



Methodology for Estimating Pneumococcal Vaccination Coverage

Monitoring the *Healthy People 2020* Objective

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1 Overview

To help the Center for Disease Control (CDC) monitor progress toward the Healthy People 2020 pneumococcal vaccination objective, Acumen estimated the annual pneumococcal vaccination rates of institutionalized adults aged 18 years and older in long-term care facilities or nursing homes (NHs) certified by the Centers for Medicare & Medicaid Services (CMS). This analysis extends across calendar years (CY) 2006-2016.

This report explains the data and methodology used for the analysis:

- *Section 2, Data Source:* This section provides background on the data source, the Minimum Data Set (MDS), and identifies the specific data elements used to calculate pneumococcal vaccination rates.
- *Section 3, Study Population:* This section explains how the study population was constructed and how resident characteristics were categorized.
- *Section 4, Vaccination Rate Methodology:* This section defines the numerator and denominator of the pneumococcal vaccination rate. This section also describes how the project team identified reasons for non-vaccination.
- *Section 5, Additional Investigations:* This section presents the results of supplemental investigations undertaken to support the main analysis and chosen methodology. Specifically, the section discusses inconsistent vaccination information and explores two alternative definitions of vaccination status.

2 Data Source

The *Healthy People 2020* objective uses the MDS as its primary data source. This section begins with an overview of the MDS and then further explains the set of items that are particularly relevant to this project.

2.1 Understanding the MDS

The MDS assesses the health and care needs of all residents admitted to Medicare- or Medicaid-certified NHs and Veterans Health Administration Community Living Centers. It was originally introduced as a means of identifying resident characteristics and issues in order to develop individualized care plans. The use of the MDS assessment tool has since expanded to include purposes such as monitoring the quality of care, determining Medicare and Medicaid payment, and providing consumer access to NH information.

There are two general types of MDS assessments: Omnibus Budget Reconciliation Act (OBRA) assessments and Medicare Prospective Payment System (PPS) assessments. OBRA assessments satisfy the Act's mandate to conduct comprehensive assessments based on uniform data with the goal of assuring quality of care. NHs are required to submit OBRA records for all residents in Medicare- or Medicaid-certified beds, regardless of the payer. PPS assessments help determine Medicare payment for Part A beneficiaries in skilled nursing facilities (SNFs), so SNFs submit these assessments only for residents covered under the Medicare Part A SNF benefit.

Assessments are conducted at time intervals relative to the date a resident entered a facility:

- Completed for all nursing home residents: The OBRA requires facilities to fill out assessments at the following points in the stay.
 - Admission (within the first two weeks)
 - Quarterly (92 days following the previous OBRA assessment of any type)
 - Annually (366 days following the last comprehensive OBRA assessment)
 - Significant change in the patient's status
 - Discharge
- Completed for Medicare SNF PPS residents: The following assessments are required for SNF PPS residents to determine Medicare payment.
 - 5-day assessment (days 1-8)
 - 14-day assessment (days 13-18)
 - 30-day assessment (days 27-33)

- 60-day assessment (days 57-63)
- 90-day assessment (days 87-93)
- Change in therapy treatment (start of therapy, end of therapy, change in intensity)

When OBRA and SNF PPS assessment time frames coincide, one assessment may be used to satisfy both requirements. Additional information about assessment scheduling may be found in Chapter 2 of the MDS [Resident Assessment Instrument \(RAI\) Manual](#).

This project extracts information from all types of MDS assessments—OBRA, PPS, and combined OBRA/PPS. These assessment requirements result in approximately five assessments each year per unique resident¹ in the study population, as shown in *Table 1*.

Table 1. Average number of assessments per resident in study population

CY 2006	CY 2007	CY 2008	CY 2009	CY 2010	CY 2011	CY 2012	CY 2013	CY 2014	CY 2015	CY 2016
4.7	4.7	4.8	4.8	4.7	5.3	5.4	5.3	5.3	5.3	5.2

2.2 Using the MDS for analysis

To answer the *Healthy People 2020* objective, Acumen used the pneumococcal vaccination questions from the MDS assessment. These questions changed during the study window of this project, however, which divided the timeframe into two periods: MDS Version 2.0 and MDS Version 3.0. The MDS was updated from Version 2.0 to 3.0 on October 1, 2010, and the new version of the assessment introduced changes to the wording, formatting, and submission requirements of the pneumococcal questions, as the following tables show. Accordingly, because the version upgrade occurred partway through CY 2010, the data from that year may have inconsistencies, and the 2006-2009 rates are not directly comparable to the rates from subsequent years.

Table 2. O0300A & W3A: The question evaluating whether or not the resident received the pneumococcal vaccination was changed in wording and formatting.

MDS 3.0	MDS 2.0
Is the resident's Pneumococcal vaccination up to date? *	Is the resident's PPV status up to date?
0. No --> Continue to O0300B, If Pneumococcal vaccine not received, state reason	0. No (If No, go to item W3b)
1. Yes --> Skip to O0400, Therapies	1. Yes (If Yes, skip item W3b)

¹ Residents are identified in the assessment data by a unique combination of resident identifier and state code. As a result, residents who lived in multiple states were included once in each state, while residents who lived in multiple nursing homes within a state were included only once in that state.

* The [RAI Manual](#) recommends a one-time revaccination if a resident is immunocompromised or if the resident received the initial dose before age 65.

Table 3. O0300B & W3B: The answers to reasons for non-vaccination changed in wording and formatting.

MDS 3.0	MDS 2.0
If Pneumococcal vaccine not received, state reason:	If PPV not received, state reason:
1. Not eligible - medical contraindication**	1. Not eligible
2. Offered and declined	2. Offered and declined
3. Not offered	3. Not offered

** The phrase "medical contraindication" is only found in MDS 3.0. The MDS RAI Manual lists the following medical contraindications: "a life-threatening allergic reaction to the pneumococcal vaccine or any vaccine component(s), a physician order not to immunize, or an acute febrile illness is present". It also states that "if the resident has a moderate to severe acute illness, he or she should not be vaccinated until his or her condition improves".

3 Study Population

Acumen created and classified a study population for analysis using information from the MDS assessments. This section first explains how Acumen created a base population of nursing home residents and implemented restrictions to improve the quality of the data. The section then discusses how the project team classified the characteristics of the cleaned resident population.

3.1 Constructing the study population

The *Healthy People 2020* objective applies to all institutionalized adults aged 18 years and older in NHs certified by CMS. To match the *Healthy People 2020* definition, Acumen identified all residents who had at least one assessment conducted with a target date between January 1 and December 31 of each calendar year in the analysis. Due to the limitations of the resident identification number, residents who lived in multiple states were included once in each state, while residents who lived in multiple nursing homes within a state were included only once in that state. Acumen then restricted the population to residents aged 18 years and older to arrive at the base population of institutionalized adults in NHs certified by CMS. After applying the missing restriction described below, this population formed the denominator of the vaccination rate.

Assessments with missing vaccination information were excluded. While the pneumococcal vaccination fields must be completed for most MDS assessment types, there are some exceptions. For MDS 2.0 assessments, reentry tracking records and inactivation requests do not require completion of the pneumococcal questions. In addition to these assessment types, MDS 3.0 also exempts non-combined unscheduled PPS assessments and entry/expire tracking records from the pneumococcal questions. Assessments from swing bed facilities² were also excluded from this project because the pneumococcal vaccination questions do not appear on MDS 2.0 swing bed assessments. Lastly, “not assessed/no information” is a valid entry value on all assessments, even if the pneumococcal questions are part of the required set for that assessment.

Though an individual assessment may be missing vaccination information, a resident's vaccination status can still be determined if he or she received other assessments with non-missing information in the calendar year or in previous years. However, if all assessments for a resident in a single calendar year and

² Swing beds are beds in acute care hospitals that can be used for patients receiving SNF care. They are more commonly found in rural areas. The MDS assessments for swing bed residents are different from the assessments required for residents in NHs.

all previous years are missing vaccination information, then the resident was excluded from the population for that calendar year (see *Table 4*).

In September of 2014, the Advisory Committee on Immunization Practices revised the pneumococcal vaccination recommendation for adults 65 years and older to include both the 13-valent pneumococcal conjugate vaccine (PCV13) and the 23-valent pneumococcal polysaccharide vaccine (PPSV23). Therefore residents who were considered vaccinated before 2015 may not be considered vaccinated under the new recommendation. For 2015 and all subsequent years, residents missing vaccination data in the current year have missing vaccination status because we no longer look back to previous years for pneumococcal vaccination status.

Table 4. Percentage of residents excluded due to missing information

CY 2006	CY 2007	CY 2008	CY 2009	CY 2010	CY 2011	CY 2012	CY 2013	CY 2014	CY 2015	CY 2016
4.8%	3.8%	3.4%	3.1%	3.5%	3.6%	3.4%	3.3%	3.3%	5.7%	4.0%

3.2 Classifying the study population

The project team characterized the study population on several dimensions to better understand the vaccination rates. Acumen used these variables to decompose the national rate into state-specific estimates and to stratify the rate by five demographic factors: educational attainment, age, sex, race/ethnicity, and marital status. The descriptions below describe the MDS 2.0 and 3.0 variables that identify each resident demographic characteristic, as well as the variable included in Acumen's SAS program `calculate_pneumococcal_rates.sas`. When applicable, the description also includes the mapping used to account for changes between the two MDS versions.

A value of "Inconsistent information" was assigned when two assessments in the same calendar year had conflicting values for a demographic variable. The age variable was an exception to this categorization, as an increase in a resident's age may plausibly be captured across assessments during a given year. To address this possibility, the age from the resident's first assessment of the year was used. A value of "Missing" was assigned only when all the assessments in the year had missing information for the demographic variable.

3.2.1 State

MDS 2.0	MDS 3.0	SAS Program
STATE_ID	STATE_CD	STATE_CODE

State-specific vaccination rates and reasons for non-vaccination were calculated for all 50 states and the District of Columbia. This category can take on the following values:

- Alaska (AK)
- Alabama (AL)
- Arkansas (AR)
- Arizona (AZ)
- California (CA)
- Colorado (CO)
- Connecticut (CT)
- District of Columbia (DC)
- Delaware (DE)
- Florida (FL)
- Georgia (GA)
- Hawaii (HI)
- Iowa (IA)
- Idaho (ID)
- Illinois (IL)
- Indiana (IN)
- Kansas (KS)
- Kentucky (KY)
- Louisiana (LA)
- Massachusetts (MA)
- Maryland (MD)
- Maine (ME)
- Michigan (MI)
- Minnesota (MN)
- Missouri (MO)
- Mississippi (MS)
- Montana (MT)
- North Carolina (NC)
- North Dakota (ND)
- Nebraska (NE)
- New Hampshire (NH)
- New Jersey (NJ)
- New Mexico (NM)
- Nevada (NV)
- New York (NY)
- Ohio (OH)
- Oklahoma (OK)
- Oregon (OR)
- Pennsylvania (PA)
- Rhode Island (RI)
- South Carolina (SC)
- South Dakota (SD)
- Tennessee (TN)
- Texas (TX)
- Utah (UT)
- Virginia (VA)
- Vermont (VT)
- Washington (WA)
- Wisconsin (WI)
- West Virginia (WV)
- Wyoming (WY)

3.2.2 Educational attainment

MDS 2.0	MDS 3.0	SAS Program
AB7_EDUCATION	-	EDUCATION_BIN

A resident's educational attainment is only available on MDS 2.0 assessments. The values for this category are therefore unavailable starting October 2010, when the MDS 3.0 was implemented. The desired bins for educational attainment differ from the options listed in MDS 2.0. **Table** describes how Acumen mapped the specific MDS 2.0 values into more general groups. This category can take on the following values:

- < High school
- High school
- Technical or trade school
- Some college
- 4-year college

- Advanced degree
- Inconsistent information (constructed value)
- Missing (constructed value)

Table 5. Educational attainment value mapping

MDS 2.0	Category Assignment
▪ No schooling	▪ < High school
▪ 8th grade/less	▪ < High school
▪ 9-11 grades	▪ < High school
▪ High school	▪ High school
▪ Technical or trade school	▪ Technical or trade school
▪ Some college	▪ Some college
▪ Bachelor's degree	▪ 4-year college
▪ Graduate degree	▪ Advanced degree

3.2.3 Age

MDS 2.0	MDS 3.0	SAS Program
AA3_BIRTH_DT (Birth Date), TRGT_DT (Target Date)	A0900_BIRTH_DT (Birth Date), TRGT_DT (Target Date)	AGE_BIN (Birth Date), TARGET_DATE (Target Date)

The resident's age was constructed using two variables from the MDS, the resident's birth date and the assessment target date. This category can take on the following values:

- 18-24 years
- 25-44 years
- 45-54 years
- 55-64 years
- 65-74 years
- 75-84 years
- 85+ years

3.2.4 Sex

MDS 2.0	MDS 3.0	SAS Program
AA2_GENDER	A0800_GNDR_CD	SEX_BIN

The question of gender/sex is consistent across MDS versions. This category can take on the following values:

- Female
- Male
- Inconsistent information (constructed value)
- Missing (constructed value)

3.2.5 Race/ethnicity

MDS 2.0	MDS 3.0	SAS Program
AA4_RACE_ETH	A1000A_AMRCN_INDN_AK_NTV_CD, A1000B ASN_CD, A1000C_AFRCN_AMRCN_CD, A1000D_HSPNC_CD, A1000E_NTV_HI_PCFC_ISLND_R_CD, A1000F_WHT_CD	RACE_ETHNICITY_BIN

The question of race/ethnicity is inconsistent across MDS versions. **Table** includes the mapping used between versions. MDS 2.0 combines Asian and Pacific Islander into the same category and does not offer the option of selecting multiple races/ethnicities. MDS 3.0 features slight alterations in wording.

Table 6. Race/ethnicity value mapping

MDS 2.0	MDS 3.0*
▪ American Indian/ Alaskan Native	▪ American Indian or Alaska Native
▪ Asian/Pacific Islander	-
-	▪ Asian
-	▪ Native Hawaiian or Other Pacific Islander
▪ Black, not of Hispanic origin	▪ Black or African American
▪ Hispanic	▪ Hispanic or Latino
▪ White, not of Hispanic origin	▪ White
-	▪ Multiple races

*In MDS 3.0, more than one race category can be selected. For this study, any resident with "Hispanic or Latino" selected was placed in the "Hispanic or Latino" category regardless of the other races selected. For example, an individual with "Black" and "Hispanic or Latino" was categorized as "Hispanic or Latino." If multiple races not including "Hispanic or Latino" were selected, then the resident was classified as "Multiple races".

This category can take on the following values (the union of the two columns in **Table**):

- American Indian or Alaska Native
- Asian or Pacific Islander

- Asian
- Native Hawaiian or Other Pacific Islander
- Black or African American
- Hispanic or Latino
- White
- Multiple races
- Inconsistent information (constructed value)
- Missing (constructed value)

3.2.6 Marital status

MDS 2.0	MDS 3.0	SAS Program
A5_MARTIAL_STATUS	A1200_MRTL_STUS_CD	MARITAL_STATUS_BIN

The question of marital status is consistent across MDS versions. This category can take on the following values:

- Never married
- Married
- Widowed
- Separated
- Divorced
- Inconsistent information (constructed value)
- Missing (constructed value)

4 Vaccination Rate Methodology

The goal of this analysis is to estimate the pneumococcal vaccination rate and the composition of reasons for non-vaccination. This section describes the methodology used to build these estimates from the population described in Section 3. The first subsection presents how the project team defined the vaccination rate. The second subsection examines the reasons for residents failing to receive the pneumococcal vaccination.

4.1 Defining the vaccination rate

The pneumococcal vaccination numerator includes all those from the denominator population described in Section 3 who were reported to be vaccinated at any assessment in that year or any prior year. The vaccination status was based on information from the O0300A (MDS 3.0) and W3a (MDS 2.0) questions. Residents with a “yes” on an assessment were counted as vaccinated for that year and all subsequent years, regardless of any “no” answers in subsequent years. In other words, a “yes” vaccinated status carried through to subsequent years. Due to a change in the pneumococcal vaccination recommendation for adults 65 years and older from the Advisory Committee on Immunization Practices in September 2014, vaccination status from before 2015 does not carry over to 2015 residents.

For 2014 and prior years:

Numerator: All those who were reported to have received the pneumococcal vaccination in any assessment in the calendar year or in any earlier year.

Denominator: All institutionalized adults aged 18 years and older in long-term care facilities or NHs certified by CMS who had resident assessments conducted with a target date in the calendar year.

For 2015 and later years:

Numerator: All those who were reported to have received the pneumococcal vaccination in any assessment in the calendar year only.

Denominator: All institutionalized adults aged 18 years and older in long-term care facilities or NHs certified by CMS who had resident assessments conducted with a target date in the calendar year.

Table 7. Vaccination status on the MDS

“Yes” on MDS 3.0	“Yes” on MDS 2.0
O0300A = 1	W3a = 1

Section 5.2 explores two other methods of defining the vaccination rate, applying different interpretations to a change in the vaccination answer. The national and state-specific vaccination rates were stratified by all five resident characteristics.

4.2 Defining non-vaccination reasons

The analysis of non-vaccination reasons was conducted at the national and state levels. The analysis also looked at non-vaccination reasons by race at the national level. Acumen used two methodologies to determine a resident's reason for non-vaccination. The first methodology classified a resident into one of five reasons for non-vaccination, based on all assessments performed between 2005 and the end of a given calendar year:

- Not eligible – medical contraindication
- Offered & declined
- Not offered
- Multiple reasons
- Missing

* MDS 3.0 phrasing: "Inability to obtain vaccine due to declared shortage"

The first three reasons are derived directly from the MDS questions explained in Section 2.2. If the assessments between 2005 and the end of the calendar year indicated different reasons for non-vaccination, the resident qualified for the "Multiple reasons" category. If all assessments for an unvaccinated resident were missing an answer for the non-vaccination question, then the resident fell under the "Missing" category.

The second methodology classified a resident into one of four reasons for non-vaccination, based only on the last assessment with non-missing vaccination information performed in a calendar year:

- Not eligible – medical contraindication
- Offered & declined
- Not offered
- Missing

Because only one assessment was used for this methodology, a resident could not have inconsistent reasons for non-vaccination and therefore could not be classified into the "Multiple reasons" category. If all assessments in a calendar year for an unvaccinated resident were missing an answer for the non-vaccination question, then the last assessment with non-missing information from a prior year is used. If all assessments between 2005 and the end of the calendar year were missing an answer for the non-vaccination question, then the resident fell under the "Missing" category.

The motivation for using this methodology was that a modification in the reported reason for non-vaccination could reflect an actual change, rather than a data inconsistency. For example, a resident may not have been offered the vaccine at the time of their first assessment, but could have been offered and declined it by the time of their last assessment. Using the last assessment with non-missing information may provide the ultimate reason why a resident was not vaccinated in the calendar year.

5 Additional Investigations

This project encountered two main data quality concerns: missing vaccination information, and inconsistent answers to the vaccination question. Acumen addressed the first concern with a population restriction, as *Section 3.1* describes. This section explains the second concern—inconsistent vaccination information—and then presents an investigation that explored how inconsistent information affects the national vaccination rates.

5.1 Interpreting inconsistent vaccination information

Inconsistent information for a given resident is defined as a "yes" for vaccinated on an assessment and a "no" on any later assessment. We consider this as inconsistent because the vast majority of residents who are up-to-date at one assessment would also be up-to-date at a later assessment during a one-year period. This applies to both the pre-2015 guidelines, which recommended one vaccine, and the post-2015 guidelines, which recommended two different single-dose vaccines. There are two cases for which a one-time revaccination is recommended: when the resident is immunocompromised, and when the resident received their initial dose before age 65. In those two cases, revaccination is recommended five years after the initial dose, and a "no" answer following a "yes" answer could simply refer to the need for revaccination. However, these two unusual cases do not explain the fact that one fifth of the cleaned study population presents this assessment pattern. Consequently, this pattern is considered an inconsistency in the data. Due to the change in the pneumococcal vaccination recommendations, a "no" for vaccination status after the start of 2015 is not considered inconsistent with a "yes" from before 2015.

Table 8. Percentage of residents with inconsistent information

CY 2006	CY 2007	CY 2008	CY 2009	CY 2010	CY 2011	CY 2012	CY 2013	CY 2014	CY 2015	CY 2016
19.7%	22.5%	24.2%	25.3%	26.6%	26.9%	26.3%	25.1%	22.7%	12.6%	12.9%

The vaccination rate calculation considers these residents vaccinated for every year following their first "yes" answer, placing higher confidence on earlier positive responses. This method makes an exception due to the change in the pneumococcal vaccination recommendations. Vaccination status from before 2015 is not carried over to vaccination status after the start of 2015.

5.2 Investigating alternative definitions of vaccination rate

Before CDC selected the *Section 4.1* definition, the project team presented two additional methods of calculating the vaccination rate. Each method varies in the level of stringency of accounting for residents

with inconsistent answers for the vaccination status. **Table** summarizes the three methods. The upper bound is the method selected by CDC and defined previously in *Section 4.1*.

Table 9. Methods for defining vaccination rate

Upper Bound	Lower Bound	Alternative Sample
Motivation		
This definition does not account for data entry errors. This definition places greater confidence in positive or earlier answers.	This definition assumes no data entry errors; changing from "yes" to "no" is interpreted as if the resident had up-to-date vaccination in the past and now requires revaccination.	This definition accounts for possible data entry errors by restricting the population to residents with consistent vaccination information.
Definition of Vaccinated Status		
Residents with a "yes" on an assessment are counted as vaccinated for that year and all subsequent years regardless of any "no" in subsequent years. Vaccinated status is reset at the start of 2015.	Residents are counted as vaccinated or not vaccinated based on their vaccination status at the end of each calendar year.	Residents with a "yes" on an assessment and a "no" on a later assessment (within or across years) are dropped from the population. A "no" for vaccination status after the start of 2015 is not considered inconsistent with a "yes" from before 2015.
Population		
<u>Full population</u> <i>Includes:</i> Residents with inconsistent info. (Table). <i>Excludes:</i> Residents with missing information (Table 4).	<u>Full population</u> <i>Includes:</i> Residents with inconsistent info. (Table). <i>Excludes:</i> Residents with missing information (Table 4).	<u>Alternative population</u> <i>Excludes:</i> - Residents with inconsistent information (Table). - Residents with missing information (Table 4).

The treatment of inconsistent information affects the estimated rate of vaccination. **Table** shows the vaccination rates using each of the three methods.

Table 10. Percentage of residents with inconsistent information

Method	CY 2006	CY 2007	CY 2008	CY 2009	CY 2010	CY 2011	CY 2012	CY 2013	CY 2014	CY 2015	CY 2016
Upper Bound	67.4%	74.3%	77.8%	79.9%	80.1%	79.8%	79.5%	79.3%	78.4%	70.8%	72.5%
Lower Bound	62.3%	68.1%	71.1%	73.0%	71.4%	70.1%	69.4%	68.6%	66.7%	65.3%	64.4%
Alternative Sample	64.0%	70.4%	73.6%	75.5%	75.0%	74.0%	73.4%	72.9%	72.0%	67.4%	68.4%