand for health care providers.

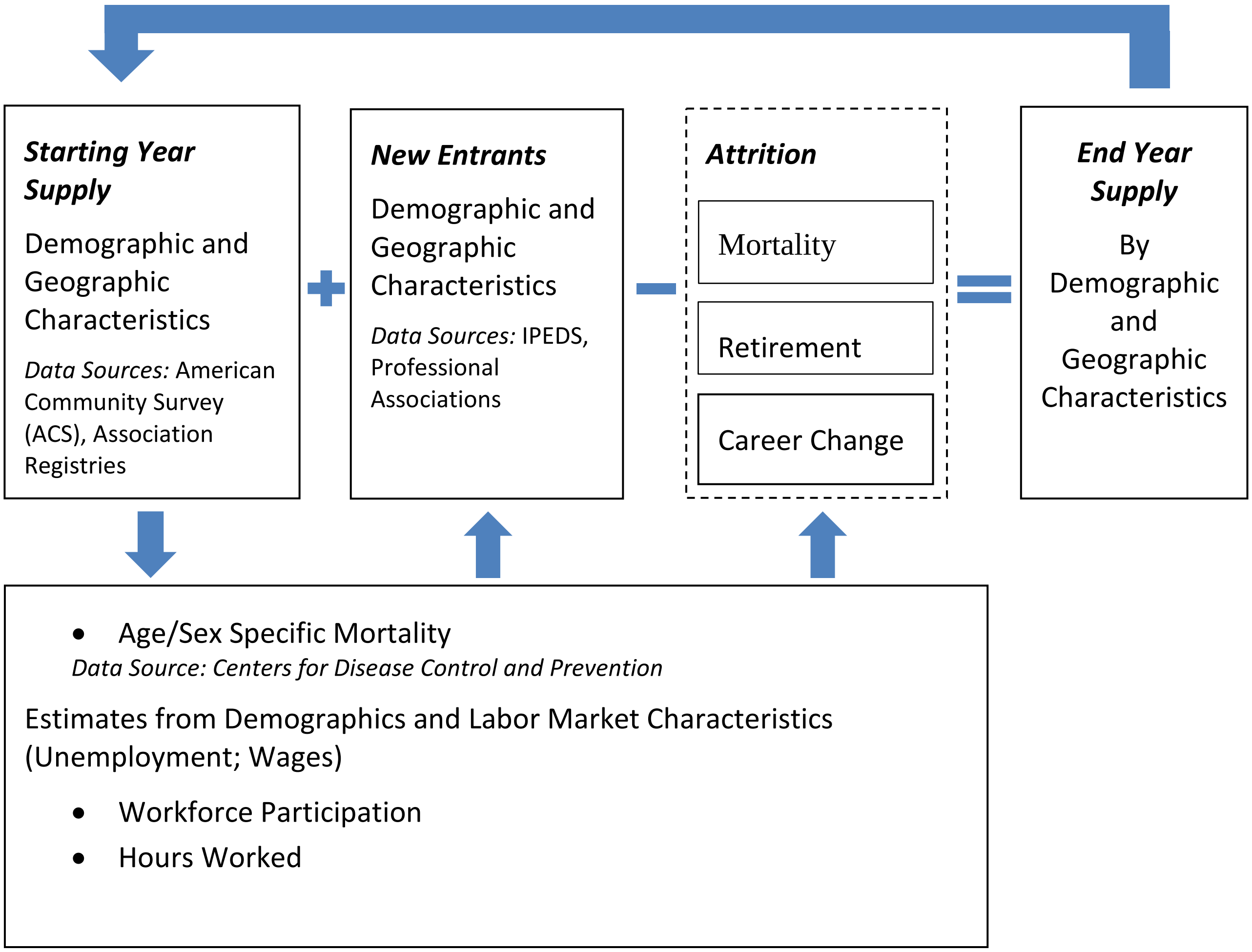
Consistent with recommended standards,[2] HWSM consists of self-contained modules that describe different components of the health care system. HWSM runs using SAS (Statistical Application Software).

II. Modeling Supply of Health Professionals

The supply component of HWSM links individual and labor market characteristics to health care workers' labor supply decisions. Exhibit 2 presents a flow diagram for the supply component of HWSM. The process depicted in Exhibit 2 is repeated for each year in the projection period. After the base year data are trended forward one year, those estimates become the starting point for the subsequent year.

[2] Citro CF and Hanushek EA. 1991. Improving Information for Social Policy Decisions: The Uses of Microsimulation Modeling – Volume I: Review and Recommendations. Washington, DC: National Academy Press. A condensed version of this report entitled: Microsimulation Models for Social Welfare Programs: An Evaluation is available at http://www.irp.wisc.edu/publications/focus/pdfs/foc153b.pdf

Exhibit 2: Flow Diagram for the Supply Component of HWSM



A. Estimating Base Year Supply of Active Health Professionals

The base year supply database in HWSM contains unique records representing each person in the health workforce in the base year. For professions (e.g. physicians, dentists, physician assistants) which have national registries with robust data describing individual characteristics, these registries were used.

For professions (e.g. nursing, technologists and technicians) where the base year supply data are estimated from surveys, records for each survey participant were replicated according to their sample weight in the survey file. For example, if a person's record in the American Community Survey (ACS) has a sample weight of 100 (indicating that it represents 100 people in that particular profession), 100 identical records were created. Creating a record for each person is important because a unique probability could be associated for each simulated person. In states with smaller population, where the sample size is small, the creation of multiple records helped "smooth" the impact of individual characteristics on labor supply decisions such as retirement.

In addition to individual characteristics, labor market characteristics associated with a particular state from BLS, namely the unemployment rate and average profession wage, were linked to each record. For some professions, overall state unemployment rate and average professional wages are inputs to modeling labor force participation.

B. Modeling New Entrants to the Workforce

> *HWSM baseline supply projections assume*
>
> - *Current age and sex distribution of new entrants will be retained in the future*
> - *Current patterns of retirement and hours worked will remain unchanged within a given age and sex group*

Data used to estimate the number and characteristics of new entrants depend on the profession being modeled; see Chapter IV for discussions by profession. Baseline estimates on the number and characteristics of new entrants in each profession over the forecast period are made under the assumption that current patterns continue throughout the projection period.

The mechanism for simulating new entrants to the workforce was done via the creation of a "synthetic" cohort based on the number and characteristics of recent entrants in each profession. First, HWSM derived the probability of an individual having certain characteristics from the base year distribution of those characteristic in the population of new entrants. HWSM then created a record for each new entrant and generated a series of random numbers. Depending upon the value of the random number and the probability of having a particular characteristic, the individual was assigned that characteristic.

C. Modeling Labor Supply of Health Care Workers

HWSM estimated the labor supply of individuals in a profession using a three-step process:

1. The probability that a person would be alive.
2. The probability that a person was active in the profession.
3. The estimated Full Time Equivalent (FTE) supply, based on predicted hours for each person divided by *current average number of hours worked per week* for those who are active in the profession. For some professions, hours worked reflect total professional

hours, while for other professions hours worked reflect patient care hours (depending on data availability).

Estimates specific to a profession or medical specialty were generally used. However, for some professions and specialties with small sample size and other data limitations, information on occupational categories or similar medical specialties were used in place of profession-specific data. Also when patient care hours were not available, the proportion of clinician time in non-patient care activities (e.g., research, teaching, and administration) was assumed to remain constant over time.

The basic assumption underlying the baseline supply projections was that the current patterns of retirement and hours worked remained unchanged within a given age group and sex and that current age and sex distribution of new entrants to the occupation was maintained. Under this scenario, supply changes over time were due solely to the changing demographic composition of the workforce and number of new workers trained.

1. Probability of Being Alive

The probability of being alive was determined from mortality rates by age and sex obtained from the Centers for Disease Control and Prevention (CDC), and accounted for the fact that age-adjusted mortality rates through age 65 for professional and technical occupations are approximately 25 percent lower than overall national rates for men and 15 percent lower for women.[3,4]

2. Workforce Participation

For individuals who were projected to still be alive (with the exception of physicians, advanced practice nurses [APNs] and physician assistants [PAs]), the probability that the person would be actively employed in the health occupation was estimated using ACS labor force participation rates. Since the ACS does not list the profession of individuals who have been retired for more than five years, profession-specific labor force participation rates were imputed for workers over age 50—many of whom may have retired more than five years ago. For these individuals who had been employed at some time during their adult life, activity rates were based on their level of education (less than baccalaureate, baccalaureate, or graduate degree). For professions where substantial portions fell into two or three of the education categories, weighted average of the

[3] Arias E. 2012. "United States life tables, 2008." *National vital statistics reports* vol 61 no 3. Hyattsville, MD: National Center for Health Statistics.

[4] Johnson NJ, Sorlie PD, Backlund E. 1999. "The impact of specific occupation on mortality in the U.S. National Longitudinal Mortality Study". *Demography*; 36:355-367.

participation rates were used. Workforce participation probabilities for physicians, APNs and PAs were modeled using survey data discussed in Chapter IV.

People sometimes change professions or further their education to enhance career opportunities. When this happens, HWSM treats these as exits from the original profession and entrants to the new profession. One limitation of the ACS is the inability to discern career changes. While this phenomenon is more common for professions with low barriers to entry and exit, data limitations did not allow this aspect to be built into HWSM. The only profession for which career progression is built into HWSM is the nursing profession (progression from licensed practical nurse [LPN] to registered nurse [RN], and from RN to nurse practitioner [NP]).

3. Hours Worked and FTE Supply

For most of the professions, Ordinary Least Squares regressions on 2006-2011 ACS data were used to derive the expected number of hours worked in a week by each individual active in the profession. Explanatory variables included age, sex, log of hourly earnings, the overall unemployment rate, and a year indicator. Occupation-specific wage and unemployment rates data were taken from the Bureau of Labor Statistics (BLS) and were included as time varying covariates. The base year estimated average number of hours worked for the profession was used as the measure of one FTE. For each subsequent year, the estimate of hours worked was divided by the average number of hours worked per week at baseline to obtain the FTE supply.

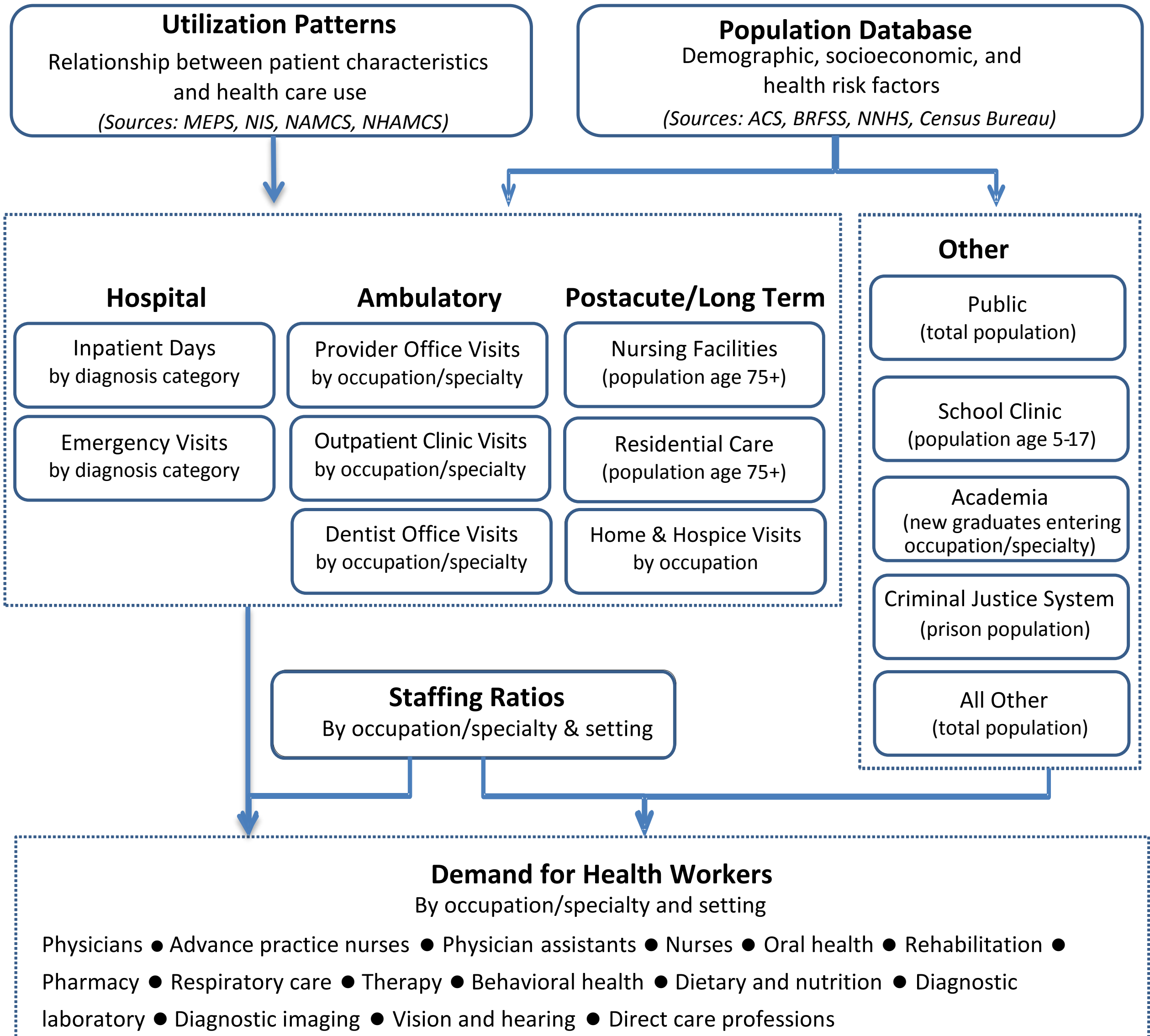
III. Modeling Demand for Health Care Services and Providers

The HWSM models demand using three major elements:

1. *Databases* that contain demographic, socioeconomic, health status and health behavior information for a representative sample of the baseline and projected populations.
2. *Regression equations* relating an individual's demographic, socioeconomic, health status and health risk factors to health service utilization by both care delivery setting and medical profession/specialty.
3. *Staffing pattern models* that convert demand for services to demand for providers.

Exhibit 3 presents a flow diagram for the demand component of HWSM, although not all care delivery sites pertain to every health profession modeled. The next section provides information on the creation of the baseline micro *database* representative of the entire U.S. population, followed by the specifications of *regression equations* connecting individual characteristics to service utilization. *Staffing pattern models*, which are combined with projected service use to generate estimation of *provider requirement*, are then described.

Exhibit 3: Flow Diagram for the Demand Component of HWSM



A. Construction of the Baseline and Projected Population Databases

The microsimulation approach—where demand for health care services is modeled for each individual—requires individual level (micro) data on the predictors of health care use for each person in a representative sample in a designated geographic area in HWSM, the state, or the nation. The core micro data file that forms HWSM's baseline population was the 2011 or 2013

American Community Survey (ACS).[5] However, while ACS provided demographic and socioeconomic characteristics of a representative sample of the population in each state, it lacked health status and health behavior variables which impact the demand for health care services. The individual "profile" required in this model included health status variables (e.g., diabetes and cardiovascular disease), and health-related behavior (e.g., obesity, smoking) in addition to, demographic information and socioeconomic characteristics (see box below).

Therefore, to create the baseline micro data file, two publicly available survey-based data sources were combined with the ACS—the Behavioral Risk Factor Surveillance System (BRFSS) and the National Nursing Home Survey (NNHS).

Explanatory Variables Used in Demand Models

<u>Demographics</u>

- *Children (ages 0-2, 3-5, 6-13, 14-17 years)*
  Adults (ages 18-34, 35-44, 45-64, 65-74, 75+ years)
- *Sex (male, female)*
- *Race/ethnicity (non-Hispanic white, non-Hispanic black, non-Hispanic other, Hispanic)*

<u>Health-related lifestyle indicators</u>

- *Body weight status (unknown, normal, overweight, obese)*
- *Current smoker status (Yes, No)*

<u>Socioeconomic conditions</u>

- *Household annual income (<$10,000, $10,000 to <$15,000, $15,000 to < $20,000, $20,000 to < $25,000, $25,000 to < $35,000, $35,000 to < $50, 000, $50,000 to < $75,000, $75,000+)*
- *Medical insurance status (private, public, self-pay)*

<u>Chronic conditions</u>

- *Arthritis, asthma, cardiovascular disease, diabetes, hypertension*
- *History of heart attack or stroke*

<u>Geographic location</u>

- *State (or county)*
- *Metropolitan area*

Behavioral Risk Factor Surveillance System

The BRFSS**,** administered annually by the CDC, collects data on a sample of over 500,000 individuals. Similar to the ACS, the BRFSS includes demographics, household income, and medical insurance status on a stratified random sample of households in each state. The BRFSS also collects detailed information on the presence of chronic conditions and other health risk factors (e.g., obesity, smoking). The 2011 & 2012 (and later the 2011 & 2013) BRFSS files were combined to create a joint file with approximately one million records.[6]

[5] The 2013 ACS file was used to develop the recent workforce projections for behavioral health occupations, paramedics and EMTs, physicians, advanced practice nurses, and physician assistants. The 2011 ACS was the most recent file available when the other health professions were modeled (e.g., nurses, technicians, therapists, oral health).

[6] The combined 2011 and 2012 BRFSS files were used for nurses, technicians, therapists, oral health (and other occupations). The workforce projections for physicians, behavioral health, and other recently modeled occupations used the combined 2011 and 2013 BRFSS files (omitting the 2012 file which lacked information on hypertension).

Population data are projected under the assumption that the prevalence rates of health behavior and health conditions by demographic groups do not change

National Nursing Home Survey

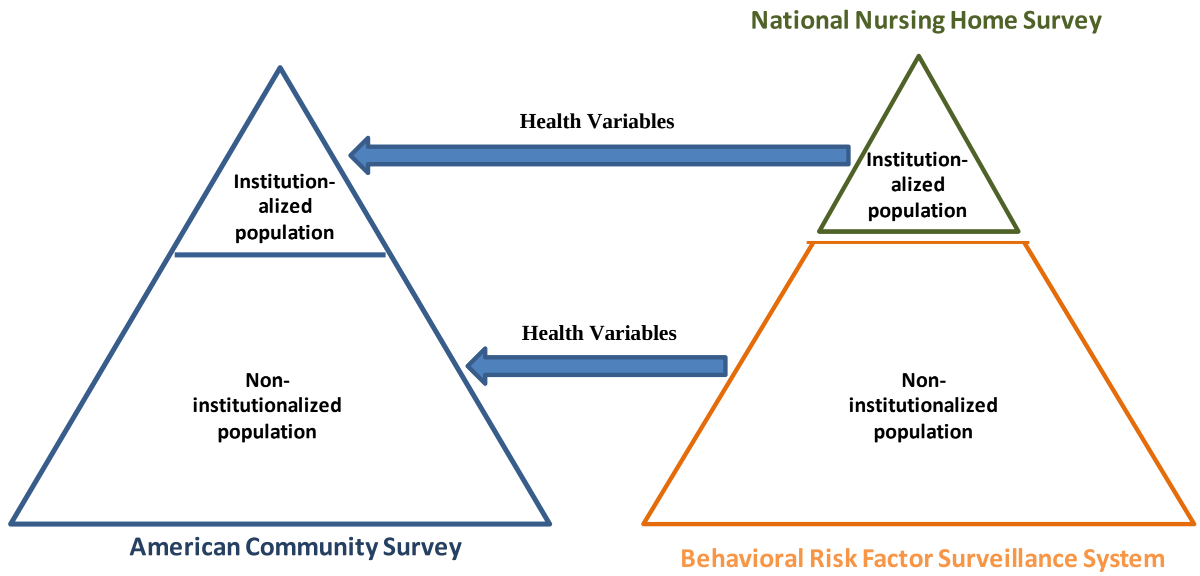
In 2004, the CDC collected data on a sample of 13,500 nursing home residents. In addition to demographics, the NNHS collected information on chronic conditions and health risk factors of this population. The inclusion of data on nursing home residents allows for unbiased estimates of health care use because this population has poorer health and different health care use patterns in comparison to the general non-institutionalized population.

The HWSM population database used a statistical matching process that combined patient health information from the BRFSS and NNHS with the larger ACS file that had a representative population in each state (and for some sub-state levels). Using information on residence type, the ACS population was stratified into those residing in nursing facilities (matched to people in the NNHS), and those not residing in nursing facilities (matched to people in BRFSS). (See Exhibit 4)

For the non-institutionalized population, each individual in the ACS was matched with someone in the BRFSS from the same sex, age group (15 age groups), race, ethnicity, insured/uninsured status, household income level (8 income categories), and state of residence.[7] Individuals categorized as residing in a nursing home were randomly matched to a person in the NNHS in the same sex, age group, and race and ethnicity strata.

[7] The first round of matching produced a match in the same strata for 93% of the population. To match the remaining 7%, the eight income levels were collapsed into four (1% matched), then the race/ethnicity dimension was dropped (2% matched), and then the same criteria as the first round was applied except State was removed as a strata (remaining 4% matched).

Exhibit 4: Population Database Mapping Algorithm



Developing demand forecasts for future years required the creation of micro data sets for future populations. This was done by assigning new sample weights to ACS respondents so that when these weights were used, the file produced population estimates that mirrored Census Bureau projections by demographic groups (age group, sex, race and ethnicity)[8] at the national level and population projections estimated by state governments. The model assumed that base year prevalence rates of health and health behavior characteristics remained the same by age, sex, race and ethnicity in the projected years. To estimate changes in insurance coverage of the future population, Congressional Budget Office (CBO) estimates were used.[9] Data for expanded coverage estimates for each state were derived from a 2010 Urban Institute publication and were scaled to be consistent with the most recent national estimates.[10] The Urban Institute's state-

[8] U.S. Census Bureau. 2012. *National Population Projections 2012 to 2060 (based on 2010 Census).* http://www.census.gov/population/projections/data/national/2012.html. Later updated to the 2014 series population projections to model demand for physicians, behavioral health, and other recently modeled health professions. http://www.census.gov/population/projections/data/national/2014.html

[9] Congressional Budget Office 2012. *Estimates for the insurance coverage provision of the Affordable Care Act. Updated for the recent Supreme Court decision*. available at http://www.cbo.gov/sites/default/files/cbofiles/attachments/43472-07-24-2012-CoverageEstimates.pdf . Later updated to: Congressional Budget Office. Insurance Coverage Provisions of the Affordable Care Act—CBO's April 2014 Baseline; Table 2. https://www.cbo.gov/sites/default/files/cbofiles/attachments/43900-2014-04-ACAtables2.pdf

[10] Urban Institute 2010. *How would states be affected by health reform?* Available at http://www.urban.org/UploadedPDF/412015_affected_by_health_reform.pdf. accessed November 2012. Urban Institute periodically updates estimates for select states. Therefore, we periodically update our estimates in the demand model to be consistent with Urban Institute estimates. Updated (2014 #s) coverage estimates for select states are at http://www.urban.org/UploadedPDF/413036-The-Launch-of-the-Affordable-Care-Act-in-Selected-States-Coverage-Expansion-and-Uninsurance.pdf

level estimates were then distributed across the projected population in a state, using predicted probabilities from a logistic equation with demographic, socioeconomic, and health risk factors as explanatory variables. Those who were predicted to be uninsured were assigned the probability of gaining coverage based on the Urban Institute's proportions.

B. Modeling Demand for Health Care Services

This section documents the development of regression equations used to estimate health care use by settings and the health care use measures that constitute the dependent variables in the regression equations (see Exhibit 5 for list). Exhibit 6 lists the population groups used to estimate the demand for health care services that depend on the population size of potential users.

Exhibit 5: Care Delivery Settings and Health Care Use Measures

Care Delivery Setting and Service Type	Health Care Use Measures
Ambulatory care	
Physician and other provider offices	Total visits, visits by provider type and specialty; Rx scripts
Outpatient departments and clinics [a]	Total visits, visits by provider type and specialty; Rx scripts
Dental offices	Dental (non-cleaning), dental cleaning, and orthodontic visits
Hospital inpatient and emergency care	
Hospital inpatient (includes skilled nursing facility (SNF) units of hospitals)	Hospitalizations and length of stay overall, and by primary diagnosis (ICD-9) , Rx scripts
Hospital emergency department	Emergency visits by primary diagnosis (ICD-9), Rx scripts;
Post-acute care and Long term care	
Home Health/Hospice	Total visits by provider type

[a] Examples of outpatient clinics include well-baby clinics/pediatric outpatient departments; obesity clinics; eye, ear, nose, and throat clinics; family planning clinics; cardiology clinics; internal medicine departments; alcohol and drug abuse clinics; physical therapy clinics; and radiation therapy clinics.

Exhibit 6: Care Delivery Settings and Potential Users that Drive Demand

Care Delivery Setting and Service Type	Potential Users
Post-acute care and Long term care	
Nursing home (includes free standing SNF)	Population aged >75
Residential care facilities	Population aged >75
Other Settings	
Educational institutions	Number of professionals trained
Public/community health	Population size
School Health	Population 5-18 years
Criminal justice system	
All Other	Population size

1. Estimating Health Care Use

Health seeking behavior was generated from econometrically estimated equations using data from approximately 177,000 participants of the 2008-2012 Medical Expenditure Panel Surveys (MEPS).[11] Multiple years of data were pooled to provide a sufficient sample size for regression analysis.

Regression analyses on baseline data yielded predicted probabilities of health care use, stratified by demographic groups, care delivery settings, and types of service, the predicated probabilities were then applied to the projected population.

To model the impact of expanded medical coverage under the Affordable Care Act (ACA) on health care use, it was assumed that a newly insured person would use health care services at the

[11] The 2007-2011 MEPS files (n~169,000) were analyzed for modeling demand for nurses, technicians, therapists, oral health, and select other health occupations prior to the 2012 MEPS becoming available.

same rate as a person with private insurance of similar demographic, health status, health risk, and economic characteristics. Baseline demand scenarios assume current patterns of care use continue into the future, controlling for changing demographics. Alternative scenarios described later make different assumptions regarding care use patterns under emerging care delivery models.

Additional care setting-specific information on provider modeling methods, workload drivers and data sources are provided below.

> *Health care utilization projections methodology in HWSM assumes:*
>
> - *The current pattern of health care use by demographic and health risk groups will be retained.*
> - *Newly insured individuals under ACA will have utilization patterns similar to other insured persons who share the same demographic and health risk characteristics.*

a) Ambulatory Medical Care Services

MEPS data were used to quantify the relationship between patient characteristics and the number of annual office, outpatient department, or clinic-based encounters with a provider of a particular profession or specialty. In addition to physicians, MEPS contains data on visits to many types of providers, including physician assistants, nurse/nurse practitioners, dentists, optometrists, opticians, physical therapists, and occupational therapists.

Models of numbers of visits by profession or specialty were run using Poisson regression. Explanatory variables were age group, race/ethnicity, smoking status, body weight category, presence of chronic conditions (diagnosed with arthritis, asthma, coronary heart disease, diabetes, or hypertension; history of cancer, heart attack, or stroke), insurance type, household income level, residence in a metropolitan area, and MEPS survey year. Enrollment in a managed care plan was added as an explanatory variable for later work on physicians, APNs, PAs, and behavioral health professionals.

MEPS reports the highest trained person seen during an ambulatory visit. Consequently, if a patient had a visit to a physician, the MEPS survey did not indicate whether the patient also saw other health professionals during the course of the visit. Predictive equations were developed from the 2010 National Ambulatory Medical Care Survey (NAMCS) to determine the likelihood that a patient would see additional health professionals (e.g., registered nurse (RN) or NP, licensed practical/vocational nurse (LPN), or PA) during a clinical visit. In addition, data from NAMCS were used to determine the number of prescriptions that were generated during an ambulatory care visit-which was then used in the demand projections for pharmacy-related professions.

b) Hospital Inpatient and Emergency Services

Demand for hospital inpatient and emergency services were modeled using 2008-2012 MEPS files, along with the 2012 Nationwide Inpatient Survey (NIS) and National Hospital Ambulatory Medical Care Survey (NHAMCS).[12] Multiple year data were used so that reliable estimates could be obtained for hospitalization and emergency department (ED) visits by medical and surgical conditions. Additional information on the data and methods for modeling demand for hospital inpatient and emergency services are described below.

(1) Hospital Inpatient Services

Utilization patterns of inpatient services by individual characteristics were modeled in two parts:

1. The probability that an individual would experience a hospitalization.
2. The expected length of stay for that hospitalization.

The probability of hospitalization in general, acute care, long term or specialty hospitals was modeled using data from MEPS. ICD-9 codes for hospitalizations recorded in MEPS were categorized in 28 broad specialty groupings to identify which specialty services were provided. Logistic regression estimated the probability of hospitalization based on patient age group, sex, race, ethnicity, insurance type, presence of diabetes among the diagnosis codes, and residence in a metropolitan area.

Using discharge records from the NIS, Poisson regressions generated the expected number of days spent or length of stay (LOS) in the hospital, conditional on a hospitalization for each medical and surgical condition. Because of the large sample size of NIS (over 8 million hospital stays), estimates derived from NIS were stable even for hospitalizations for rare conditions. Expected LOS calculated from NIS was applied to the individuals in the population database who were predicted to experience a hospitalization, so HWSM was able to simulate each person’s expected number of inpatient days during the year for different types of medical or surgical conditions. The NIS was also used to determine the expected number of prescriptions that would be filled by hospitalized individuals.

(2) Hospital Emergency Department Services

Modeling demand for emergency services consisted of two components:

1. The probability that a person with given characteristics would have an emergency visit.

[12] Nurses, technicians, therapists, and select other health occupations used the 2010 NIS and NHAMCS files prior to the 2012 MEPS and 012 NIS becoming available.

2. The types of services that the person would receive. The types of services included specialty consults, services from non-physician clinicians, and prescriptions.

MEPS data on annual hospital ED visits were used to determine the ED service use in the population for 20 categories of services, with ICD-9 codes for ED visits recorded in MEPS used to identify which specialty services were provided during an ED visit. Logistic regressions estimated the predicted probability that a person with given characteristics would have an ED visit during the year by specialty service.

However, MEPS does not identify the medical specialty of the providers and it lists only the highest level of provider seen. Therefore, the NHAMCS was used to identify the types of services that typically accompany an emergency visit for a particular category of services (namely, medications prescribed and lab tests or exams performed), and the probability that another provider was seen (e.g., physician, PA, RN/NP or LPN).

c) Post-Acute and Long Term Care Settings and Services

Within post-acute care settings, HWSM modeled the demand for home and hospice care services. Demand for post-acute care in hospitals and SNFs that are a part of a hospital were modeled as inpatient service. Freestanding SNFs were modeled as nursing facility stays (see Exhibit 3).

(1) Home Care Visits

The 2008-2012 (n=22,108) or 2007-2011 (n=16,016) pooled files from MEPS were used to model home visits. The files included annual use of home health services (including information on the types of health care workers providing home health services), reasons for home health care, and type of services provided. Various therapists also provided care during visits, and a relatively small number of visits were listed as hospice visits (with no provider type specified). Home visits not related to health providers (e.g., companion, homemaker), providers with very few visits (e.g., dietitian, IV therapist, physicians), and visits where the type of provider was unclear (e.g., skilled, non-skilled, other) were excluded.

Poisson regressions were used to determine the expected number of annual visits by each provider type. Explanatory variables included patient demographics, socioeconomic characteristics, medical insurance type, health related behavior, and presence of chronic conditions.

(2) Nursing Facility and Residential Care Stays

> *Staffing Ratios are determined by assuming that*
>
> - *The current demand for services in each setting is met by the current supply of professionals in those settings*
> - *Staffing ratios remain constant through the projection period*

Since age is an important determinant of nursing home use, HWSM assumed that the proportion of the 75 years and older age group that experience nursing home and residential care stays would remain constant in the future. Therefore, the projected demand for services in these settings was in proportion to the future size of the 75 years and older population.

d) Other Settings Where Health Care Professionals Work

Some health care providers, such as nurses and counselors, provide services in schools and the community as public health providers. In addition, some health care professionals are engaged in teaching and preparing new entrants to the workforce. There are no survey data that capture the demand for these services. Therefore, demand was based on the expected number of individuals who would likely use such services (Exhibit 5). For example, the demand for school-based services was derived by HWSM directly from the projected size of the population of school-aged children.

2. Staffing to Meet Demand for Health Care Services

This section discusses the assumptions and methods used to convert demand for services into demand for providers. Services provided (e.g., visits, hospitalizations, procedures, or prescriptions written) or demand drivers for services for which there are no survey data (e.g., total population, population over age75, and school aged children) in each setting were compared with the number of providers working in that setting. For professions that provide services across a wide array of setting (e.g., nurses and therapists), information on the employment distribution of the care providers in the base year from the BLS was used to determine the number of individuals working in each setting. Assuming that the base year demand for services in each setting was fully met by the available professionals in that setting, the base year staffing ratio was calculated by dividing the volume of service used by the number of health care professionals employed in each setting. For professions that provide services in a single setting, base year utilization was divided by the base year supply to derive the staffing ratio for that profession. The staffing ratio was then applied to the projected volume of services to obtain the projected demand for providers in every year after the base year.

The baseline scenarios in HWSM assumed that care delivery patterns remained unchanged over time given the demand for health care services. However, the number and mix of health professionals required to provide the level of health care services demanded is influenced by how the care system is organized and care is reimbursed, provider scope of practice requirements, economic constraints, technology, and other factors. Emerging health care delivery models and advances in technology may alter health care delivery in the future, changing the relationship between patient characteristics and the probability of receiving care in a particular setting. The staffing ratios would also change under new care delivery models. Scenarios modeled for physicians, APNs and PAs that explore how care delivery patterns might change include greater enrollment in risk-bearing plans such as managed care or Accountable Care Organizations (ACOs), greater use of health information technology that allows for productivity gains and some delegation of work from specialists to generalists and from physicians to non-physicians, and greater use of retail clinics where care is predominantly provided by NPs and PAs.

IV. Application of HWSM to Project Supply and Demand for Specific Occupations

Although the HWSM structure, as described in the previous sections of this document, is consistent across occupations, some factors of the estimation process (for example, input data or assumptions made) vary across occupations. This section presents occupation-specific information about the estimation process.

A. The Nursing Model

1. Estimating Base Year Nurse Supply

Estimates of the current supply of RNs and LPNs in each state came from the pooled 2006-2011 ACS files. Multiple years of data were combined to increase the sample size required to get stable estimate of the distribution of nurses by state, age, sex, and education level.[13] The ACS sample weights for each nurse were recalibrated to sum to the national totals of RNs and LPNs in the 2012 ACS. HWSM was designed to use data from state licensure files as that data becomes available for use instead of ACS data.

[13] A forthcoming web-based version of the HWSM will use the nursing minimum datasets being developed by individual states as the basis for estimating current supply.

2. Modeling New Entrants to the Nursing Workforce

HWSM used first time, U.S.-educated candidates taking the National Council Licensure Examination (NCLEX) as a proxy for the number of new entrants to the nursing workforce.[14] In 2012, there were 150,266 first-time U.S.-educated takers of the NCLEX-RN. Of these, 62,535 nurses had completed a baccalaureate degree and 87,731 had completed a diploma or an associate degree.[15] There were 64,061 first time takers of NCLEX-PN in 2012.[16] For modeling future supply, HWSM assumed that annually the nation would produce 62,500 new RNs (baccalaureate level), 87,700 new RNs (less than the baccalaureate level), and 64,100 new LPNs. The statistics on new RN supply included the estimated 16,000 LPNs who further their education and would become RNs each year.

Published state-level supply projections were modeled under the assumption that all nurses educated in a given state (using data on NCLEX first-time takers) became new entrants to the nursing workforce in that same state and did not migrate across states.

The age and sex distribution of new graduates came from a National League of Nursing (NLN) survey of students enrolled in entry level nursing programs during the 2008 academic year (Exhibit 7). Although the sex distributions of students enrolled in nursing programs varied by type of program, they were predominantly female.

Exhibit 7: Age and Sex Distribution of New RNs and LPNs

Profession	Annual No of Graduates	Female (%)	Age Distribution (%)			
			≤25	26-30	31-40	≥41
RN	150,200	85%	42%	21%	24%	14%
LPN	64,100	85%	26%	24%	31%	19%

Source: National League for Nursing. 2013. Annual Survey of Schools of Nursing, Fall 2012. Retrieved from http://www.nln.org/researchgrants/slides/topic_nursing_stud_demographics.htm

[14] First time takers of the NCLEX, rather than total passing, are used as a proxy for the number of new entrants to the nursing workforce. The vast majority of nurse graduates eventually pass the NCLEX Data on first time NCLEX-RN takers is reported by nurse educational attainment, whereas data on number of nurses who pass the NCLEX is not available by education level.

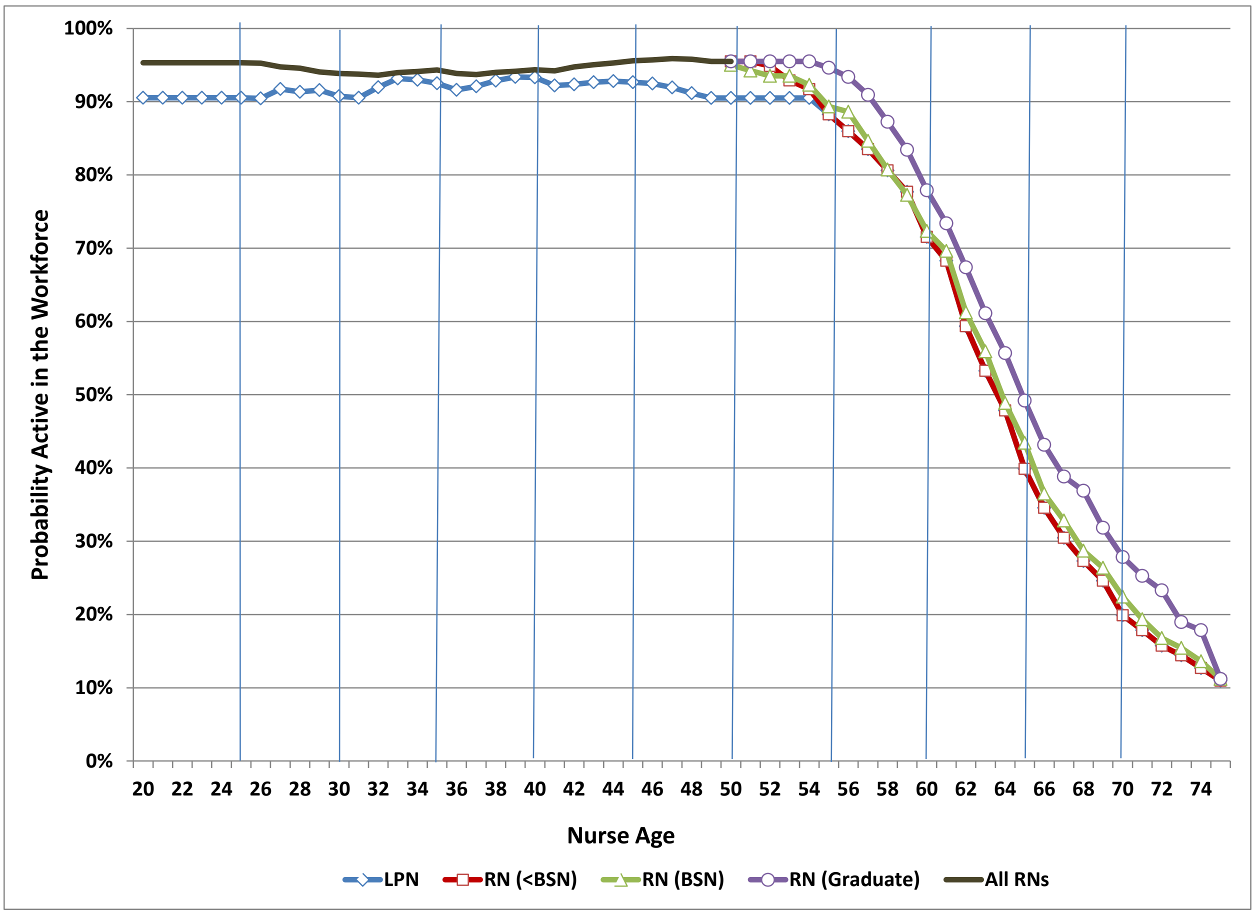
[15] National Council of State Boards of Nursing, Inc. *2012 and 2013 Nurse Licensee Volume and NCLEX® Examination Statistics.* pg. 25 and pg. 47 available at https://www.ncsbn.org/14_2012_2013_NCLEXExamStats_vol61.pdf downloaded August 2013, Copyright by the National Council of State Boards of Nursing Inc. All rights reserved.

[16] National Council of State Boards of Nursing, Inc. 2012. *Quarterly Examination Statistics: Volume, Pass Rates & First-Time Internationally Educated Candidates' Countries* available at https://www.ncsbn.org/NCLEX_Stats_2012.pdf downloaded August 2013.

3. Modeling Nurse Workforce Participation

Labor force participation rates for nurses were calculated directly for individuals through age 50 using ACS data. ACS does not capture profession for individuals out of the workforce for five years or more but does capture education, so activity rates based on the highest educational attainment were used for nurses over age 50. ACS data were used to determine the highest level of education (less than baccalaureate degree, baccalaureate degree, and graduate degree) and to calculate labor force participation rates of each group of nurses. RNs over the age of 50 with baccalaureate education were assumed to have similar labor force participation rates as other women with a baccalaureate degree. For RNs educated at the associate level and for LPNs, the HWSM used activity rates of women educated at the associate level. HWSM assumed that the age-specific workforce participation rates shown in Exhibit 8 would remain unchanged in future years.

Exhibit 8: Estimated Percent of Nurses Remaining Active in the Workforce 2006-2011



Source: Analysis of the 2006-2011 American Community Survey

As illustrated in Exhibit 8, through age 50, approximately 95 percent of RNs and approximately 91 to 93 percent of LPNs were active in nursing. It is likely that the attrition of some of the younger nurses reflects a temporary hiatus to raise family, or reflects a career change. However from age 50 onwards, the drop in labor force participation likely reflects retirement. Exhibit 8 shows that people with a graduate degree had slightly higher activity rates than people of similar age who had a baccalaureate or less education.

Estimates of LPN attrition reflected that each year some LPNs became RNs. The 2008 National Sample Survey of Registered Nurses (NSSRN) reports that 17.9 percent of RNs previously worked as LPNs. This included approximately 7.1 percent of RNs at the diploma level, 30 percent of RNs at the associate level, and 8.3 percent of RNs at the baccalaureate or higher level.[17] No recent data were available on LPN-to-RN transition rates, but the above estimates—if applied to the number of RN graduates in 2001-2007 (years immediately preceding the 2008 survey)—show that about 16,000 LPNs were becoming RNs each year; about 2.5 percent of the LPN workforce transitioned to the RN workforce each year.

4. Modeling Hours Worked

Forecasting equations related average hours worked to nurse age, sex, education level, state overall unemployment rate, and average wage in the profession. Data for all variables came from the ACS with the exception of average wage, which was obtained from the BLS. Ordinary Least Squares regression coefficients showed that average hours worked declined substantially among older nurses, increased slightly as the unemployment rate rose, and fell with higher predicted wages. To convert average hours worked into Full Time Equivalents (FTEs), an assumption needed to be made about the average number of hours worked per week by a full-time nurse. One FTE was defined as the average number of hours worked by RNs and LPNs (35 and 36 hours, respectively) in the base year. This was then used as the standard for defining FTEs in subsequent years.

5. Developing Nursing Demand Projections

The projected demand for nurses was derived from the common model outlined in Section III. Predicted probabilities were applied to the simulated micro-data set for future years to obtain projected service use specific to the settings where nurses were employed. For example, projected growth in hospital inpatient days was used to project growth in demand for RNs and

[17] U.S. Department of Health and Human Services, Health Resources and Services Administration. 2010. *The registered nurse population: findings from the 2008 National Sample Survey of Registered Nurses*. Available at http://bhw.hrsa.gov/healthworkforce/rnsurveys/rnsurveyfinal.pdf accessed April 2014

LPNs employed in hospitals. For work settings outside the traditional health care system, HWSM used the size of the population most likely to use those services to project demand (Exhibit 9).

The HWSM used provider staffing patterns to project demand for health care workers by delivery setting based on the demand for health care services. As Exhibit 9 shows, nurses were found in almost all care delivery settings. Nurse staffing patterns were calculated using the portion of national FTE nurses providing care in each setting, and dividing by current estimates of the workload driver in that work setting. The baseline demand projections assumed these ratios remained constant over time. The demand for nurses in academia was based on the estimated number of nursing graduates, assuming that current ratios of nurse educators-to-students remained constant.

National staffing ratios by care delivery setting at baseline were applied to the projected service use to obtain the staffing requirement by setting. These were aggregated to obtain the total demand for nurses. Projections were made at the state level and summed to produce national estimates.

Exhibit 9: Summary of Nursing Workload Drivers by Work Setting: 2012

	Distribution (%)		Number		Workload[a]		Staffing Ratios *(workload per nurse)*	
	RNs[b]	LPNs[c]	RNs	LPNs	Volume	Metric	RNs	LPNs
Office	7.4	8.6	214,344	62,776	957,824,918	Visits	4,469	15,258
Outpatient	4.0	5.7	115,862	41,607	44,293,310	Visits	382	1,065
Inpatient	55.6	29.3	1,610,476	213,876	171,483,258	Days	106	802
Emergency	6.4	0.0	185,379	--	113,437,741	Visits	612	--
Home Health Care	6.2	6.3	179,586	45,987	11,307,359	Visits	63	246
Nursing Home	5.3	30.7	153,517	224,096	19,173,536	Population 75+	125	86
Residential Care	1.7	1.3	49,241	9,489	19,173,536	Population 75+	389	2,021
School Health	1.9	--	55,034	--	49,526,495	Students	900	--
Nurse Education	3.1	0.3	89,793	2,190	150,266 (RNs) 64,061 (LPNs)	NCLEX 1st time takers	2.4 (RN+LPN)	29.3 (LPN)
All Other	8.4	17.8	243,309	129,932	314,004,465	Population	1,291	2,417
Total	**100**	**100**	**2,896,540**[d]	**729,953**[d]				

Note: Numbers may not sum to 100 percent because of rounding.

Sources: [a] estimates from HWSM; [b] BLS Occupational Employment Statistics 2012; [c] HRSA/NCHWA *The US Nursing Workforce: Trends in Supply and Education*, 2013, Table 6. Data from 2008-2010 pooled ACS; [d] ACS 2006-2012

B. Health Care Support and Technical Occupations' Model

This section summarizes the methodology for projecting the national supply and demand for health care support and technical occupations.

1. Estimating the Base Year Workforce Supply

The base year counts for the occupations in this section came from pooled 2006-2011 ACS. When small sample size in ACS resulted in unreliable estimates, information from BLS' Occupational Employment Statistics (OES) was used to calibrate ACS data. Data from multiple years of the ACS were pooled and calibrated to 2012 national estimates to provide more stable estimates of the age and sex distribution of workforce. Because these occupations were projected only at the national level, no other characteristics were attached to the ACS data file.

2. Modeling New Entrants

The primary source for estimating annual numbers of new entrants in each occupation was the 2010 Integrated Postsecondary Education Data System (IPEDS). As described in section II B, new entrants were added to the workforce via a "synthetic" cohort. The size of the cohort was based on the number and characteristics of recent graduates in each occupation. Each new worker was assigned an age and sex that reflected the distributions seen in recent years (Exhibit 10). The number of new entrants and their age-sex distribution were assumed to remain constant during the projection period. Supply projections were not made for a number of healthcare support occupations and technicians because the high turnover rates in these professions make the supply forecast unreliable.

Exhibit 10: Age and Sex Distribution of New Entrants to Health Care Support and Technical Occupations

Profession	Annual Graduates	Female (%)	Age Distribution (%) <25	26-30	31-40	>41
Behavioral Health Services						
Psychologists	5,744	68	5	71	22	2
Diagnostic Services						
Diagnostic medical sonographers	Not Estimated					
Medical and clinical laboratory technicians	Not Estimated					
Medical and clinical laboratory technologists	Not Estimated					
Nuclear medicine technologists	Not Estimated					
Radiologic technologists	Not Estimated					
Dietary and Nutrition Services						
Dietitians and nutritionists	3,526	96	64	16	14	6
Direct Care Services						
Home health aides	Not Estimated					
Nursing assistants	Not Estimated					
Pharmacy Occupations						
Pharmacists	12,346	62	63	18	14	6
Pharmacy technicians	Not Estimated					
Pharmacy aids	Not Estimated					
Rehabilitation Services						
Occupational therapists	4,477	92	64	17	14	6
Physical therapists	7,423	68	72	13	11	4
Occupational therapy assistants	Not Estimated					
Physical therapy assistants	Not Estimated					
Respiratory Care Services						
Respiratory therapist	8,116	69	26	24	32	19
Respiratory therapy technicians	Not Estimated					
Therapeutic Services						
Chiropractor	2,601	37	32	57	12	0
Podiatrists	537	42	5	69	24	2
Vision Services						
Opticians	880	67	47	19	19	15
Optometrists	1,404	39	5	70	23	2

Source: 2010 IPEDS .

3. Modeling Workforce Participation

Using data from 2006-2011 ACS, the age-sex specific probability that individuals would remain active in their occupation was estimated by occupation similar to the approach used for modeling nurse supply. For those over age 50, retirement patterns by age and sex reflect retirement patterns by highest level of educational attainment. Since many of the health care support and technical occupations showed representation from multiple educational groups, weights were created in HWSM that blended the proportions of workers in each category to reflect the attrition rate for those over age 50 (Exhibit 11). The predicted probabilities were applied to the starting year supply of professionals in those occupations to simulate individuals who were expected to leave the occupation over the year.

Exhibit 11: Highest Educational Attainment in Health Care Support and Technical Occupations

	2006-2011 American Community Survey Data on Education Distribution of Current Workforce (%)			HWSM Weights for Blending Workforce Participation Rates		
Profession	**Less than Baccalaureate**	**Baccalaureate**	**Graduate**	**Less than Baccalaureate**	**Baccalaureate**	**Graduate**
Behavioral Health Services						
Clinical psychologists	0%	2%	98%			100%
Diagnostic Services						
Diagnostic medical sonographers	Not Estimated					
Medical and clinical laboratory technicians	Not Estimated					
Medical and clinical laboratory technologists	Not Estimated					
Nuclear medicine technologists	Not Estimated					
Radiologic technologists	Not Estimated					
Dietary and Nutrition Services						
Dietitians nutritionists	35%	37%	28%	35%	37%	28%
Direct Care Services						
Home health aides	Not Estimated					
Nursing assistants	Not Estimated					
Pharmacy Occupations						
Pharmacists	6%	44%	50%	6%	44%	50%
Pharmacy technicians	Not Estimated					
Pharmacy aids	Not Estimated					
Rehabilitation Services						
Occupational therapist	10%	54%	36%		60%	40%
Physical therapist	11%	41%	48%		46%	54%
Occupational therapy assistants	Not Estimated					
Physical therapy assistants	Not Estimated					
Respiratory Care Services						
Respiratory therapist	72%	23%	4%	76%	24%	
Respiratory therapy technicians	Not Estimated					
Therapeutic Services						
Chiropractors	3%	3%	94%			100%
Podiatrists	1%	2%	97%			100%
Vision Services						
Opticians	84%	14%	3%	100%		
Optometrists	2%	1%	97%			100%

Source: 2006-2011 ACS

4. Modeling Hours Worked

For the professions for which supply projections were made, data from 2006-2011 ACS were used to derive the number of hours each individual spent in professional activities. Explanatory variables included age, sex, unemployment rate, and expected hourly earnings. The BLS estimates of the average wage for each occupation and the overall unemployment rate in each year were incorporated in the model so that wages and unemployment rates varied by year. The number of hours per week worked for future years was simulated for each individual by applying the expected number of hours for each age and sex cohort. The hours for each individual was divided by the average hours worked by professionals in the occupation in the base year to estimate the FTE supply in future years.

The supply projections for health care support and technical occupations were made under the basic assumption that the current patterns of retirement and hours worked would remain unchanged within a given age and sex group, and that the current number of new entrants to the occupation would remain constant.

5. Developing Health Care Support and Technical Occupations' Demand Projections

The projected demand for professionals in health care support and technical occupations was derived from the common model estimated on the baseline population and health care usage as outlined in Section III B. Demand for health care services was projected under the assumption that recent patterns of care use and delivery would remain unchanged. Predicted probabilities were applied on the simulated micro-data set for future years to obtain projected health care service use specific to the settings where these professionals are employed. Demand for physical and occupational therapists who often visit people in their homes were tied to demand for home health visits, in addition to nursing home stays, and office visits; demand for pharmacist was tied to number of prescriptions written during patient visits to provider offices, out-patient clinics, and EDs, according to BLS distribution (see appendix, Exhibit A-1). Data on the number of medications prescribed from the 2010 NAMCS, NHAMCS and NIS were used to model the number of prescriptions that an individual would receive. These were aggregated for the entire population.

The number of health workers employed in a setting in the base year was assumed to reflect demand for services in that setting. Therefore, projections of future demand for providers were based on the 2012 ratio of providers to services. The information on the distribution of employment across care settings came from the May 2012 OES. Exhibit A-1 in the Appendix provides detailed data on employment setting, workload and staffing-ratios by provider type.

C. Dental Health Care Provider Model

This section contains a description of the data, assumptions, and methods used to adapt the HWSM to model the supply of and demand for dentists and dental hygienists. Projections for these oral health professionals were developed at the state level and then aggregated to obtain the national projections

1. Estimating the Base Year Workforce Supply

The first step to modeling future dental health workforce at the state level was to obtain an estimate of the number and characteristics of dental health providers in each state in the base year (2012). For dentists, these data come from the American Dental Association's (ADA) 2010 Master File calibrated to published statistics from the 2012 Master File.[18] The Master File contains information on every individual who completed dental school. Base year supply estimates for dental hygienists came from the ACS. ACS data files for 2006 through 2011 were combined to obtain stable state-level estimates. The sample weights in the ACS were re-scaled such that the aggregate data file was representative of the 2012 national population. The individual records that contained information on age, sex, and state of residence from the ACS and the ADA were retained as the base year supply of active dental health professionals, but were assigned adjusted weights as described above.

2. Modeling New Entrants

The number of new dentists entering the workforce each year increases gradually from about 5,000 in 2012[19] to 5,500 by 2020. The increase reflects new schools opening and program expansions that have been announced to take place by 2020. The number of new entrants then remains constant through 2025. Age, sex, and state of residence data on dentists who had graduated in 2008 and 2009 from the 2010 ADA Master File were used to project the age, sex and state of residence of new dentists. The 2010 IPEDS was used to determine the number of

[18] At the time the model was being developed, NCHWA did not have access to the 2012 ADA Master File.

[19] American Dental Association. 2010-2011 Survey of Dental Education Series, 2012. http://www.ada.org/en/science-research/health-policy-institute/data-center/dental-education

dental hygienists which was assumed to remain constant at 8,000 annual entrants through 2025. The age and sex distribution of dental hygienists were derived from NCES[20] (Exhibit 12).

Exhibit 12: Age and Sex Distribution of Annual New Entrants to Oral Health Professions

Profession	Estimated Number	Female (%)	Age Distribution (%)			
			≤25	26-30	31-40	≥41
Dentists (generalists and specialists)	5,000-5,500	46	5	69	24	2
Dental hygienists	8,000	97	47	21	20	12

Sources 2010-2011 Survey of Dental Education for estimated number and 2010 ADA Master File for age and sex distribution of dentists; 2009-2010 IPEDS for estimated number and 2012 National Center for Education Statistics (NCES) for age and sex distributions of dental hygienists

The ADA 2010 Master File data suggested that 46 percent of new dentists were female. In contrast, 97 percent of new dental hygienists were female. HWSM assumed that the age and sex distribution of new oral health professionals remained the same in the future. Because Microsimulation requires individual level data, individual records of future dentists and dental hygienists were simulated using the age and sex distributions in Exhibit 12. After simulating the age and sex of the new entrants, the state where new dental health providers would practice was simulated based on a model that regressed the probability of practicing in a state on the relative difference between the projected supply and demand for dental services in that state.

3. Modeling Workforce Participation

The workforce participation rates for dental health professions are calculated as the number of persons in the profession who are *active in the labor force* divided by the *total number of persons in that profession*. Because ACS only lists the professions of individuals who have been in the workforce sometime during the past five years, it was necessary to account for those in the profession who had been retired for more than five years in the denominator. It was assumed that few dentists and dental hygienists under age 50 would have stopped practicing their profession for more than five continuous years. Therefore the denominator was estimated directly from ACS data on profession for individuals under age 50. For individuals over age 50, it was initially assumed that their work force participation rates would mirror the participation

[20] National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Postsecondary Education. Digest of Education Statistics 2012. http://nces.ed.gov/pubs2014/2014015.pdf

rates of individuals in their education group and the denominator was calculated on the basis of their highest educational attainment (less than baccalaureate, baccalaureate, or graduate degree) of those individuals who have been employed at some time during their adult life. Since an overwhelmingly large proportion of dentists possess graduate degrees, the activity rate of individuals with graduate degree was used for activity rates for dentists over age 50 (Exhibit 13). For dental hygienists over age 50, a blended labor force participation rate for persons with a baccalaureate degree and those with less than a baccalaureate degree was used—reflecting the fact that approximately two thirds of hygienists have less than a baccalaureate degree and one third have a baccalaureate degree. The group of dental hygienist with graduate degrees was too small to obtain reliable estimates, and was folded in one of the other groups.

Exhibit 13: Highest Educational Attainment by Oral Health Profession

Profession	Education Distribution of Current Workforce (%)			HWSM Weights for Blending Workforce Participation Rates (%)		
	Less than Baccalaureate	Baccalaureate Degree	Graduate Degree	Less than Baccalaureate	Baccalaureate Degree	Graduate Degree
Dentist	1	1	98	0	0	100
Dental hygienists	65	31	5	68	32	0

Source: 2006-2011 ACS

Further analyses based on the age distribution of oral health providers suggested that dentists have slightly earlier retirement relative to patterns for people with a graduate degree, so age-specific activity rates for dentists were re-scaled to adjust for this difference. Likewise, analysis of the age distribution of dental hygienists suggested that they retire at rates slightly faster than others with similar levels of education. Adjustments were made in the age pattern of dental hygienists' activity rates to reflect the faster retirements.

4. Modeling Hours Worked

Equations describing weekly work patterns came from Ordinary Least Squares regressions from 2006-2011 ACS data. One regression equation estimated hours worked by dentists[21], and a separate regression modeled hygienists' hours worked. The dependent variable in the estimating

[21] The regression included orthodontists.

equation was the log of hours worked in the previous week, and explanatory variables included age group, sex, log of expected hourly earnings, state-level estimate of the overall unemployment rate, and a year indicator. Wages and unemployment rates were introduced as time varying covariates and were derived from the BLS state-level estimates for each of the years between 2006 and 2011. The expected number of hours worked by each individual was converted to FTE supply by dividing the total person-hours worked by the average number of hours worked per week in the base year by dentists (37 hours) and dental hygienists (29 hours).

5. Modeling Dental Health Workforce Demand

To adapt HWSM to oral health services, MEPS Dental Visit Files from 2007-2011 were analyzed. Information on two types of visits was extracted from MEPS Dental Visit Files: 1) dental visits for acute or preventive care; and, 2) visits for dental cleanings.

Poisson regressions for each type of service visits were estimated for adults and children separately. Explanatory variables included the demographic, economic, health status, and health behavior variables described earlier for modeling other health professions. These regressions were used to derive the expected numbers of the two types of visits for every individual. The number of visits by individuals was then aggregated using the sample weights in the population file to project future demand in each state.

Data limitations precluded the inclusion of dental insurance as a determinant of the demand for services. Therefore, the influence of dental insurance on use of oral health services is reflected in the regression intercept and other explanatory variables such as presence of medical insurance (which is likely positively correlated with having dental insurance).

The simulated demand for dental services was translated to demand for providers through the national provider-to-visit ratios. Because dental service is delivered mainly in a clinic setting, staffing ratios by other settings were not developed. HWSM assumed that the national demands for oral health services in the base year were met exactly by the base year supply of providers for the purpose of determining the provider to visit ratios (Exhibit 14). However, given that visits modeled from MEPS data only captured met demand, combined with the recognized shortage of dentists in Dental Health Professional Shortage Areas (DHPSA), the demand for dentist FTE in the base year was augmented by 7,014, the number needed to de-designate DHPSAs.[22]

[22] HRSA estimated that 7,101 dentists are needed to de-designate DHPSAs in 2012, including 87 dentists in Puerto Rico and U.S. territories.

It was assumed that the provider-to-visits ratio will remain unchanged during the projection period and oral health service delivery in each state followed the national patterns controlling for population characteristics. National ratios of dentists-to-dental visits (excluding teeth cleaning) in the base year were applied to the projected visits to determine the future demand for dentists; the ratio of dental hygienists-to-teeth cleaning visits were applied to project the future demand for dental hygienists.

Exhibit 14: Summary of Dentist and Dental Hygienist Workload Drivers: 2012

Provider Type	Estimated Providers[1]	Estimated Visits[2]	Provider to Visit Ratio
Dentists	190,800	215,700,000	1:1,130
Dental hygienists	153,600	285,200,000	1:1,860

Source: [1] ADA 2010; [2] and MEPS 2007-2011 applied to 2012 population.

D. Primary Care Provider Model

This section summarizes the methodology for projecting the supply and demand for primary care physicians, advanced practice nurses (APNs) and physician assistants (PAs) at the national, U.S. census division and region levels by specialty. Selected specialties identifying primary care providers include general and family medicine, general internal medicine, geriatrics, and general pediatrics.

1. Estimating the Current Active Workforce Supply

The source for estimating the current active supply of physicians is the 2013 American Medical Association (AMA) Master File Extract. The analysis was limited to active physicians. Because the AMA file is known to misclassify older physicians who have retired as ‘active’, those over age 75 were deleted form the analysis file. In addition, retired physicians between 50 to 75 years of age were identified and deleted based on predicted probabilities derived from a logistic regression on age and specialty. In addition to adjusting for misclassification of retirees as active physicians, the AMA Masterfile was adjusted for undercounting hospitalists, a large proportion of who are listed under the specialty in which they received their training.

The method to separate hospitalists trained in primary care from physicians actually providing office-based primary care services builds on ongoing work by AAMC’s Center for Workforce Studies. Using the NPI numbers from 2014 Medicare fee-for-service billing records and the

AMA Masterfile, physicians where close to 100% of their Evaluation and Management billing was hospital-based were identified as hospitalists in the AMA Masterfile. About twenty five thousand hospitalist physicians were listed in the AMA Masterfile as general internists, family physicians, or geriatricians. Hospitalists trained in pediatrics could not be identified using Medicare billing records. A comparison of the counts from the original AMA file with the new file with hospitalists removed provided the discount factor. The base numbers in 2013 AMA Masterfile were then discounted by that factor.

The base year counts for APNs come from the 2013 National Plan and Provider Enumeration System (NPPES) which contains a unique identifier (National Provider Identification, NPI) for each clinician. The 2013 National Commission on Certification of Physician Assistants (NCCPA) Professional Profile Survey was utilized to develop the base year counts for PAs by age and gender.

2. Modeling New Entrants

The mechanism for adding new entrants to the workforce each year is the creation of a "synthetic" population of the profession based on the number and characteristics of recent graduates in each profession. As described in section II.B, Each new clinician is assigned an age and sex that reflect the distribution seen in recent years.

Estimates of total annual new physicians, APNs, and PAs and the specialty distribution came from multiple sources. The primary sources of data on characteristics of new graduates are the Association of American Medical Colleges (AAMC) 2012-2013 Graduate Medical Education Census completed by residency program directors and administrators, the 2013 AMA Master File and the American Board of Medical Specialties (ABMS) for physician specialties. Numbers and characteristics of new NPs, in the workforce entrants come from the 2012 American Association of Colleges of Nursing (AACN) survey. The 2013 NCCPA Professional Profile is the primary source for characteristics on new PA workforce entrants and the Physician Assistants Education Association the source of data on new PAs trained. Exhibit 15 summarizes the age and sex distribution of new entrants to the primary care workforce.

Exhibit 155: Age and Sex Distribution of New Physicians, APNs and PAs in Primary Care

Specialty/Profession	Annual Graduates	Percent Female	Age Distribution			
			<25	26-30	31-40	>41
Primary Care Physicians						
General & Family Medicine	3,270	55%	0%	30%	60%	9%
General Internal Medicine	3,301	44%	0%	34%	60%	7%
Geriatrics	279	58%	0%	15%	77%	8%
General Pediatrics	1,642	71%	0%	49%	48%	3%

Specialty/Profession	Annual Graduates	Percent Female	Age Distribution <25	26-30	31-40	>41
Total	29,032	45%	0%	18%	75%	7%
Advanced Practice Nurses & Physician Assts.						
Nurse Practitioner	6080[a]	95%	2%	22%	32%	44%
Physician Assistant	2,182 -2,570[b]	64%	9%	38%	42%	11%

Sources: 2013 AMA Master File, 2012-2013 AAMC GME Census,2012 American Association of Colleges of Nursing (AACN) survey, 2013 NCCPA Professional Profile, Physician Assistance Education Association. [a] Estimates of new NPs trained reflect analysis of the 2012 NSSNP of the proportion of new NPs in primary care that work in a position requiring NP licensure. [b] Grows from 2,128 to 2,570 between 2013 and 2025 reflecting projected growth in number and average size of PA programs. Primary sources of data on new graduates include the AMA Masterfile for physicians, PAEA and the NCCPA for Physician Assistants, and the AACN for APNs.

After simulating the age and sex of the new entrants, the state where new providers would practice was simulated based on a model that regressed the probability of practicing in a state on the relative difference between the projected supply and demand for services for that kind of provider in that state

3. Modeling Workforce Attrition

Data sources for modeling retirement patterns of physicians by individual specialty are limited. The primary source of retirement information for physicians in HWSM is the 2012 and 2013 Florida Bi-annual Physician Licensure Survey which asks active physicians about their intention to retire in the upcoming five years. The retirement patterns from this source were compared to the AAMC's 2006 Survey of Physicians over Age 50 which collected information on age at retirement or age expecting to retire. The Florida survey has a larger sample size and more detailed information on individual specialties.

Retirement rates also differ by medical specialty. This analysis used the age, gender and specialty specific retirement rates from the 2012 and 2013 Florida Bi-annual Physician Licensure Survey to calculate the retirement rates for physician providers with primary care specialties. Retirement patterns for APNs and PAs were unavailable. As a result, retirement patterns for primary care physicians were used as proxies.

4. Modeling Hours Worked

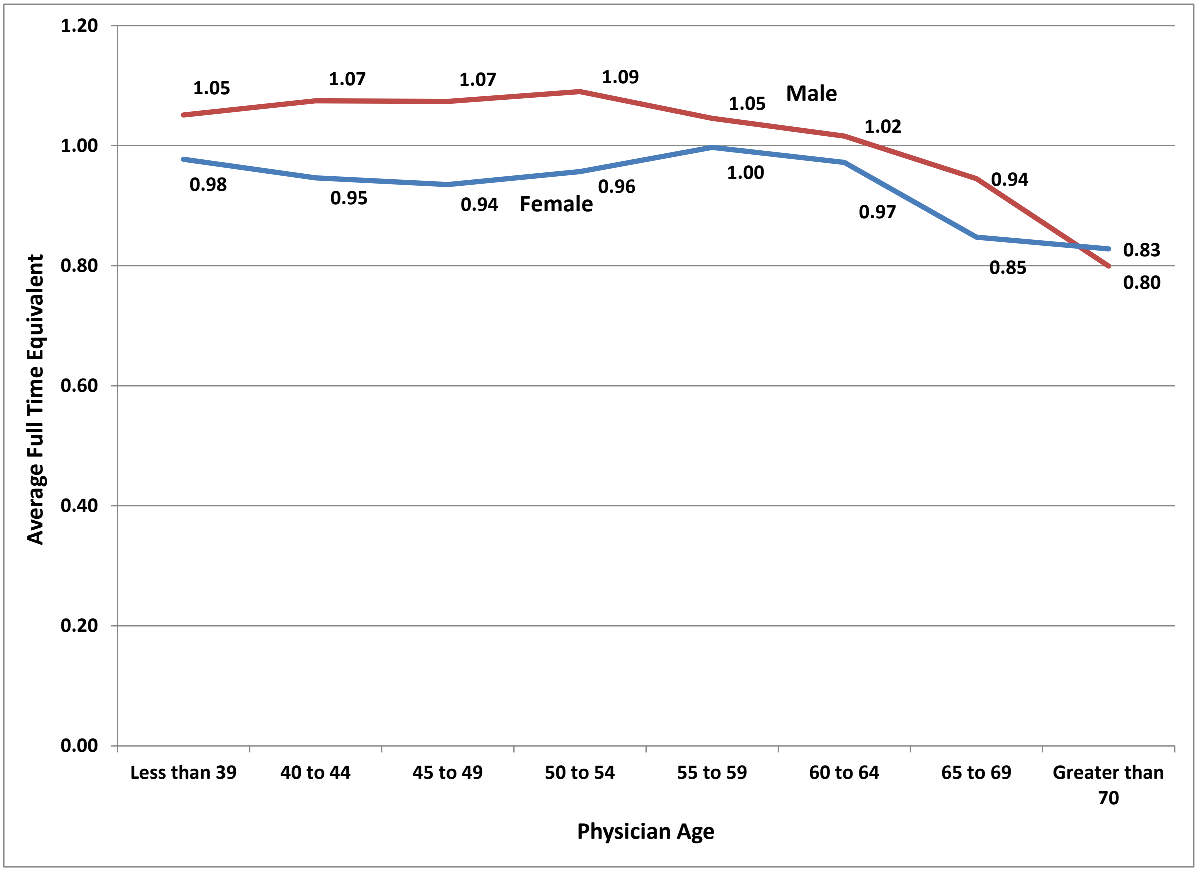
Average hours worked differs by clinician age, sex, specialty, and this has an impact on the future FTE supply of providers because of the changing demographics of the health workforce. Data for modeling hours worked by physician specialty comes from the Florida 2012-2013 bi-annual Physician Licensure Workforce Survey (n=18,016) of physicians in Florida who renewed their license.[23] Hours worked patterns differed by specialty in addition to age and sex. Ordinary Least Squares regression was conducted using physicians' reported average patient care hours per week as the dependent variable. Explanatory variables included indicators variables for specialty, age group, female gender, and age-group by gender interaction. Average hours worked by primary care physicians varied by specialty. FTE for primary care physicians for each specialty was defined as the average hours worked per week in that specialty. These were 40.4 hours for physicians in family practice, 44 hours for general internists, 40.5 for pediatricians and geriatricians. Exhibit 16 shows hours worked pattern by physician age and sex. Young, male physicians tended to work more hours per week than their female counterparts, while the gender gap in hours worked largely disappeared after age 55.

Similar regression analyses were conducted using 2013 NCCPA licensure files to model hours worked patterns of PAs, and the 2012 National Sample Survey of Nurse Practitioners **(***NSSNP***)** to model hours worked patterns for NPs. However, no sex-by-age interaction terms were included for APNs because the large majority is female. An FTE was calculated for these occupations as the average hours worked among clinicians working at least 20 hours per week.

On average, NPs in primary care worked 32 hours weekly in patient care related activities. Average weekly hours worked patterns varied slightly across PA primary care specialties, ranging from 39 hours (pediatrics) to 42 hours (general internal medicine and geriatrics). PAs in general family practice worked on average about 41 hours weekly.

[23] Analysis of Maryland's physician licensure files found similar work patterns by physician age, sex, and specialty

Exhibit 16: Primary Care Physician Hours Worked Patterns, in FTEs



Sources: Florida 2012-2013 bi-annual Physician Licensure Workforce Survey

5. Developing Primary Care Physician, APN and PA Demand Projections

Consistent with the approach adopted for other health professions modeled, the projected demand for physicians, APNs and PAs was derived from the common model outlined in Section III. Predicted probabilities were applied on the simulated micro-data set for future years through 2025 to obtain projected service use specific to the settings where these providers work. For work settings outside the traditional health care system (e.g., school health) HWSM used the size of the population most likely to use those services. Due to small sample sizes HWSM does not model profession-setting combinations where service volume is small (e.g., physicians providing care in home health and residential facilities). Also, the proportion of physician time in non-patient care activities (e.g., research, teaching, and administration) was assumed to remain constant over time.

Demand for primary care physician, was tied to projected demand for office visits. In addition, the demand was tied to a specific proportion of inpatient services to account for hospital rounds conducted by primary care physicians.

Prediction equations for use of office and outpatient services were estimated using Poisson regression with 2008-2012 MEPS data. Separate regressions were estimated for children and adults, and by physician specialty. The dependent variables were annual office visits and annual outpatient visits for each specialty. Explanatory variables consisted of the patient characteristics, socioeconomic and insurance variables, and health status variables described previously.

To account for the demand for primary care clinicians for hospital rounds, HWSM developed predictive equations for inpatient days by relevant population groups. For example, the demand for Geriatricians was derived from the expected number of hospital days in the 75plus age group, while the demand for Pediatricians in a hospital was derived from the expected number among the 18 and younger age group (Exhibit 17).

Exhibit 17: Hospital Inpatient Demand Drivers by Primary Care Physicians

Medical Specialty	Workload Driver
Family Practice	Inpatient days for all hospitalizations
General Pediatrics	Inpatient days for all hospitalizations by patients age <18
Internal Medicine	Inpatient days for all hospitalizations by patients age 18+
Gerontology	Inpatient days for all hospitalizations by patients age 75+

Source: HWSM estimates from the Medical Expenditure Panel Survey (2008-2012) and the 2012 Nationwide Inpatient Sample

Predicted number of inpatient days were developed using the common methodology described in Section 3.B.1 of this report, and aggregated across the relevant population groups. Current national estimates of the workload driver for primary care services and physician distribution are shown in Exhibit 18

Exhibit 18: Summary of National Physician Workload Measures for Primary Care, 2013

	Office Visits	Outpatient Visits	Inpatient Days
Primary Care Services			
General & Family Practice	214,093,000	5,542,000	183,050,000 [a]
General IM	139,668,000	887,000	135,154,000 [b]
Pediatrics	130,940,000	614,000	47,896,000 [c]
Geriatrics	1,069,000	28,000	37,523,000 [d]
Primary Care Physicians			
General & Family Practice	90,260	2,250	2,280
General IM	73,290	420	19,830
Pediatrics	44,310	210	4,380
Geriatrics	2,640	70	870
Physician Staffing Ratio			
General & Family Practice	2,372	2,463	80,285
General IM	1,906	2,112	6,816
Pediatrics	2,955	2,924	10,935
Geriatrics	405	400	43,130

Sources: HWSM Projections for 2013 and analysis of 2013 AMA Master File. Distributions by care delivery site based on multiple data sources: 2008-2012 MEPS, 2010 NHAMCS, 2012 NIS, 2012 Medical Group Management Association survey, 2010 American Board of Internal Medicine survey, specialty-specific surveys.
Notes:. [a] All hospitalizations. [b] All hospitalizations by patients age <18, [c] All hospitalizations by patients age 18+, [d] All hospitalizations by patients age 75+.

The HWSM uses provider staffing patterns to project demand for physician specialties based on demand for health care services. Staffing patterns were calculated using the portion of national FTE providers delivering care in each setting and dividing by current national estimates of the workload driver in that work setting (Exhibit 21). These ratios were then applied to projections of future demand for services that assumes the status quo in terms of care use and delivery patterns. Estimated FTE requirements to care for each person were then aggregated and inflated by the number of Physicians required to overcome primary care provider shortages in Health Professions Shortage Areas (HPSA)[24] to obtain the total demand for primary care physicians.

Because of limitations in identifying which visits/hospitalizations resulted in consultation with a NP and because NPPES, the data source used to determine the baseline NP supply did not identify the practice site, the demand for NPs in primary care were assumed to grow in the same rate as the demand for primary care physicians. This implies that the physician to NP staffing ratio remains the same for the duration of the projection period.

However, for PAs, a process similar to estimating the physician staffing ratio was used to estimate current and project future FTE demand for PAs. Data from the 2013 NCCPA PA Professional Profile Survey was analyzed to provide estimates of PAs providing care in each primary care delivery setting and specialty, and the national volume of care in each care setting and specialty, divided by the number of FTE PAs in that setting, provided estimates of PA FTE required per unit of health care service delivered in that setting. (Exhibit 19)

Exhibit 19: Summary of FTE Physician Assistant Distribution by Care Delivery Site for Primary Care, 2013

Specialty	Office	Outpatient	Inpatient
Primary Care Services			
General & Family Practice	214,093,000	5,542,000	183,050,000 [a]
General IM	139,668,000	887,000	135,154,000 [b]

[24] U.S. Department of Health and Human Services, Health Resources and Services Administration 2013 Primary Medical Care HPSA Designation Overview. Available at http://bhw.hrsa.gov/shortage/hpsas/designationcriteria/primarycarehpsaoverview.html accessed September 22, 2015.

Specialty	Office	Outpatient	Inpatient
Pediatrics	130,940,000	614,000	47,896,000 [c]
Geriatrics	1,069,000	28,000	37,523,000 [d]
Primary Care Physician Assistant	**16,730**	**13,640**	**1,690**
General & Family Practice	11,000	10,230	210
General Internal Medicine	3,870	2,490	920
General Pediatrics	1,800	840	530
Geriatrics	60	80	30
Primary Care Physician Assistant Staffing Ratio			
General & Family Practice	19,463	542	871,667
General Internal Medicine	36,090	356	146,907
General Pediatrics	72,744	731	90,370
Geriatrics	17,817	350	1,250,767

Source: HWSM Projections for 2013 and Analysis of 2013 National Commission on Certification of Physician Assistants Professional Profile Survey.
Notes: [a] All hospitalizations. [b] All hospitalizations by patients age <18, [c] All hospitalizations by patients age 18+, [d] All hospitalizations by patients age 75+.

E. Behavioral Health Care Provider Model

Behavioral health care is a term that covers the full range of any behavioral problem, including mental health and substance abuse conditions, stress-linked physical symptoms, patient activation and health behaviors. In 2014-2015, HRSA updated the behavioral health component of HWSM and added the following five occupations: substance abuse and behavioral disorder counselors (addiction counselors), mental health and substance abuse social workers (clinical social workers), mental health counselors, school counselors, and marriage and family therapists.[25] There is substantial overlap in the types of services provided by the above behavioral health providers.

1. Estimating the Base Year Workforce Supply

The sources for data on current supply were the 2013 AMA Master File for psychiatrists; the 2013 NCCPA Master File for physician assistants; the 2012 NSSNP and 2013 NPPES for nurse practitioners; the 2013 ACS for psychologist; and the 2013 ACS and the 2013 BLS Occupational Employment Statistics (OES) for counselors, social workers, and technicians. State-level data from the OES were used to estimate the number of social workers and counselors who employed as behavioral health professionals. The age and gender distributions of behavioral health

[25] Brief descriptions of each occupation come from the Bureau of Labor Statistics http://www.bls.gov/ooh/community-and-social-service/home.htm

professionals with graduate degrees were used as proxy for the age and gender distribution of for counselor and social worker occupational categories. The resulting person-level provider files were then used in the microsimulation model.

2. Modeling New Entrants to the behavioral health workforce

Supply projections account for new behavioral health professionals that enter the workforce each year. As detailed in section II B, a synthetic population was created for use in HWSM, which reflected the number, and age-gender distribution of new graduates annually in the profession (Exhibit 20).

Exhibit 20: Age and Sex Distribution of New Behavioral Health Professionals

Licensed Health Workers	Annual No of Graduates	Female (%)	Age Distribution (%)			
			≤25	*26-30*	*31-40*	*≥41*
Psychologists	5,744	68%	5%	71%	22%	2%
Mental health counseling/counselor	5,038	83%	40%	22%	25%	13%
Marriage and family therapy/counselor	662	83%				
Substance abuse/addiction counselor	3,623	73%				
Education/ school counselor	5,631	84%				
Clinical/medical social worker	2,462	88%				

Sources: Annual graduates and percent female from 2013 IPEDS. Age distribution for new counselors and social workers in behavioral health reflects age of students in master's level social worker programs. Council of Social Work Eduction. 2013 Statistics on Social Work Education in the United States. http://www.cswe.org/File.aspx?id=74478

3. Modeling Workforce Participation

Labor force participation rates for all licensed behavioral health professionals were calculated directly for individuals through age 50 using 2013 ACS data. Because social workers and counselors working in behavioral health were not identifiable in ACS, data on the broad social workers and counselors group were used as a proxy for workforce participation patterns of social workers and counselors in behavioral health services. ACS does not capture profession for individuals out of the workforce for five years or more, making it difficult to estimate the denominator for the rates. Information on workforce participation by education was used to estimate the retirement pattern for workers over age 50. Age gender specific activity rates for individuals with a graduate degree (masters level or higher) were used to model retirement patterns for counselors and social workers over age 50. Retirement patterns for psychiatrists were derived from Florida's 2012-2013 Physician Survey and applied nationwide.

4. Modeling Hours Worked

Estimates for weekly hours work for behavioral health counselors and clinical social workers came from Ordinary Least Squares (OLS) regression equations on 2008-2013 ACS data. Because the ACS does not distinguish types of counselor and social worker, data on employed individuals with a graduate degree were used as proxy. The dependent variable in the regressions was the log of hours worked in the previous week, and explanatory variables included age group, sex, log of expected hourly earnings, state-level estimate of the overall unemployment rate, and a year indicator. Wages and unemployment rates were introduced as time varying covariates and were derived from the BLS state-level estimates for each of the years between 2008 and 2013. The projected number of hours worked by each individual was converted to FTE supply by dividing the total person-hours worked by the average number of hours worked per week for counselors and social workers employed at least 20 hours per week in the base year.

Data for modeling hours worked patterns of psychiatrists come from analysis of Florida's 2012-2013 Physician Survey. Data on PAs in mental health came from the 2013 National Commission on Certification of Physician Assistants (NCCPA) Master File; data for NPs in mental health came from the 2012 National Sample Survey of Nurse Practitioners (NSSNP) for NPs employed at least 20 hours per week. The approach to modeling hours worked patterns for psychiatrists, PAs, and NPs used OLS regression analysis where log of hours worked per week in patient care activities was the dependent variable. Explanatory variables were dummy variables for each medical specialty, clinician age groups, sex, and interaction terms between age and sex.

5. Modeling Behavioral Health Demand Projections

To determine the demand for behavioral health services of HWSM, the MEPS Visit Files from 2008-2012 were analyzed. Poisson regressions for each type of service visits were estimated for adults and children separately. The dependent variables were annual visits to each type of behavioral health professional. Explanatory variables consisted of the demographic, economic, insurance, health status, and health behavior variables described in section III A.

Because family therapists are not listed among the MEPS occupation codes, the information of mental health and substance abuse counseling where the person had at least one visit during the year was analyzed as a proxy for demand for family therapy services. MEPS also does not specifically identify mental health counselors as an occupation, so visits with a mental health diagnosis code for occupations in the "other non-physician specialist" category was analyzed. Likewise, MEPS does not specifically identify addiction counselors in the occupation list. The regression for addiction counselor includes all visits where the occupation indicated "other non-physician specialist" and the visit had an indication code that alcohol or drug abuse counseling or treatment was provided.

To account for the demand for behavioral health workers, national estimates of total FTE providers in each care delivery setting was estimated. Total workload measures were divided by FTE supply in 2013 to calculate staffing ratios by profession and care delivery setting (Exhibit A1, Appendix). The Baseline demand scenarios assumed that the current demand for providers were met exactly by the providers available in each setting nationally and that the provider-to-visits ratio will remain unchanged during the projection period. It was also assumed that behavioral health service delivery in each state followed the national patterns.

In addition to the baseline scenario, an alternative scenario was developed to assess current and projected effects of unmet the demand for behavioral health care, using information that indicates approximately 20 percent of the 2013 U.S. population may have needed but did not receive treatment for mental illness, substance use, and/or substance dependence in 2013. Assuming that the only barrier to access behavioral health services for this population was lack of providers, 2013 demand estimates for services and providers would need to be inflated, consequently, the 2025 demand projections developed would also be correspondingly higher.

Development of the alternative unmet demand scenario relied on data from SAMHSA's 2013 National Survey on Drug Use and Health, which found an estimated 43.8 million U.S. adults had any mental illness in the past year, yet only 19.6 million of those 43.8 million received mental health services.[26] SAMHSA also estimated that 22.7 million adolescents and adults needed treatment for an illicit drug or alcohol use problem, yet only 2.5 million of those 22.7 million received treatment at a specialty facility and only 4.1 million people received any treatment for a problem related to the use of alcohol or illicit drugs.[27]

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[26] U.S. Department of Health and Human Services, Substance Abuse and Mental Health Services Administration. 2014. Results from the 2013 National Survey on Drug Use and Health: Mental Health Findings, NSDUH Series H-49, HHS Publication No. (SMA) 14-4887. Rockville, MD. Accessed 11/16/2015: http://www.samhsa.gov/data/sites/default/files/NSDUHmhfr2013/NSDUHmhfr2013.pdf.

[27] U.S. Department of Health and Human Services, Substance Abuse and Mental Health Services Administration. 2014. Results from the 2013 National Survey on Drug Use and Health: Summary of National Findings, NSDUH Series H-48, HHS

These estimates suggest that between 40 million and 45 million individuals (roughly 20 percent of the U.S. 2013 population[28]) may have needed but did not receive behavioral health care in 2013.

V. HWSM Validation, Strengths, and Limitations

This section summarizes activities undertaken to validate HWSM and discusses the strengths and limitations of the model.

A. HWSM Validation

A model, by definition, is a simplified version of reality. Validation activities are important to help ensure that the model reflects reality as accurately as possible. Validation of HWSM is a continual process. As different health professionals are accommodated and the model is updated with the new data, validation activities will continue.

Following International Society for Pharmacoeconomics and Outcomes Research (ISPOR) guidelines on best practices, validation activities in HWSM included the following:[29]

1. **Review by subject matter experts (face validity)**. *The model framework should conform to observations about how the system works, and be consistent with theory. Expert review also helps ensure that the model uses the best available inputs and parameters. Model outputs should be consistent with expectations of subject matter experts*.

   The model framework was approved by a technical evaluation panel consisting of experts in health care workforce at HRSA. The modeling approach was selected because it is particularly useful for analyzing complex systems such as the health care system, where decision-making is decentralized and autonomous. For supply modeling, each individual makes his or her career and labor force participation decisions based on their own unique characteristics and in response to external factors such as earnings potential and

Publication No. (SMA) 14-4863. Rockville, MD. Accessed 11/16/2015: http://www.samhsa.gov/data/sites/default/files/NSDUHresultsPDFWHTML2013/Web/NSDUHresults2013.pdf.

[28] U.S. Department of Commerce, Bureau of the Census. U.S. 2013 Population. Accessed Nov 16, 2015: http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk. [Adolescent/adult population = 267.56 million]

[29] Eddy DM, Hollingworth W, Caro JJ, Tsevat J, McDonald KM, Wong JB. 2012."Model transparency and validation: a report of the ISPOR-SMDM Modeling Good Research Practices Task Force—7." *Value Health*;15(6):843-850.

unemployment risks. For demand modeling, decisions to use health care services are made by individuals depending upon their health risks and financial constraints. HWSM has the potential to capture the complex dynamic interactive processes that characterize the demand for and supply of health care providers.

The model makes use of the most recent data available to date and can be updated with new data as they become available without changing the basic features of the model.

The outputs from the nursing model have been verified by an established researcher in the area of health workforce.[30]

2. **Internal validation (verification)**. *This set of activities involved reviewing computer code for accuracy, validating parameters in the model against their source, and putting HWSM through a "stress test" by modeling extreme input values to test whether the model produces expected results.*

   Internal validation activities have been conducted on all parts of the model used to forecast supply and demand for oral health, nursing, and the cross-occupation professions. Regression coefficients were examined to flag unrealistic estimates and results were examined to ensure that state-level estimates add up to national estimates.

3. **External and predictive validation**. *This form of validation was used to identify external data sources (not used in model development) for comparison to model outputs*.

   As an example, the health-related characteristics of the baseline population data base created in HWSM were calibrated by comparing the prevalence estimates to published U.S. Centers for Medicare and Medicaid Services (CMS) and the most recent American Health Care Association (AHCA) resident counts in each state. Similarly, the expected numbers of home health visits generated by HWSM were compared to the results from the latest version of the National Home and Hospice Care Survey (NHHCS). Validation and calibration activities were conducted on the labor force participation rates which included developing preliminary supply projections to determine if the base year age distribution of the workforce was consistent with labor force retirement patterns. In addition, information from occupational associations and other sources were used to validate the model inputs.

[30] Personal communication, Dr. Thomas Ricketts.

4. **Between-model validation (cross validation)**. *This type of validation compared model outputs with results of other models.*

   The cross-model comparisons made thus far have compared HWSM projections with the BLS 10-year (2012 to 2022) employment forecasts for select occupations. The BLS forecasts are based on two major components: (1) employment opportunities due to demand growth; and, (2) employment needs to replace people who have left the labor force. HWSM produces similar outputs. HWSM and BLS projections are relatively similar despite using very different modeling approaches, data, and assumptions. Results from published articles[31,32] on nursing supply were also used to validate the HWSM projections on the nursing workforce

B. HWSM Strengths and Limitations

The main strengths of HWSM are the use of recent data sources and a sophisticated microsimulation model for projecting health workforce supply and demand. Compared to population-based approaches, this approach has a number of advantages:

- More predictive variables can be used in modeling, which enhances the accuracy of results.
- Lower levels of geography can be modeled, which meets HRSA's goal of building more accurate state level projections.
- Projection models can be easily consolidated across professions, with profession-specific equations integrated into a single platform.
- The modular approach in HWSM allows for refinements and improvements to be carried out in sub-components of the model.

HWSM uses individuals as the unit of analysis. This level of analysis creates flexibility for incorporating changing prevalence of certain chronic conditions or health-related behaviors and risk factors into demand estimations. HWSM also provides added flexibility for modeling the workforce implications of changes in policy (such as expanded health insurance coverage under the ACA).

[31] Auerbach, D. I., Buerhaus, P. I. & Staiger, D. O. 2014. "Registered nurses are delaying retirement, a shift that has contributed to recent growth in the nurse workforce." *Health Affairs*, 33(8):1474-1480.

[32] Auerbach, D. I., Buerhaus, P. I. & Staiger, D. O. 2011. "Registered nurse supply grows faster than projected amid surge in new entrants ages 23-26." *Health Affairs*, 30(12):2286-2292.

Many of the limitations of HWSM stem from current data limitations. For example, HWSM uses the ACS to estimate current supply of many health professions, although many states have access to more complete supply data collected through the licensure/certification processes. On the demand side, one limitation of the BRFSS as a data source is that as a telephone-based survey, it tends to exclude people who may not have their own telephone.

Other current data limitations associated with HWSM include the following:

- There is little information on the influence of provider and payer networks on demand and consumer care migration patterns.
- Data are currently lacking to estimate demand and adequacy of supply at the state and sub-state levels for many health professions.
- On the demand side, there is a paucity of information on how care delivery patterns might change over time in response to the ACA and other emerging market factors.
- Due to lack of data, it is not possible to identify services received in certain specialized settings such as ambulatory surgical units.

Exhibit A-1: Summary of Workload Measures and Staffing Ratios for Health Care Support and Technical Occupations

Health Workforce DISTRIBUTION (N) by Delivery Site										
Profession	**Total**	**Delivery Sites**								
		Ambulatory	***Emergency***	***Inpatient***	***Home Health***	***Nursing Home***	***Public Health***	***School Health***	***Education***	***Other***
Behavioral Health Services										
Psychiatrists [a]	100% (45,580)	67% (30,540)		13% (5,930)						20% (9,110)
Psychologists [b]	100% (186,710)	53% (98,960)		12% (22,410)	1% (1,870)			8% (14,940)	15% (28,010)	11% (20,520)
Nurse Practitioners [c]	100% (7,690)	46% (3,580)	2% (160)	17% (1,270)	20% (1,560)			1% (60)	4% (330)	10% (730)
Physician assistants [d]	100% (1,280)	60% (770)	2% (30)	33% (420)						5% (60)
Addiction counselors [b]	100% (85,100)	18% (15,320)		12% (10,210)	18% (15,320)					52% (44,250)
Clinical social workers [b]	100% (110,900)	27% (29,940)		15% (16,640)	15% (16,640)					43% (47,680)
Mental health counselors [b]	100% (120,000)	18% (21,600)		12% (14,400)	18% (21,600)					52% (62,400)
School counselors [b]	100% (246,500)							100% (246,500)		
Family therapists [b]	100% (30,600)	73% (22,330)			5% (1,530)				12% (3,670)	10% (3,070)
Diagnostic Services [e]										
Diagnostic medical sonographers	100% (58,000)	38% (21,771)		61% (35,616)					1% (613)	
Medical and clinical laboratory technicians	100% (161,500)	20% (32,300)	5% (8,075)	75% (121,125)						
Medical and clinical laboratory technologists	100% (164,300)	20% (32,860)	5% (8,215)	75% (123,225)						
Nuclear medicine technologists	100% (20,900)	31% (6,386)		68% (14,243)					1% (271)	
Radiologic technologists	100% (194,790)	34% (66,139)		64% (123,862)			2% (4,788)			

Health Workforce DISTRIBUTION (N) by Delivery Site										
Profession	**Total**	**Delivery Sites**								
		Ambulatory	***Emergency***	***Inpatient***	***Home Health***	***Nursing Home***	***Public Health***	***School Health***	***Education***	***Other***
Dietary and Nutrition Services [e]										
Dietitians and nutritionists	100% (67,400)	18% (12,097)		35% (23,703)	2% (1,392)	11% (7,394)	20% (13,162)	2% (1,685)		12% (7,967)
Direct Care Services [e]										
Home health aides	100% (839,930)				100% (839,930)					
Nursing assistants	100% (1,420,020)	7% (97,350)		26% (371,080)	5% (63,490)	55% (786,660)				7% (101,440)
Pharmacy Services [e]										
Pharmacists	100% (264,100)	78% (206,451)	22% (57,649)							
Pharmacy technicians	100% (334,400)	84% (280,730)	16% (53,670)							
Pharmacy aids	100% (42,600)	95% (40,380)	5% (2,220)							
Rehabilitation Services [e]										
Occupational Therapists	100% (86,286)	26% (22,780)		38% (32,444)	11% (9,319)	11% (9,319)		14% (12,425)		
Physical Therapists	100% (191,563)	46% (87,353)		34% (64,365)	12% (23,754)	8% (16,091)				
Occupational therapy assistants	100% (29,500)	46% (13,548)		18% (5,272)	6% (1,643)	24% (7,026)		7% (2,011)		
Physical therapy assistants	100% (76,492)	46% (35,309)		32% (24,164)	9% (7,160)	13% (9,860)				
Respiratory Care Services [e]										
Respiratory therapist	100% (104,086)	19% (19,755)	44% (46,290)	37% (38,018)	0.02% (23)					
Respiratory therapy technicians	100% (13,460)	19% (2,555)	44% (5,986)	37% (4,916)	0.02% (3)					
Therapeutic Services [e]										
Chiropractor	100% (58,800)	100% (58,800)								
Podiatrists	100% (10,700)	100% (10,700)								

Health Workforce DISTRIBUTION (N) by Delivery Site										
Profession	**Total**	**Delivery Sites**								
		Ambulatory	***Emergency***	***Inpatient***	***Home Health***	***Nursing Home***	***Public Health***	***School Health***	***Education***	***Other***
Vision Services [e]										
Optometrist	100% (36,260)	100% (36,260)								
Opticians	100% (54,500)	100% (54,500)								

Health Workforce DISTRIBUTION (N) by Delivery Site										
Profession	**Total**	**Delivery Sites**								
		Ambulatory	***Emergency***	***Inpatient***	***Home Health***	***Nursing Home***	***Public Health***	***School Health***	***Education***	***Other***
Behavioral Health Services										
Psychologists	100% (188,300)	100% (188,300)								
Diagnostic Services										
Diagnostic medical sonographers	100% (58,000)	38% (21,771)		61% (35,616)					1% (613)	
Medical and clinical laboratory technicians	100% (161,500)	20% (32,300)	5% (8,075)	75% (121,125)						
Medical and clinical laboratory technologists	100% (164,300)	20% (32,860)	5% (8,215)	75% (123,225)						
Nuclear medicine technologists	100% (20,900)	31% (6,386)		68% (14,243)					1% (271)	
Radiologic technologists	100% (194,790)	34% (66,139)		64% (123,862)			2% (4,788)			
Dietary and Nutrition Services										
Dietitians and nutritionists	100% (67,400)	18% (12,097)		35% (23,703)	2% (1,392)	11% (7,394)	20% (13,162)	2% (1,685)		12% (7,967)
Direct Care Services										
Home health aides	100% (839,930)				100% (839,930)					
Nursing assistants	100% (1,420,020)	7% (97,350)		26% (371,080)	5% (63,490)	55% (786,660)				7% (101,440)
Pharmacy Services										
Pharmacists	100% (264,100)	78% (206,451)	22% (57,649)							

Health Workforce DISTRIBUTION (N) by Delivery Site										
Profession	**Total**	**Delivery Sites**								
		Ambulatory	***Emergency***	***Inpatient***	***Home Health***	***Nursing Home***	***Public Health***	***School Health***	***Education***	***Other***
Pharmacy technicians	100% (334,400)	84% (280,730)	16% (53,670)							
Pharmacy aids	100% (42,600)	95% (40,380)	5% (2,220)							
Rehabilitation Services										
Occupational Therapists	100% (86,286)	26% (22,780)		38% (32,444)	11% (9,319)	11% (9,319)		14% (12,425)		
Physical Therapists	100% (191,563)	46% (87,353)		34% (64,365)	12% (23,754)	8% (16,091)				
Occupational therapy assistants	100% (29,500)	46% (13,548)		18% (5,272)	6% (1,643)	24% (7,026)		7% (2,011)		
Physical therapy assistants	100% (76,492)	46% (35,309)		32% (24,164)	9% (7,160)	13% (9,860)				
Respiratory Care Services										
Respiratory therapist	100% (104,086)	19% (19,755)	44% (46,290)	37% (38,018)	0.02% (23)					
Respiratory therapy technicians	100% (13,460)	19% (2,555)	44% (5,986)	37% (4,916)	0.02% (3)					
Therapeutic Services										
Chiropractor	100% (58,800)	100% (58,800)								
Podiatrists	100% (10,700)	100% (10,700)								
Vision Services										
Optometrist	100% (36,260)	100% (36,260)								
Opticians	100% (54,500)	100% (54,500)								

Source: May 2012 Occupational Employment Statistics and HWSM baseline results

Health Workforce WORKLOAD by Care Delivery Site									
Profession	**Delivery Sites (Units)**								
	Ambulatory (Visits)	***Emergency (Visits)***	***Inpatient (Days)***	***Home Health (Visits)***	***Nursing Home (Population)***	***Public Health (Population)***	***School Health (Population)***	***Education (Trainees)***	***Other (Population)***
Behavioral Health Services									
Psychologists	5,726,228								
Diagnostic Services									
Diagnostic medical sonographers	957,824,918		171,483,258					Not Estimated	
Medical and clinical laboratory technicians	957,824,918	113,437,741	171,483,258						
Medical and clinical laboratory technologists	957,824,918	113,437,741	171,483,258						
Nuclear medicine technologists	3,208,056		34,404					Not Estimated	
Radiologic technologists	3,208,056		34,404			314,004,465			
Dietary and Nutrition Services									
Dietitians and nutritionists	957,824,918		171,483,258	65,361,194	19,173,536	314,004,465	58,004,764		314,004,465
Direct Care Services									
Home health aides				34,887,385					
Nursing assistants	1.002,118,228	113,437,258	171,483,258	4,477,903	19,173,536				314,004,465
Pharmacy Services (Prescriptions)									
Pharmacist	1,955,699,897	224,332,952							
Pharmacy	1,955,699,897	224,332,952							

Health Workforce WORKLOAD by Care Delivery Site									
Profession	**Delivery Sites (Units)**								
	Ambulatory (Visits)	***Emergency (Visits)***	***Inpatient (Days)***	***Home Health (Visits)***	***Nursing Home (Population)***	***Public Health (Population)***	***School Health (Population)***	***Education (Trainees)***	***Other (Population)***
technicians									
Pharmacy aids	1,955,699,897	224,332,952							
Rehabilitation Services									
Occupational Therapist	1,840,597		680,697	310,041	19,173,536		58,004,764		
Physical Therapist	60,755,485		680,697	745,589	19,173,536				
Occupational therapy assistants	1,840,597		680,697	310,041	19,173,536		58,004,764		
Physical therapy assistants	60,755,485		680,697	745,589	19,173,536				
Respiratory Care Services									
Respiratory Therapist	11,389,732	21,660,663	15,446,529	21,525					
Respiratory therapy technicians	11,389,732	21,660,663	15,446,529	21,525					
Therapeutic Services									
Chiropractor	57,275,468								
Podiatrists	12,437,351								
Vision Services									
Optometrist	24,732,085								
Opticians	24,732,085								

Source: HWSM baseline results

Health Workforce STAFFING RATIOS by Care Delivery Site									
Profession	**Delivery Sites (Units per Provider)**								
	Ambulatory (Visits)	***Emergency (Visits)***	***Inpatient (Days)***	***Home Health (Visits)***	***Nursing Home (Population)***	***Public Health (Population)***	***School Health (Population)***	***Education (Trainees)***	***Other (Population)***
Behavioral Health Services									
Psychologists	30								
Diagnostic Services									
Diagnostic medical sonographers	43,996		4,815						
Medical and clinical laboratory technicians	29,654	14,048	1,416						
Medical and clinical laboratory technologists	29,149	13,809	1,392						
Nuclear medicine technologists	502		2						
Radiologic technologists	49					65,575			
Dietary and Nutrition Services									
Dietitians and nutritionists	79,178		7,235	46,947	2,593	23,857	34,430		39,412
Direct Care Services									
Home health aides				42					
Nursing assistants	10,294		462	71	24				3,095
Pharmacy Services (Prescriptions)									
Pharmacist	9,473	3,891							
Pharmacy technicians	6,966	4,180							
Pharmacy aids	48,432	101,051							
Rehabilitation Services									
Occupational Therapist	81		21	33	2,057		46,68		
Physical Therapist	696		11	31	1,192				
Occupational therapy assistants	136		129	189	2,729		28,847		

Health Workforce STAFFING RATIOS by Care Delivery Site									
Profession	**Delivery Sites (Units per Provider)**								
	Ambulatory (Visits)	***Emergency (Visits)***	***Inpatient (Days)***	***Home Health (Visits)***	***Nursing Home (Population)***	***Public Health (Population)***	***School Health (Population)***	***Education (Trainees)***	***Other (Population)***
Physical therapy assistants	1,721		28	104	1,945				
Respiratory Care Services									
Respiratory therapist	577	468	406	942					
Respiratory therapy technicians	4,458	3,619	3,142	7,287					
Therapeutic Services									
Chiropractor	974								
Podiatrists	1,162								
Vision Services									
Optometrist	682								
Opticians	454								

Source: May 2012 Occupational Employment Statistics and HWSM baseline results