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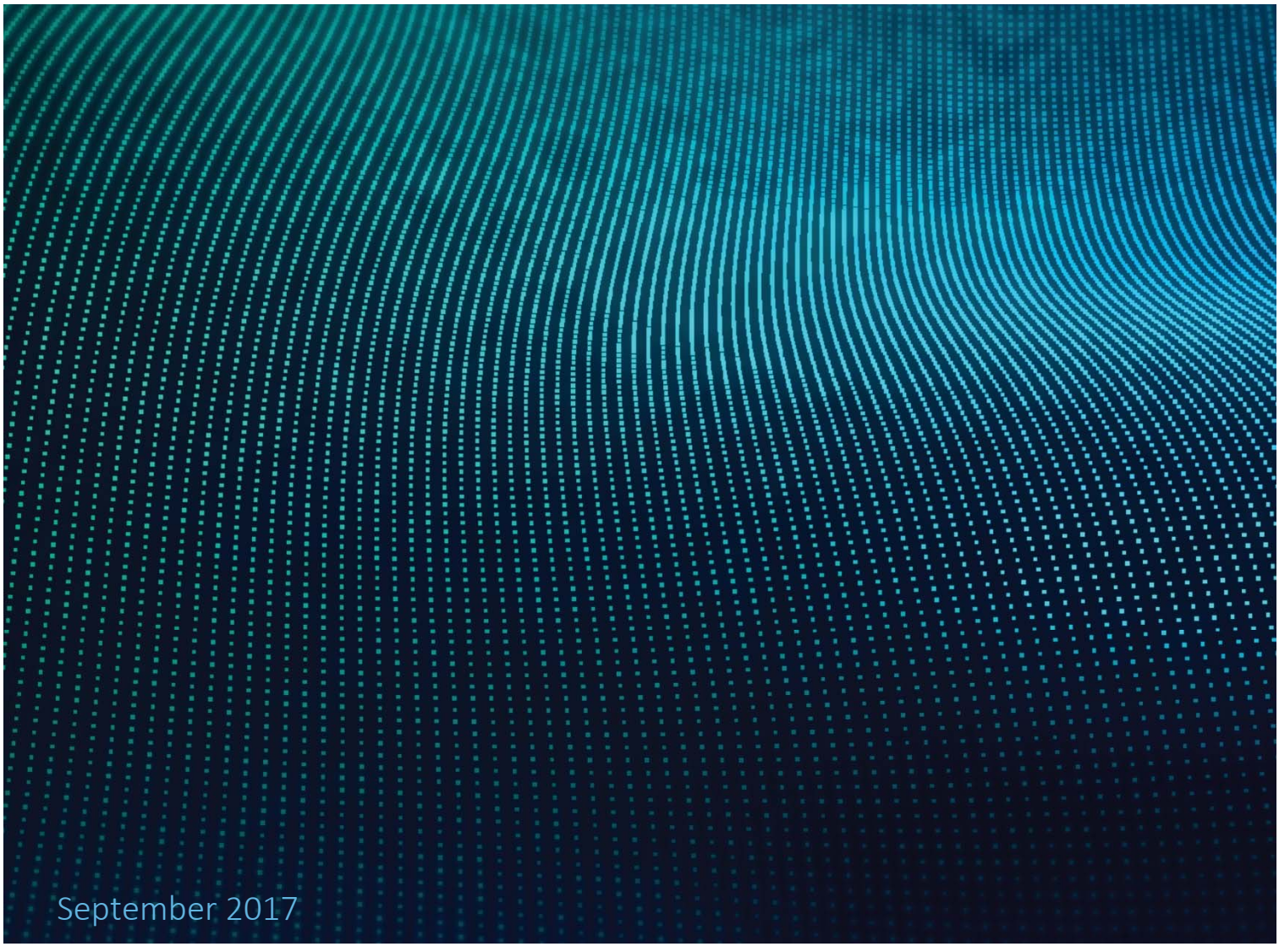
Seasonal Influenza in the United States 2016-2017



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Seasonal Influenza in the United States 2016-2017

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Caveat and Disclaimer

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Executive Summary

This report provides observations and commentary on the 2016-2017 and recent flu seasons with relation to various mortality and morbidity measures available through the Centers for Disease Control and Prevention (CDC). The report serves a secondary purpose of providing interested readers with a guide to the various analyses and data produced by the CDC. While this information is freely available and easily accessible, it is widely dispersed across the CDC influenza website. The references and insights provided in this report will reduce the amount of time needed for someone to learn about the resources available at the CDC on this topic.

Each year, seasonal influenza has a significant impact in the United States. A typical flu season results in millions of illnesses, hundreds of thousands of hospitalizations and thousands of flu-related deaths. Constant vigilance of seasonal influenza is necessary to apply prevention measures and manage its occurrence. Because the flu virus can mutate rapidly, it poses a continuous risk that varies seasonally.

The CDC reports a variety of weekly influenza morbidity and mortality indicators during the flu season. These indicators serve a primary purpose of judging the timing and intensity or rate of change of flu outcomes during a current season. The CDC also produces lagged annual estimates of influenza morbidity and mortality. Because the 2016-2017 annual season estimates will not be available until December 2017, this report relies on the weekly seasonal indicators to draw conclusions about the 2016-2017 season. Using this work, we draw inferences about the approximate rank (high, medium or low) of 2016-2017 morbidity and mortality relative to the recent seasons studied in this report.

The burden (combination of morbidity and mortality) of the 2016-2017 flu season was medium to high, based on most seasonal indicators, relative to recent seasons. Most of the reported morbidity, with the exception of high cumulative hospitalization rates, and mortality measures were not extremely high or low relative to recent seasons. Late season estimates of vaccine effectiveness for 2016-2017 were estimated to be 34% against illness caused by influenza A(H3N2) virus, and 56% against influenza B virus. On a combined basis, there was an estimated overall 42% effectiveness of the vaccine.

> Outpatient Medical Visits – Influenza-like illness (ILI), likely but unconfirmed cases of influenza, is monitored as a proxy for influenza levels. The percentage of ILI during outpatient visits in the 2016-2017 season were medium to high relative to recent seasons. ILI was low through November and began to increase in December, with peak activity of 5.1% in February. Peak activity was lower than the recent high seasons of 2012-2013 and 2014-2015 (which traced nearly identical paths), and higher than the relatively mild 2011-2012 season. The percentage of ILI exceeded an elevated level (indicative of significant ILI) for 17 consecutive weeks. This is slightly longer, but similar to the length of the 2010-2011, 2012-2013 and 2014-2015 seasons.

Hospitalizations - Reported cumulative hospitalization rates from 2016-2017, 64.9 per 100,000, matched 2014-2015 as the highest season, including the pandemic 2009-2010 season. The 2016-2017 season was unusual because it had a longer period of its highest weekly levels than other seasons. Even though its peak weekly levels were lower than 2014-2015, the longer period of elevated levels produced cumulative seasonal hospitalizations matching that season. The lowest cumulative seasonal rate, 8.7 per 100,000 occurring in 2011-2012, was consistent with the low ILI levels of that season.

Mortality – The 2016-2017 season's reported mortality levels, measured as the percentage of deaths attributable to pneumonia and influenza (P&I), were low to moderate relative to the highest recent seasons of 2012-2013 and 2014-2015. However, given a tendency for reported hospitalizations to track with mortality in earlier seasons, the 2016-2017 P&I mortality percentages may be understated because, while 2016-2017 hospitalizations were high, corresponding mortality was low. This may be explained by a change in the CDC's mortality reporting source officially effective for the 2016-2017 season, but also used at least partially for the prior season. Pediatric deaths, which are not subject to the reporting change, totaled 101 late in the flu season. That level was in the middle of most recent seasons, except for the outlier of 288 deaths reported during the pandemic 2009-2010 season.

Section 1: Background

1.1 Impact

Each year, seasonal influenza has a significant impact in the United States. A typical flu season results in millions of illnesses, hundreds of thousands of hospitalizations and thousands of flu-related deaths [1]. While the focus of this report is on human influenza, the flu virus also afflicts birds and mammals with subsequent effects on the economy, e.g. bird flu and egg production [2]. Flu strains that affect animals do not normally transmit to humans, but can do so, posing subsequent infection risk to the United States' population [3].

Constant vigilance of seasonal influenza is necessary to apply preventative measures and manage its occurrence. Because the flu virus can mutate rapidly, it poses a continuous risk that varies seasonally. Prior exposure to the virus does not assure immunity because of its continuous evolution. The annual incidence and impact in the United States from seasonal influenza varies due to a number of factors including vaccination rates, vaccine alignment and its effectiveness with circulating strains, incidence of unexpected strains, severity of circulating strains and susceptibility of the population to different strains.

1.2 Flu Types [4]

Three antigenically different types of flu, A, B and C, infect humans. Seasonal epidemics of influenza affecting humans are confined to types A and B. Type C affects humans and generally causes mild respiratory illness, but is not thought to cause epidemics. A fourth flu type, D, primarily affects cattle and is not known to cause illness to people.

Type A is typically referred to with its subtype classification such as H1N1. The subtype refers to the types of proteins on the surface of the virus and their respective variations. The letter descriptors refer to the hemagglutinin (H) and the neuraminidase (N) proteins, each of which have numerical subtypes, 18 and 11 respectively. Three A subtypes affect humans, H1N1, H1N2 and H3N2. Type B does not carry a subtype reference per naming standards. Individual viruses are further classified by the CDC with respect to their lineage and strains following a convention that was accepted in 1979 by the World Health Organization [5]. In addition to the letter type and subtype (type A only), viruses are classified by their host origin, geographic origin, strain number and year of isolation. As examples of the naming convention, the virus strains recommended for the 2017-2018 seasonal vaccination are listed below [6]. Because the host origin is human, a host is not listed.

an A/Michigan/45/2015 (H1N1)pdm09-like virus
an A/Hong Kong/4801/2014 (H3N2)-like virus
a B/Brisbane/60/2008-like (B/Victoria lineage) virus
a B/Phuket/3073/2013-like (B/Yamagata lineage) virus.

Although there are limited instances of disagreement, [7], [8], most sources take the view that the severity of symptoms and impact on humans are similar, independent of whether a particular flu virus strain is type A or B. A CDC study supports this view [9]. Its authors conclude that, among hospitalized adults, influenza A and B infections resulted in similar morbidity and mortality. The authors also cite other studies not involving hospitalized patients as supportive of their conclusions [10], [11].

1.3 Morbidity and Mortality Measures

The seasonal influenza surveillance system is one of the largest and most timely surveillance systems at the CDC. The system consists of five complementary surveillance categories that gather morbidity and mortality data. Morbidity measures consist of lab-based viral surveillance, outpatient surveillance of the incidence of influenza-like symptoms, hospitalizations and state and territorial reports of influenza activity. Mortality measures consist of pediatric deaths (required to be reported as a nationally notifiable condition) and the percentage of deaths where pneumonia or influenza is the underlying or other cause of death (inclusive of pediatric deaths) recorded on a death certificate.

Section 2: Reliance and Limitations

All data in the graphs and charts in this report is from the CDC Influenza website, https://www.cdc.gov/flu/index.htm. Stated data may change, particularly with respect to the current season 2016-2017 as the CDC updates and revises its reported experience. While the data may be useful for application in specific purposes, no advice is given with respect to stating any specific purpose(s).

The CDC cautions about drawing conclusions of the severity of influenza across seasons from the surveillance indicators shown in Section 3. This is because most of the surveillance indicators are derived from data submitted by clinics, labs, hospitals, providers and other sources, which are not uniform over time and are samples of the total population experience. While this caveat is generally applicable to all surveillance data, the following two specific areas are noted:

1. Caution should be applied in drawing conclusions from the percentage of positive influenza tests (Figure 1) as an indicator of the relative severity of the seasons. For example, the 2011-2012 season had relatively low activity based on other measures (see Table 1), yet exceeds the most recent season on this surveillance measure and is at a similar level as the 2013-2014 and 2014-2015 seasons. Though not validated with data, it is possible that this occurred due to the low number of specimens tested in the 2011-2012 season. Because the public labs must test a minimum number of specimens for type, sub-type and lineage identification, clinics deliver known positive test specimens to the public labs, which could have caused an upward bias to the level of positive tested specimens.

2. The CDC switched from using a sample of 122 reporting cities to receiving data from the states through the National Center for Health Statistics (NCHS). While this was announced in October 2016, the CDC states that it was using the new data for most of the 2015-2016 season, too. Because of this change, the years prior to the 2015-2016 season may not be comparable to subsequent seasons. The CDC also states that there is a backlog of manually coded records in the current season. Therefore, currently reported pneumonia and influenza (P&I) data for the 2016-2017 season is expected to increase as more deaths are recorded.

Section 3: 2016-2017 Surveillance Detail with Contrast to Prior Seasons

The morbidity and mortality surveillance indicators for the 2016-2017 and recent seasons are presented in this section. Because CDC estimates of morbidity and mortality for the 2016-2017 season will not be available until December 2017, these indicators are used to draw limited conclusions about 2016-2017 morbidity and mortality relative to recent seasons. Despite the caveat noted in Section 2, some of the indicators within a season tend to show similar levels of activity (high or low) within a season relative to another season. This suggests that, even if the degree of severity differences cannot be gauged from the data, the approximate rank (high, medium or low) of the morbidity and mortality of the 2016-2017 flu season, as compared to recent seasons, might be inferred from it. All data presented in these exhibits and descriptions of surveillance methods are derived from CDC sources [12], [13].

All of the graphs in this section use the convention of flu season weeks that convert the CDC standard flu season of Morbidity and Mortality Weekly Report (MMWR) week[1] 40 (traditional start of the flu season) running through the following calendar year to MMWR week 39 to weeks one to 52. An exception to the starting MMWR week was made by the CDC for the pandemic 2009-2010 season because it was deemed to start in week 35 of 2009. We include that season in these exhibits to show the highest severity experience in recent years, but show the season starting in MMWR week 40 in the graphs (weeks 35 through 39 in 2009 are truncated) to have consistency with the other seasons that all start in week 40. We also truncate week 53 of the 2014-2015 season, which is immaterial to the comparisons due to low activity at that time.

The CDC publishes an annual overview of the flu season [14]. Overall, the 2016-2017 season had medium to high levels of influenza activity. Levels were low through November and began to increase in December, with a peak of activity in February. The peak of activity occurred during the normal timespan (December through February). Except for high cumulative hospitalization rates, morbidity and mortality measures (detailed below) were moderate, not extremely high or low relative to recent seasons. Highlights of the 2016-2017 season are discussed with respect to each surveillance indicator below.

3.1 Virologic Surveillance

There are approximately 110 U.S. World Health Organization (WHO) Collaborating Laboratories and 240 National Respiratory and Enteric Virus Surveillance System (NREVSS) laboratories, which include both public health and clinical laboratories located throughout the United States, that participate in virologic surveillance of influenza. Generally, most public labs report as WHO entities and most clinics report as NREVSS entities. Clinics report the virus type and incidence of influenza. Their data is most useful for monitoring the timing and intensity of influenza. Public labs report more details including experience by age groups of virus types, subtypes (type A only) and lineage. Public lab data is most useful for identifying the mix of active influenza viruses and the population groups affected. In order to analyze enough samples,

[1] The *MMWR* week is the week of the epidemiologic year for which the National Notifiable Diseases Surveillance System (NNDSS) disease report is assigned by the reporting local or state health department for the purposes of *MMWR* disease incidence reporting and publishing. Values for *MMWR* week range from 1 to 53, although most years consist of 52 weeks. The first day of any *MMWR* week is Sunday. *MMWR* week numbering is sequential beginning with one and incrementing with each week to a maximum of 52 or 53. *MMWR* week one of an *MMWR* year is the first week of the year that has at least four days in the calendar year.

public labs will often receive samples from clinics that have already tested positive. Because of this, the percentage of positive public lab tests is expected to be biased upward relative to clinics.

Because of the different purposes of clinic and public lab data, the CDC splits the reporting of its experience starting with the 2015-2016 season. For the purposes of these exhibits that contain years pre-dating that split, the clinic and lab data for 2015-2016 and 2016-2017 were combined for consistency with prior years. The effect of the expected upward bias of positive tests from public labs on the combined data may be mitigated by the larger number of tests done by clinics versus public labs. The first year of separate data in 2015-2016 shows the clinics and public labs tested 814,021 (8.7% positive) and 78,973 (36.4% positive) specimens respectively. Because the clinics tested more than ten times as many specimens, the upward bias of the public labs on the percentage of positive tests is reduced in the combined clinic and public lab data for that season. Separate clinic and public lab data is not available from earlier seasons to judge the effect of combining their data to determine the percentage of positive tests.

Figure 1 shows the percentage of positive test specimens for influenza reported by WHO and NREVSS entities. Although the public lab data is biased upward, the combined clinic and public lab data is a good indicator of the timing and weekly proportional change of flu incidence within the seasons shown. However, because the mix and number of public labs and clinics changes from season to season, the indicator is not comparable across seasons. The flu season typically peaks in December through February (flu season weeks 9 through 23). The 2016-2017 peak occurred during flu season weeks 19 through 21. All seasons, except the pandemic 2009-2010 season which peaked very early, and 2011-2012 which peaked late (week 24), reached the flu season highs during the traditional timeframe. The timing of this indicator's seasonal peaks aligns closely with the outpatient influenza-like illness indicator.

Figure 1

PERCENTAGE OF WHO/NREVSS INFLUENZA POSITIVE TEST SPECIMENS

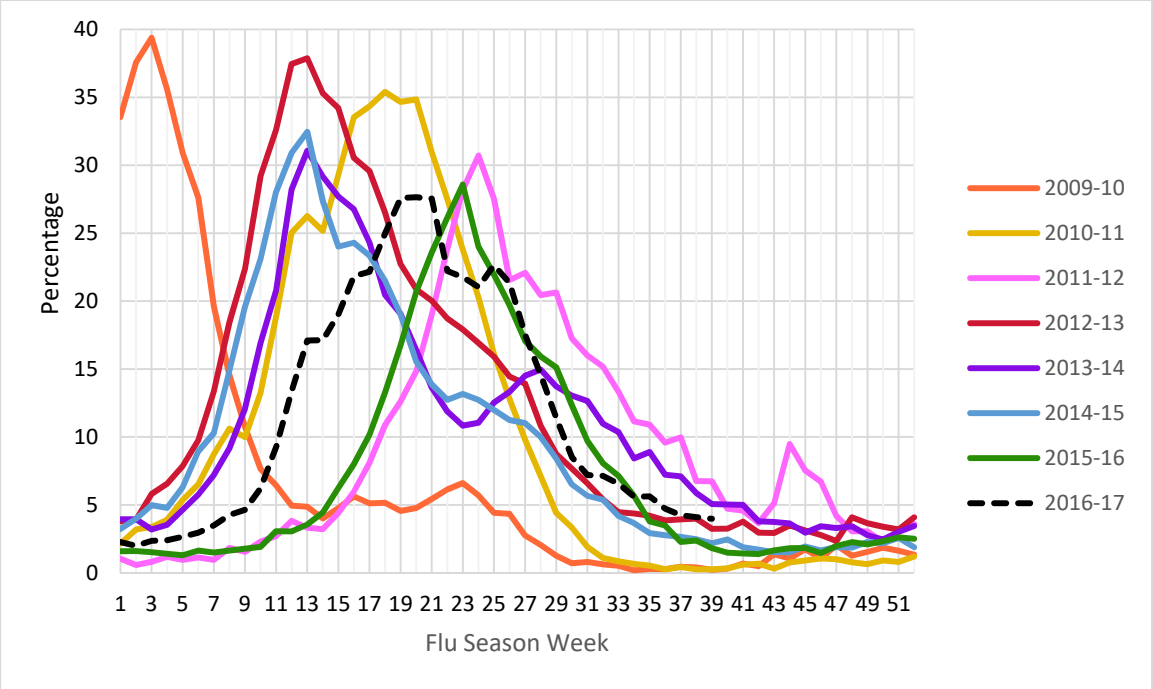
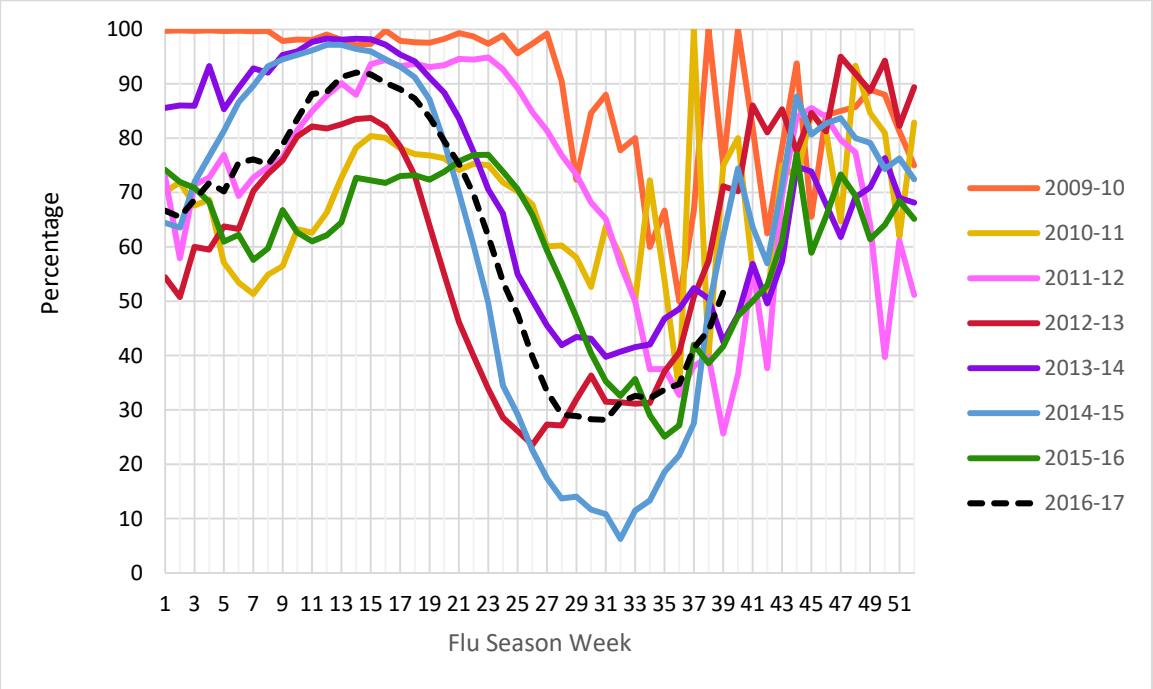


Figure 2 shows the proportion of positive test specimens that were type A. Because there are only two types of seasonal flu affecting humans (A and B), this gives an indication of their mix throughout the season. The 2016-2017 season was similar to other seasons where the proportion of people afflicted with type A influenza viruses increased going into the peak of the season and then decreased late in the season. There is no apparent pattern after flu season week 36. That is a reasonable result from a normal low incidence of flu at that point in the season, which then produces substantial variations in the mix of viruses at that time.

Figure 2

TYPE A PROPORTION OF POSITIVE TEST SPECIMENS



3.2 Outpatient Influenza-Like Illness Incidence

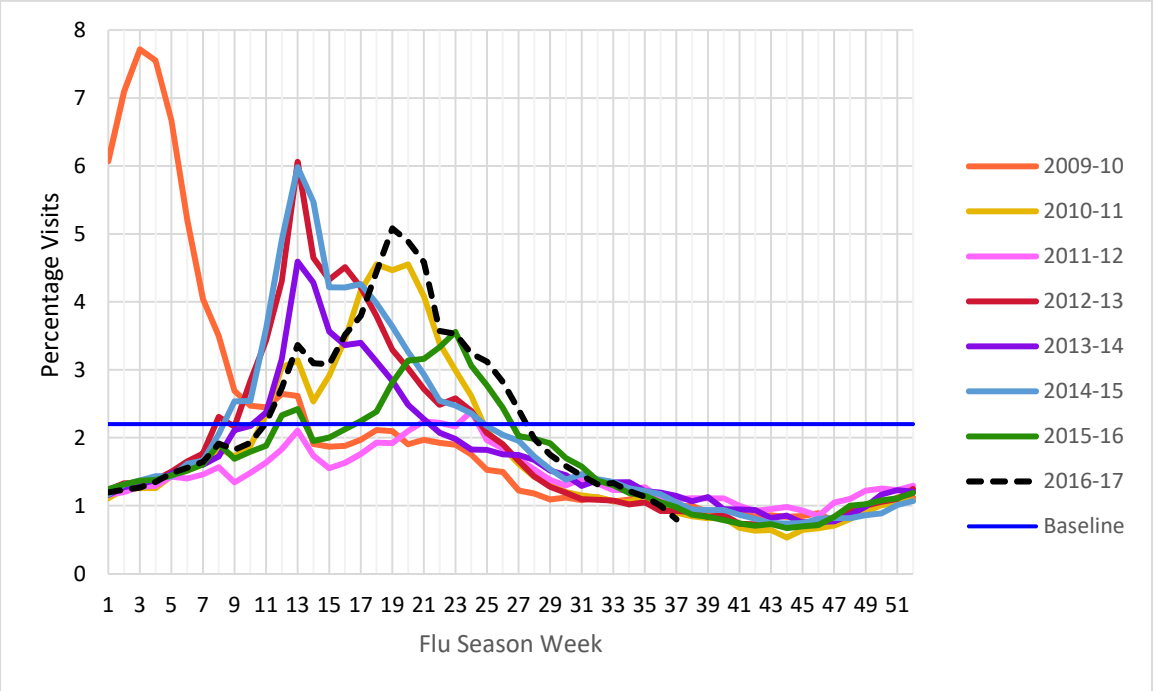
Information on patient visits to health care providers for influenza-like illness (ILI)[2] is collected through the U.S. Outpatient Influenza-like Illness Surveillance Network (ILINet). ILINet consists of more than 2,800 enrolled outpatient healthcare providers in all 50 states, Puerto Rico, the District of Columbia and the U.S. Virgin Islands, reporting more than 36 million patient visits each year. Each week, approximately 2,000 outpatient healthcare providers around the country report data to CDC on the total number of patients seen for any reason, and the number of those patients with ILI. Patient visits for ILI, likely but unconfirmed cases of influenza, are monitored as a proxy for influenza levels.

[2] Influenza-like illness is defined by the CDC as fever (temperature of 100°F or greater) and a cough and/or a sore throat without a known cause other than influenza.

Figure 3 shows the percentage of ILI visits from the 2016-2017 and prior seasons. The timing of ILI activity, but not the relative magnitude of it to other seasons, is similar to the level of positive test specimens in Figure 1. Generally based on the level of ILI visits, the 2016-2017 season was medium to high, with peak activity in February at 5.1% (flu season week 19). It was lower than 2012-2013 and 2014-2015 seasons (which traced nearly identical paths) and higher than the relatively mild 2011-2012 season. The 2016-2017 season was above the 2.2% baseline[3] of elevated activity for 17 consecutive weeks. This is slightly longer than, but similar to, the 2010-2011, 2012-2013 and 2014-2015 seasons.

Figure 3

OUTPATIENT INFLUENZA-LIKE ILLNESS VISITS



[3] The baseline is a measure designed by the CDC to identify significant levels of influenza activity. It is developed by calculating the mean percentage of patient visits for ILI during non-influenza weeks for the previous three seasons and adding two standard deviations. A non-influenza week is defined as periods of two or more consecutive weeks in which each week accounted for less than 2% of the season's total number of specimens that tested positive for influenza in public health laboratories.

3.3 Hospitalizations

Laboratory confirmed influenza-associated hospitalizations in children and adults are monitored through the Influenza Hospitalization Surveillance Network (FluSurv-NET). This network conducts surveillance for population-based, laboratory-confirmed influenza-related hospitalizations in children (persons less than 18 years) and adults. The network covers over 70 counties in the ten Emerging Infections Program (EIP) states (CA, CO, CT, GA, MD, MN, NM, NY, OR, and TN) and three additional states (MI, OH, and UT). Cases are identified by reviewing hospital laboratory and admission databases and infection control logs for patients hospitalized during the influenza season with a documented positive influenza test (i.e., viral culture, direct/indirect fluorescent antibody assay (DFA/IFA), rapid influenza diagnostic test (RIDT), or molecular assays including reverse transcription-polymerase chain reaction (RT-PCR)). The rates provided are likely to be underreported either because testing for influenza was not performed or because cases may be attributed to other causes of pneumonia or other common influenza-related complications.

Figures 4 and 5 show weekly and cumulative hospitalization rates respectively for the 2016-2017 and prior seasons. The 2016-2017 season was unusual relative to reported rates from prior seasons because it had a longer period of its highest levels than other seasons. Even though the peak levels were lower than 2014-2015, the longer period of elevated levels produced cumulative seasonal hospitalizations, 64.9 per 100,000, nearly the same amount as 2014-2015. Those cumulative hospitalization rates were the highest of all prior seasons in this study, including the pandemic 2009-2010 season. The lowest cumulative seasonal rate, 8.7 per 100,000 occurring in 2011-2012, was consistent with the low ILI levels of 2011-2012.

Figure 4

INFLUENZA HOSPITALIZATIONS

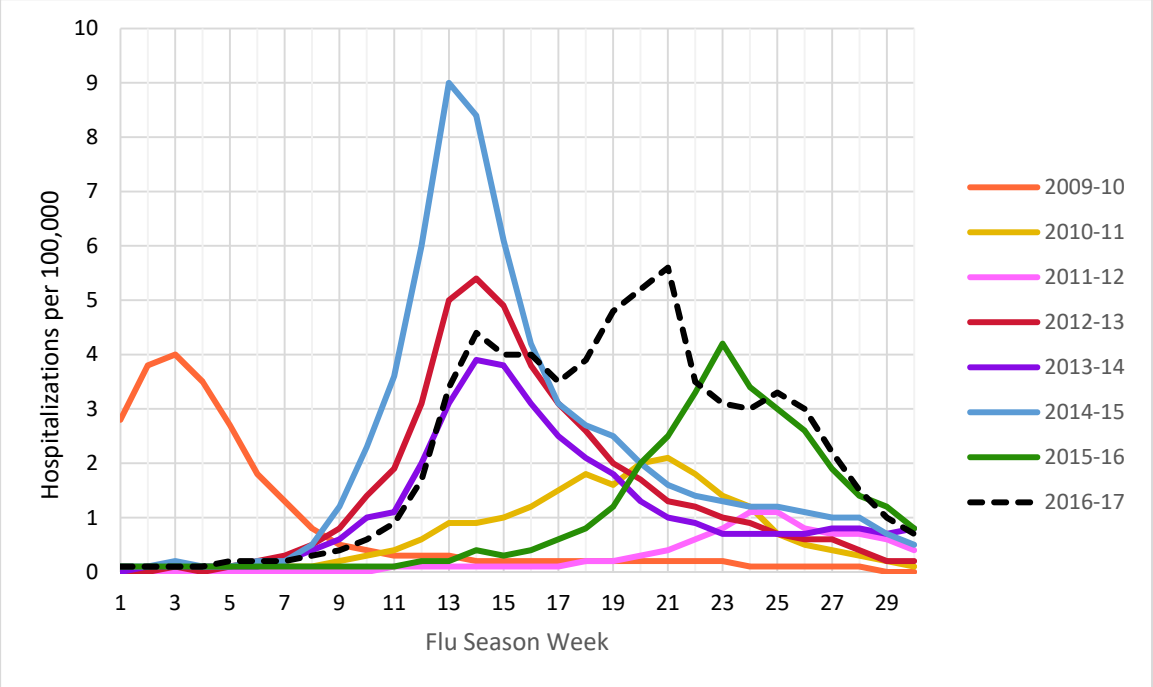
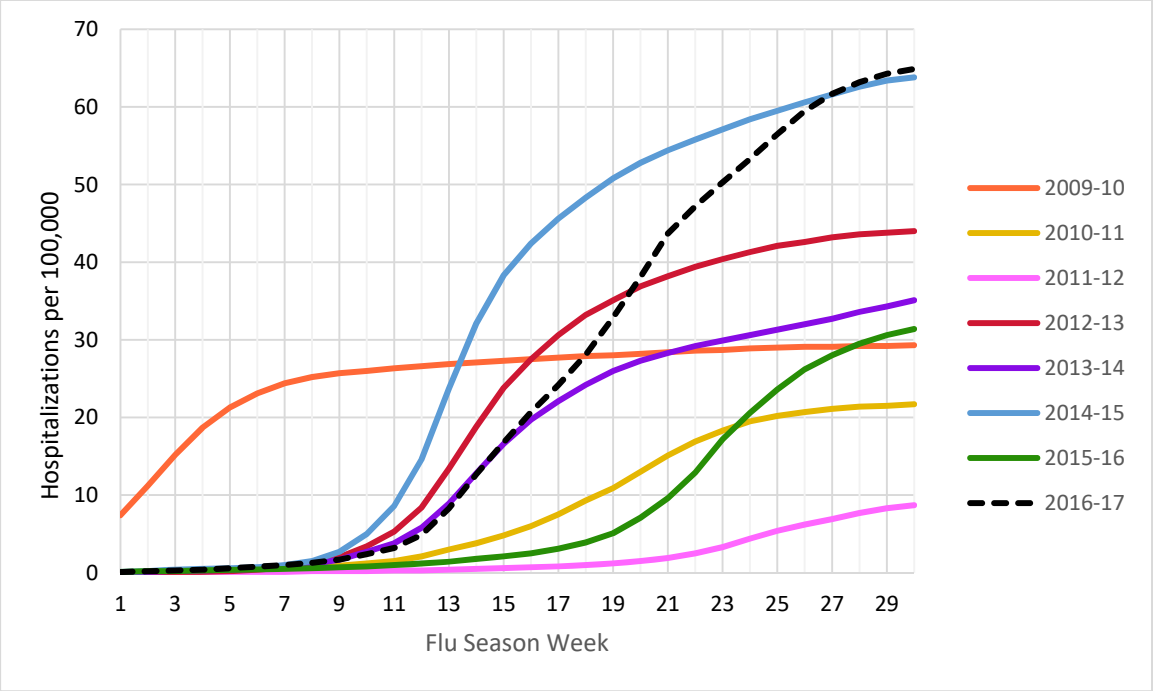


Figure 5

CUMULATIVE INFLUENZA HOSPITALIZATIONS



3.4 Pneumonia and Influenza Mortality

The NCHS collects death certificate data from state vital statistics offices for all deaths occurring in the United States. P&I deaths are identified based on international classification of diseases (ICD-10) multiple cause of death codes. The percentage of P&I deaths to all deaths is used as an indicator of the level of influenza activity relative to the seasonal baseline (normal seasonal percentage of P&I deaths varying by week) and epidemic level[4].

[4] The seasonal baseline of P&I deaths is calculated using a periodic regression model that incorporates a robust regression procedure applied to data from the previous five years. An increase of 1.645 standard deviations above the seasonal baseline of P&I deaths is considered the "epidemic threshold," i.e., the point at which the observed proportion of deaths attributed to pneumonia or influenza was significantly higher than would be expected at that time of the year in the absence of substantial influenza-related mortality.

Figure 6 shows that all seasons in this report produce a peak level of P&I mortality as a percentage of all deaths above the epidemic threshold, except for the 2011-2012 season. The length of the 2016-2017 season above the epidemic threshold, at 13 weeks, was less than the same season ILI indicator. However, given a tendency for reported hospitalizations to track with mortality in earlier seasons, the 2016-2017 P&I mortality percentages may be understated because, while 2016-2017 hospitalizations were high, corresponding mortality was low. This may be explained by a change in the CDC's mortality reporting source, switching from using reported P&I deaths from a 122 city sample to reports from the states and territories.

Figure 6

PROPORTION OF PNEUMONIA AND INFLUENZA DEATHS

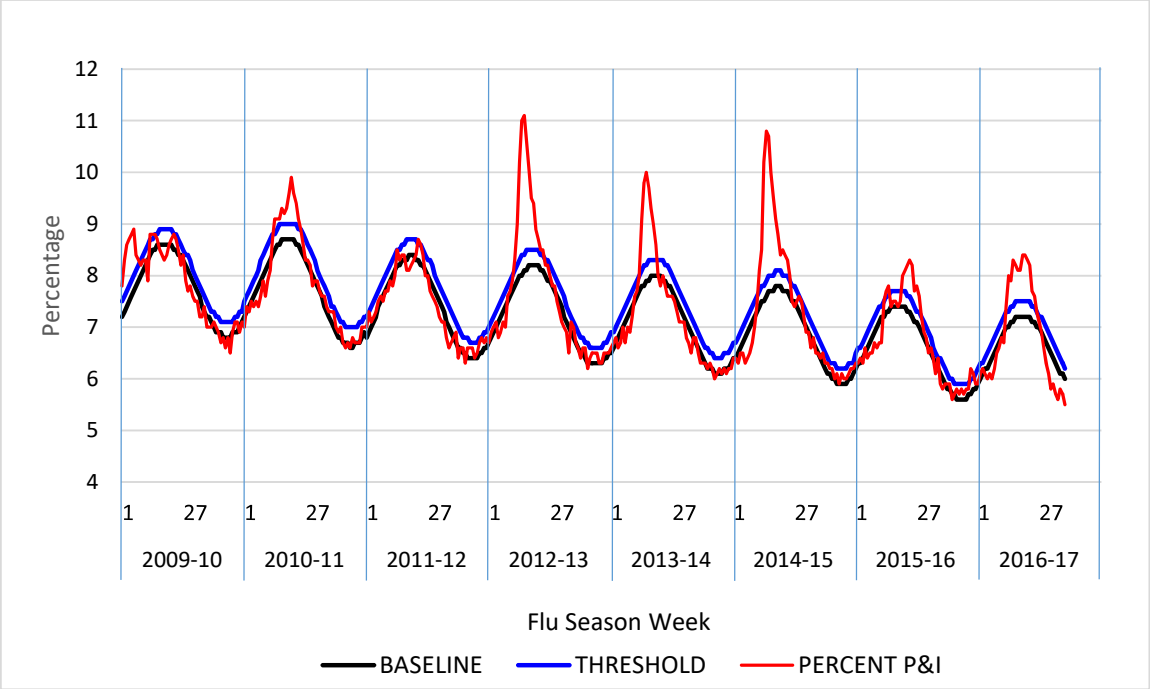
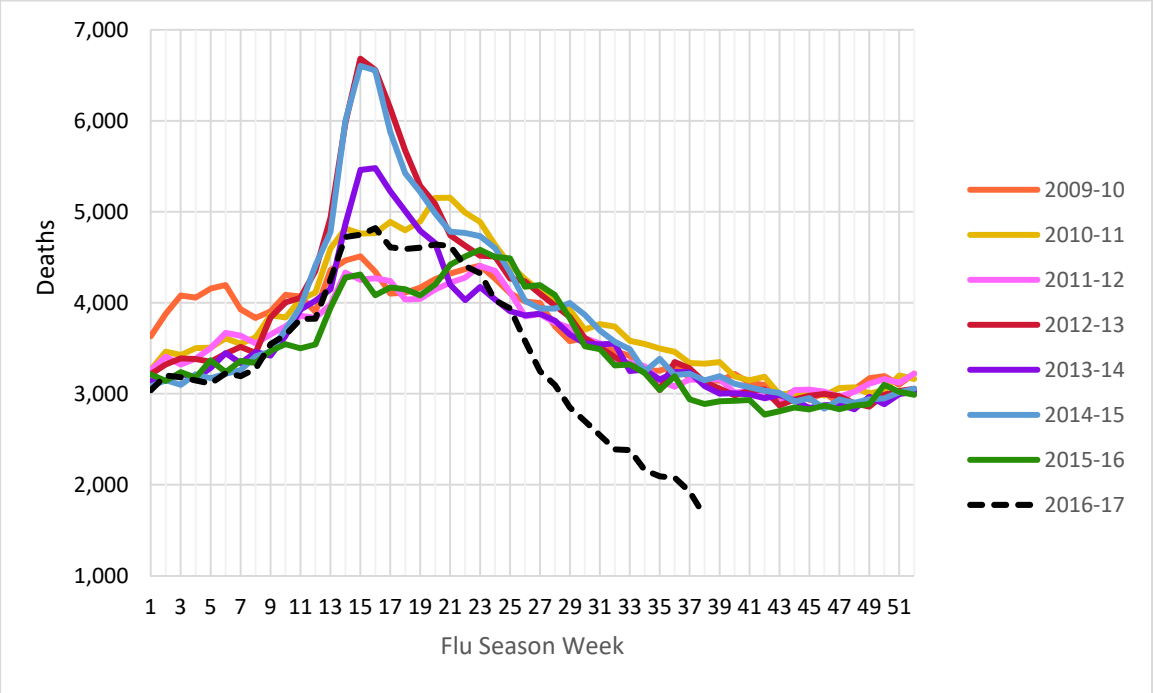


Figure 7 shows the reported P&I deaths that are used to derive the percentages shown in Figure 6. At week 27 of the current season, 96% of the 2016-2017 data is reported and the deaths look unexplainably low. The low level of 2016-2017 deaths provides additional support that the change in reporting sources may affect the comparability of the P&I mortality indicator across seasons.

Figure 7

PNEUMONIA AND INFLUENZA DEATHS



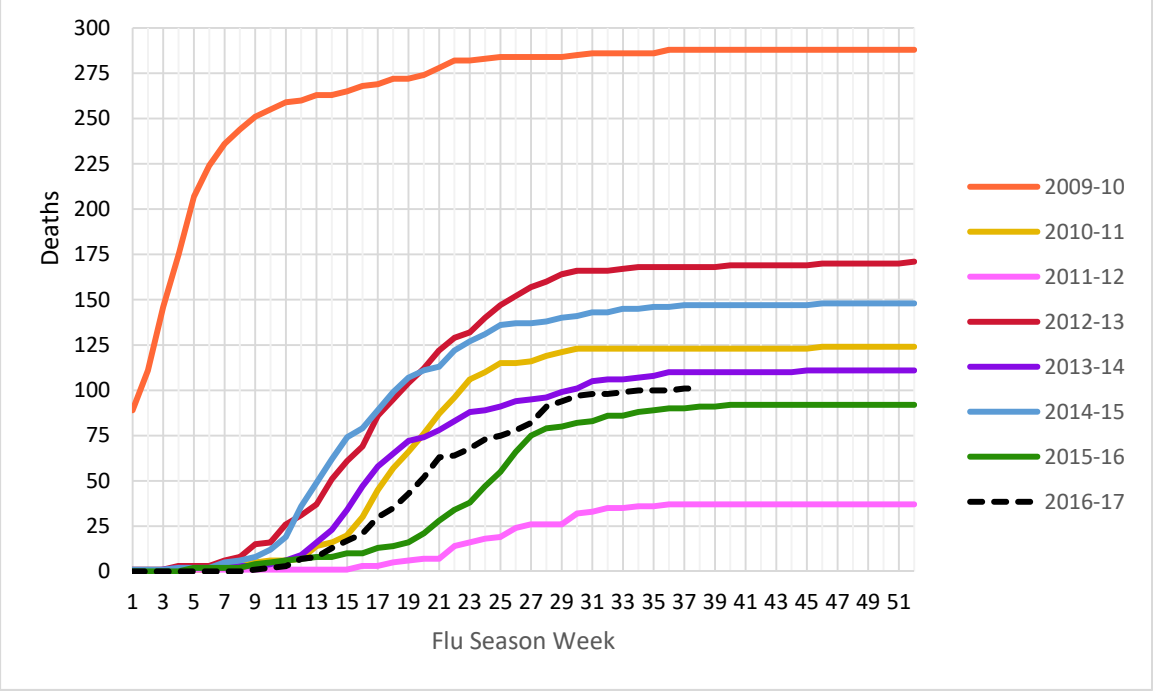
3.5 Pediatric Mortality

Beginning in 2004, influenza-associated deaths in children (persons less than 18 years) were added as a nationally notifiable condition. Any laboratory-confirmed influenza-associated death in a child is reported through the Influenza-Associated Pediatric Mortality Surveillance System. Demographic and clinical information are collected on each case and are transmitted to the CDC. Because of this, reported data is comparable across the seasons covered in this report. However, the CDC estimates that these totals are underreported by a factor of two to three due to some children not being tested for influenza and others being treated later when the flu virus was not detectable from respiratory samples [15].

Figure 8 shows pediatric mortality for 2016-2017 and prior seasons. The most recent count of cumulative 2016-2017 reported deaths is 101, which places the current season near the middle of other seasons (high in 2012-2013 of 171; low in 2011-2012 of 37), with the exception of the 2009-2010 pandemic season, 288 deaths.

Figure 8

PEDIATRIC INFLUENZA DEATHS



Section 4: Prior Seasons' Morbidity and Mortality

Table 1 is an abridged version of CDC estimates of recent seasons' influenza morbidity and mortality [15]. The complete table, including the confidence intervals, is shown in Appendix A. There are no directly comparable estimates currently available for the 2016-2017 season.

Although death certificate reporting makes provision for influenza as a cause of death, the exact number of deaths due to seasonal influenza of the entire population is not known. As stated by the CDC, this is due to a number of reasons[5] [16]. Because of this, the CDC estimates influenza-associated mortality with statistical models [17]. As shown in Table 1 , the most recent CDC estimate of seasonal influenza deaths covering the seasons from 2010-2011 through 2013-2014 ranges from a low of 12,000 in the 2011-2012 season to a high of 56,000 in the 2012-2013 season. Corresponding estimates of 2014-2015 and 2015-2016 mortality are not included because of a three-year data lag of reported respiratory and circulatory deaths.

There is wide variability of the burden of seasonal influenza. Generally, the impact of an influenza season can vary by the severity of the virus strains, age groups most affected, effectiveness of the vaccine and vaccination rates. While the 2011-2012 season has the lowest estimated influenza deaths of the seasons covered in this study, there is no season which is highest in all morbidity and mortality categories. The two highest recent seasons, 2012-2013 and 2014-2015, both had H3N2 as the dominant type A strain. This is relevant because the antigenic properties of the A(H3N2) virus make it more likely to drift (minor change in the virus structure) than A(H1N1) or type B viruses [18]. A drift in the virus, which can occur during egg-based vaccine production or while the virus is circulating, increases the likelihood of the population's vulnerability to it (decreased vaccine effectiveness and/or lower antibody match gained from prior influenza exposure to strains of A(H3N2)). The 2016-2017 season type A was dominated by H3N2.

[5] Per the CDC, "First, states are not required to report individual seasonal flu cases or deaths of people older than 18 years of age to CDC. Second, seasonal influenza is infrequently listed on death certificates of people who die from flu-related complications (https://www.cdc.gov/flu/about/disease/complications.htm#complications). Third, many seasonal flu-related deaths occur one or two weeks after a person's initial infection, either because the person may develop a secondary bacterial co-infection (such as bacterial pneumonia) or because seasonal influenza can aggravate an existing chronic illness (such as congestive heart failure or chronic obstructive pulmonary disease). Also, most people who die from seasonal flu-related complications are not tested for flu, or they seek medical care later in their illness when seasonal influenza can no longer be detected from respiratory samples. Sensitive influenza tests are only likely to detect influenza if performed within a week after onset of illness. In addition, some commonly used tests to diagnose influenza in clinical settings are not highly sensitive and can provide false negative results (i.e. they misdiagnose flu illness as not being flu.) For these reasons, many flu-related deaths may not be recorded on death certificates."

Table 1

CDC ESTIMATED SEASONAL INFLUENZA MORBIDITY AND MORTALITY

Season	Estimated Illnesses	Estimated Medical Visits	Estimated Hospitalizations		Estimated Excess Deaths	
					Pneumonia & Influenza Deaths*	Respiratory & Circulatory Deaths**
	No.	No.	Hosp. Rate‡ (per 100,000)	No.	No.	No.
2010-2011	21,096,749	9,956,056	91.2	281,589	13,541	39,008
2011-2012	9,231,004	4,298,616	44.8	139,497	4,154	12,182
2012-2013	35,590,424	16,638,347	188.8	592,688	19,962	56,102
2013-2014	28,445,377	12,613,671	101.9	322,123	13,590	31,864
2014-2015	34,292,299	16,184,354	221.8	707,155	19,490	–
2015-2016	24,577,163	11,092,867	95.9	308,232	11,995	–

* P&I deaths are a subset of the total deaths associated with influenza that occur each year, which may be two to four times higher when deaths due to other complications are also considered.

** R&C deaths include P&I deaths. These include deaths with an underlying cause of death other than P&I where influenza was deemed to have been a material contributing cause of death. R&C data is available on a lagged basis.

‡ The CDC estimated hospitalization rate differs from corresponding surveillance data to account for CDC estimates of underreporting of hospitalization rates.

Section 5: Vaccine Coverage and Effectiveness

The CDC tracks vaccination rates throughout the season and makes estimates of the vaccine's effectiveness to estimate averted influenza outcomes. These estimates are shown in Appendix B. The averted outcomes are generally a result of the combination of coverage (vaccination rate) and vaccine effectiveness. While the CDC has a goal of 70% vaccine coverage, the rate varies significantly by age group. Generally the youngest (6 months – 4 years) and oldest (65 years and over) age groups have the highest vaccination rates. The vaccination rates are 70% for the youngest age group and 63-66% for the oldest age group. Vaccine effectiveness varies by season, by strain and by age group. Table 2 shows CDC estimated vaccine coverage and effectiveness for the 2014-2015 and 2015-2016 seasons as samples of this variability. Notably, the effectiveness of the vaccine for A(H3N2) was only 10-12% in 2014-2015. The CDC did not break out effectiveness by type A and B for the 2015-2016 season. Late season estimates of vaccine effectiveness for 2016-2017 were estimated to be 34% (95 CI = 24-42%) against illness caused by the influenza A(H3N2) virus and 56% (95 CI = 47-64%) against the influenza B virus. On a combined basis, there was an estimated overall 42% effectiveness of the vaccine (95% CI = 35-48%).

Table 2

VACCINE COVERAGE AND EFFECTIVENESS FOR 2014-2015 AND 2015-2016

	2014-2015			2015-2016		
Age Group	Vaccine Coverage	Vaccine Effectiveness	Vaccine Effectiveness (95% CI)	Vaccine Coverage	Vaccine Effectiveness	Vaccine Effectiveness (95% CI)
6 months – 4 years	70%	10%, A(H3N2); 51%, B/Yamagata	0–20%, A(H3N2); 37–62%, B/Yamagata	70%	57%	33-72%
5–17 years	56%	10%, A(H3N2) 51%, B/Yamagata	0–20%, A(H3N2) 37–62%, B/Yamagata	56%	51%	33-64%
18–49 years	33%	10%, A(H3N2) 51%, B/Yamagata	0–20%, A(H3N2) 37–62%, B/Yamagata	32%	49%	35-60%
50-64 years	47%	10%, A(H3N2) 51%, B/Yamagata	0–20%, A(H3N2) 37–62%, B/Yamagata	43%	24%	-1-43%
≥65 years	66%	12%, A(H3N2) 74%, B/Yamagata	0–40%, A(H3N2) 45–87%, B/Yamagata	63%	41%	4-64%

Table 3 is an estimate of the implied overall reduction of the influenza burden from the combination of vaccine coverage and its effectiveness for those vaccinated. Because the CDC uses estimates of those factors to derive its estimated averted outcomes, the average reduction of the burden can be estimated from the data in Appendix A (Seasonal Influenza Burden) and Appendix B (Averted Influenza Outcomes). The average reduction of the burden is the number of averted outcomes divided by the sum of the averted outcomes plus the number of afflictions (burden of influenza) for a given morbidity or mortality measure. The reduction of influenza was lowest in the years dominated by A(H3N2), 2012-2013 and 2014-2015. Per Table 2, the vaccine effectiveness against A(H3N2) in 2014-2015 was about 10%. That is why the overall reduction in Table 3 for that season is so low. In the other seasons where A(H1N1) was more prevalent than A(H3N2), the reductions were larger, ranging from a 17% reduction of illnesses in 2015-2016 to a 23% reduction of excess deaths in 2011-2012.

Table 3

ESTIMATED REDUCTION OF INFLUENZA FROM VACCINATION COVERAGE AND EFFECTIVENESS

Season	Illnesses	Medical Visits	Hospitalizations	Excess P&I Deaths	Excess R&C Deaths
2010-2011	19%	20%	20%	20%	20%
2011-2012	18%	18%	22%	23%	23%
2012-2013	14%	14%	9%	8%	9%
2013-2014	19%	20%	21%	22%	22%
2014-2015	4%	5%	6%	7%	*
2015-2016	17%	18%	19%	19%	*

* Data not available for these years.

References

[1] Seasonal Influenza, More Information. https://www.cdc.gov/flu/about/disease/2015-16.htm

[2] "Impact of Poultry and Egg Production Losses and Poultry Processing Losses Due to the Avian Influenza" University of Minnesota. https://www.extension.umn.edu/community/economic-impact-analysis/reports/docs/2015-impact-of-poultry-production-losses-due-to-avian-infuenza.pdf

[3] Transmission of Influenza Viruses from Animals to People. https://www.cdc.gov/flu/about/viruses/transmission.htm

[4] Types of Influenza Viruses. https://www.cdc.gov/flu/about/viruses/types.htm

[5] Bulletin of the World Health Organization, 58(4):585-591 (1980). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2395936/pdf/bullwho00427-0070.pdf

[6] Frequently Asked Flu Questions 2017-2018 Influenza Season. https://www.cdc.gov/flu/about/season/flu-season-2017-2018.htm

[7] "Differences in Influenza A and B" Dr. Tina M. St. John. Nov 2, 2015. http://www.livestrong.com/article/90814-differences-influenza-b/

[8] Types of Flu. Physicians' Alliance of America. https://www.physall.com/types-of-flu

[9] "Comparing Clinical Characteristics Between Hospitalized Adults With Laboratory-Confirmed Influenza A and B Virus Infection", Su Su et al. https://academic.oup.com/cid/article-lookup/doi/10.1093/cid/ciu269

[10] Chi CY, Wang SM, Lin CC, et al. Clinical features of children infected with different strains of influenza B in southern Taiwan. Pediatr Infect Dis J 2008; 27:640–5. https://www.ncbi.nlm.nih.gov/pubmed/18520968

[11] Irving SA, Patel DC, Kieke BA, et al. Comparison of clinical features and outcomes of medically attended influenza A and influenza B in a defined population over four seasons: 2004–2005 through 2007–2008. Influenza Other Respir Viruses 2012; 6:37–43. https://www.ncbi.nlm.nih.gov/pubmed/21668663

[12] Weekly U.S. Influenza Surveillance Report. https://www.cdc.gov/flu/weekly/index.htm

[13] Overview of Influenza Surveillance in the United States. https://www.cdc.gov/flu/weekly/overview.htm

[14] Blanton L, Alabi N, Mustaquim D, et al. Update: Influenza Activity in the United States During the 2016–17 Season and Composition of the 2017–18 Influenza Vaccine. MMWR Morb Mortal Wkly Rep 2017;66:668–676. DOI: http://dx.doi.org/10.15585/mmwr.mm6625a3

[15] Rolfes MA, Foppa IM, Garg S, Flannery B, Brammer L, Singleton JA, et al. Estimated Influenza Illnesses, Medical Visits, Hospitalizations, and Deaths Averted by Vaccination in the United States. 2016 Dec 9 [2017 July 25]; https://www.cdc.gov/flu/about/disease/2015-16.htm

[16] Estimating Seasonal Influenza-Associated Deaths in the United States. https://www.cdc.gov/flu/about/disease/us_flu-related_deaths.htm

[17] Foppa IM, Cheng PY, Reynolds SB, Shay DK, Carias C, Bresee JS, et al. Deaths averted by influenza vaccination in the U.S. during the seasons 2005/06 through 2013/14. Vaccine. 2015 Jun 12;33(26):3003-9. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4834450/

[18] Vaccine Effectiveness - How Well Does the Flu Vaccine Work? https://www.cdc.gov/flu/about/qa/vaccineeffect.htm

Appendix A—Seasonal Influenza Burden

Season	Estimated Illnesses		Estimated Medical Visits		Estimated Hospitalizations			Estimated Excess Deaths Pneumonia & Influenza Deaths*		Estimated Excess Deaths Respiratory & Circulatory Deaths†	
	No.	95% CI	No.	95% CI	Hosp. rate (per 100,000)	No.	95% CI	No.	95% Cr I§	No.	95% Cr I¶
2010-2011	21,096,749	17,582,319-27,698,870	9,956,056	8,187,913-13,224,822	91.2	281,589	239,013-373,931	13,541	12,111-15,372	39,008	34,283-44,986
2011-2012	9,231,004	7,281,179-13,835,345	4,298,616	3,392,861-6,450,996	44.8	139,497	115,865-206,066	4,154	3,691-4,747	12,182	10,638-14,346
2012-2013	35,590,424	30,113,616-44,250,092	16,638,347	13,979,214-20,765,551	188.8	592,688	509,813-733,307	19,962	18,006-22,434	56,102	50,252-63,709
2013-2014	28,445,377	24,968,054-33,040,119	12,613,671	10,942,829-14,817,158	101.9	322,123	283,230-376,646	13,590	12,252-15,307	31,864	27,832-37,234
2014-2015	34,292,299	30,332,937-40,051,029	16,184,354	14,105,043-19,181,789	221.8	707,155	624,149-838,516	19,490	17,718-21,740	–	–
Approximate Five Season Range (No.)	9,200,000-35,600,000		4,300,000-16,700,000		140,000-710,000			4,000-20,000		12,000-56,000**	
2015-2016	24,577,163	21,504,826-28,626,313	11,092,867	9,566,867-13,137,840	95.9	308,232	271,143-362,029	11,995	10,634-13,914	–	–

*Only data on pneumonia & influenza deaths are available in real-time during an influenza season; however, they are only a subset of the total deaths associated with influenza that occur each year, which may be 2 to 4 times higher when deaths due to other complications are also considered.

†Data on respiratory & circulatory deaths are available with a three-year lag; therefore, estimates on averted respiratory & circulatory deaths are available for the 2010-2011 through 2013-2014 influenza seasons but not for the 2014-2015 or 2015-2016 seasons.

§A 95% credible interval (95% Cr I) is provided because of the Monte Carlo approach used to estimate excess pneumonia & influenza deaths.

Appendix B – Averted Seasonal Influenza Outcomes

Season	Averted Illnesses		Averted Medical Visits		Averted Hospitalizations				Averted Deaths Pneumonia & Influenza Deaths*		Averted Deaths Respiratory & Circulatory Deaths†	
	No.	95% CI	No.	95% CI	No.	95% CI	Fraction prevented (%)	95% CI	No.	95% CI	No.	95% CI
2010-2011	5,039,277	3,435,322-7,716,921	2,514,353	1,702,599-3,885,779	70,821	33,965-141,708	20.8	13.1-30.3	3,434	1,422-6,906	9,880	3,883-19,362
2011-2012	1,981,571	1,160,279-3,666,130	968,312	555,687-1,809,753	39,301	17,610-88,885	22.7	13.0-34.0	1,227	505-2,450	3,618	1,400-6,909
2012-2013	5,628,332	4,235,767-8,327,082	2,701,875	1,997,056-4,085,452	61,522	31,580-162,836	11.1	6.25-19.6	1,823	724-5,517	5,280	2,149-15,029
2013-2014	6,683,929	5,037,991-8,898,309	3,080,284	2,252,594-4,190,948	86,730	56,447-129,736	21.5	17.2-26.1	3,840	2,298-5,844	9,172	5,267-14,465
2014-2015	1,606,813	609,744-3,456,741	792,958	296,449-1,744,001	47,449	10,795-144,291	7.5	2.09-15.9	1,419	312-4,255	–	–
2015-2016	5,083,498	3,538,000-7,081,344	2,504,323	1,725,971-3,532,835	71,479	42,344-112,228	18.9	14.3-24.2	2,882	1,588-4,562	–	–

*Only data on pneumonia & influenza deaths are available in real-time during an influenza season; however, these are only a subset of the total deaths associated with influenza that occur each year, which may be 2 to 4 times higher when other complications are also considered.

†Data on respiratory & circulatory deaths are available with a three-year lag; therefore, estimates on averted respiratory & circulatory deaths are only available through 2013-2014 influenza season at this time.

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