

MILLIMAN RESEARCH REPORT

Effect of Influenza Vaccination on Health Care Utilization and Costs among Commercially Insured Individuals

For the 2016-17 and 2017-18 Influenza Seasons

February 2021

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Commissioned by Aetna, Inc.

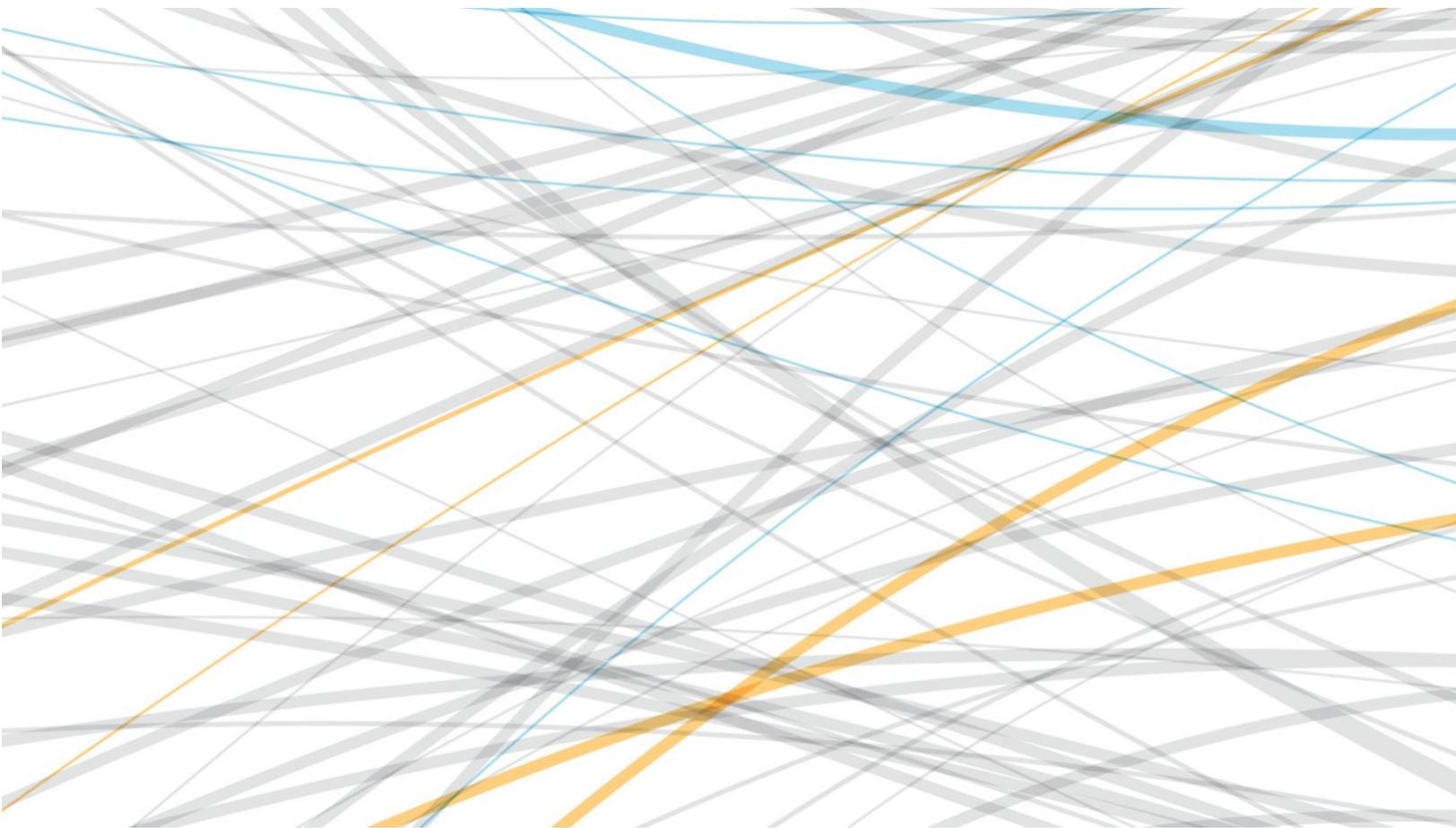




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Executive Summary

The Centers for Disease Control and Prevention (CDC) recommends annual vaccination against influenza for the United States (U.S.) general population starting at six months of age; yet, fewer than one in two individuals receive the vaccine each year.^{1,2,3} Not meeting the CDC's recommendations can be financially burdensome, especially when considering costly inpatient hospitalizations that might be avoided by receiving the vaccine.

We conducted a claims-based retrospective matched case-control study to evaluate health care utilization and costs for more than 16 million continuously enrolled members with commercial health insurance over two influenza seasons to better understand differences associated with vaccination against influenza.

Our findings demonstrated a decrease in influenza hospitalizations of 15% (0.22 versus 0.26 per 1,000) and 19% (0.40 versus 0.49 per 1,000) for vaccinated individuals during the 2016-17 and 2017-18 influenza seasons (August through September), respectively, compared to unvaccinated matched controls. For influenza-like illness, the reductions were 4% (4.43 versus 4.63 per 1,000) and 13% (5.09 versus 5.83 per 1,000), respectively.

Costs expressed as per member per season (PMPY) dollars allowed (contracted) by health plans for commercial enrollees for influenza-associated hospital inpatient, emergency department, and outpatient utilization were \$20 (2016-17: \$31 versus \$11 and 2017-18: \$43 versus \$23) higher for vaccinated than unvaccinated members for both seasons studied. For influenza-like illness-associated utilization, differences were -\$15 (\$237 versus \$222) for 2016-17 and \$23 (\$280 versus \$303) for 2017-18. These amounts accounted for 0.52% and 0.64% of total allowed PMPY, and 6.9% and 8.0% of influenza-like illness allowed PMPY, respectively. Figure 1 below summarizes differences in influenza-like illness health care utilization and cost savings for vaccinated individuals overall and stratified by risk.

FIGURE 1: PERCENT REDUCTION IN INFLUENZA-LIKE ILLNESS* UTILIZATION AND SAVINGS IN ALLOWED COSTS FOR VACCINATED INDIVIDUALS OVERALL AND AT HIGH-RISK FOR INFLUENZA-RELATED COMPLICATIONS BY UTILIZATION CATEGORY AND SEASON**

MEASURE	CATEGORY	2016-17		2017-18	
		OVERALL	HIGH-RISK FOR INFLUENZA-RELATED COMPLICATIONS	OVERALL	HIGH-RISK FOR INFLUENZA-RELATED COMPLICATIONS
PERCENT REDUCTION IN UTILIZATION	Office Visits	-20.5%	-25.3%	-14.1%	-8.8%
	Emergency Department (ED) Visits	9.1%	1.7%	15.5%	14.1%
	Hospitalizations	4.3%	9.5%	12.7%	12.4%
	Without Intensive Care Unit (ICU)	2.2%	7.3%	9.9%	10.3%
	With ICU	11.5%	16.5%	20.6%	18.0%
SAVINGS IN ALLOWED COSTS PER MEMBER PER SEASON (PMPY)	Office Visits	-\$9.69	-\$17.44	-\$7.06	-\$6.95
	Outpatient Facility	\$0.76	\$2.61	\$2.72	\$7.42
	ED Visits	\$1.12	-\$0.06	\$2.87	\$5.21
	Hospitalizations without ICU	\$6.87	\$43.01	\$24.68	\$87.49
	Hospitalizations with ICU	\$7.44	\$38.58	\$25.45	\$73.21
ALLOWED COST OF INFLUENZA VACCINATION		\$21.79		\$25.23	
		Total	-\$15.30	\$23.43	\$141.15

Prescription drug costs were not included. Negative values indicate higher utilization and costs (instead of savings) among vaccinated members. Column entries may not sum to totals due to rounding.

* Influenza-like illness was defined by the diagnosis codes listed in the Methods section of the report. ** High-Risk was defined as age less than two or greater than 64 years at the start of the season, or the presence of at least two medical claims 30 days apart or more during the baseline period for asthma, blood disorders, neurologic and neurodevelopment conditions, chronic lung disease, endocrine disorders, heart disease, kidney disorders, liver disorders, metabolic disorders, obesity, weakened immune system, or nursing home / long-term care residence (see Methods section for definitions adapted from Charlson and Elixhauser indices).

¹ CDC. Prevention and Control of Seasonal Influenza with Vaccines, 2020-21. Retrieved November 18, 2020, from <https://www.cdc.gov/flu/professionals/acip/index.htm>.

² National Committee for Quality Assurance. Flu Vaccinations (FVA, FVO). Retrieved November 18, 2020, from <https://www.ncqa.org/hedis/measures/flu-vaccinations/>.

³ CDC. Results for General Population Influenza Vaccination Coverage. Retrieved November 18, 2020, from <https://www.cdc.gov/flu/fluview/interactive-general-population.htm>.

Cost savings were greater for vaccinated members at high-risk for influenza-related complications at \$45 (\$611 versus \$656) and \$141 (\$771 versus \$912) PMPY for the two seasons, which accounted for 0.54% and 1.34% of their total allowed PMPY, and 7.0% and 16% of their influenza-like illness allowed PMPY, respectively.

Differences in utilization, and therefore costs, are likely to vary from year to year due to influenza virulence, vaccine coverage, and vaccine match to circulating strains. Furthermore, the vaccination rate identified in the claims data used was lower than reported by the National Committee for Quality Assurance.³ Misclassification of vaccination status is possible when using administrative claims data in circumstances where vaccines are administered in various settings and may not be processed by an individual's health insurance plan.

Background

The Centers for Disease Control and Prevention (CDC) recommends annual vaccination against influenza for the United States (U.S.) general population starting at six months of age; yet, fewer than one in two individuals receive the vaccine each year.^{1,2,3} Not meeting the CDC's recommendations can be costly; estimates of the annual economic burden of infection due to influenza are in the billions of dollars for direct medical costs.⁴

Hospital inpatient health care utilization accounts for most of these costs. Research from the CDC estimated reductions in expected hospitalizations for influenza associated with vaccination against influenza during the 2017-18 influenza season to range from a high of 41% in children aged six months to four years to a low of seven percent in adults aged 18 to 49 years.⁵ Conversely, a Cochrane Review of vaccines preventing influenza in healthy adults continues to find that hospitalization rates are comparable between vaccinated and unvaccinated healthy adults with the caveat that the conclusion is based on under-powered studies for which the majority were conducted prior to CDC's 2010 expanded influenza vaccination recommendation.⁶

Understanding the costs of health care for influenza that may be affected by vaccination not only informs recommendations, such as CDC's, but also strategies that may be employed to achieve recommended vaccine coverage, or the proportion of individuals in a given population that receive a vaccine. Current estimates of per-person influenza and influenza-like illness costs are lacking for adults aged 18 to 64 years for whom vaccine coverage tends to be the lowest.^{2,3}

We sought to compare health care utilization and costs between commercially insured individuals vaccinated and not vaccinated against influenza. We employed a claims-based retrospective propensity score matched case-control methodology and measured the difference in health care utilization and average allowed costs to estimate savings.

Findings

STUDY POPULATION

The eligible study population was comprised of more than 16 million members continuously enrolled in commercial health insurance plans. Nearly one-quarter were less than 18 years of age for the two seasons, 2016-17 and 2017-18, studied (Figure 2). After matching three unvaccinated individuals to each vaccinated individual on propensity score, the study population was comprised of just over 14 million members.

Baseline characteristics including age, sex, region, select concomitant underlying health conditions, and health care utilization, were similarly distributed among vaccinated and matched unvaccinated members for each season. However, more individuals aged less than 18 years in 2016-17 and five years in 2017-18 and fewer individuals aged 18 to 64 years during both seasons received vaccination (see Appendix Figures 1A and 1B for additional detail). Individuals at high-risk for influenza-related complications represented approximately 16% of the study population in the first season and 19% in the second.

At least one occurrence of a diagnosis code for influenza was identified for 327,408 (2%) members of the study population in 2016-17 and 540,153 (4%) in 2017-18. For influenza-like illness, at least one occurrence of a diagnosis code was identified for 3,771,987 (27%) and 3,737,784 (27%) of members in each season, respectively. The percentage of individuals at high-risk for influenza-related complication(s) with an occurrence of a diagnosis code was similar of influenza across the two seasons (2% and 4%), but higher for influenza-like illness at 34% and 33%, respectively.

⁴ Putri W. C., et al. (2018). Economic Burden of Seasonal Influenza in the United States. *Vaccine*. Retrieved December 22, 2020, from https://simdos.unud.ac.id/uploads/file_penelitian_1_dir/a26d5aecc01813ec88cc6a28687636b1.pdf.

⁵ Rolfes M.A. et al. (February 2, 2019). Effects of Influenza Vaccination in the United States During the 2017–2018 Influenza Season. *CID*. Retrieved November 18, 2020, from <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7188082/pdf/ciz075.pdf>.

⁶ Demicheli V. et al. (2018). Vaccines for Preventing Influenza in Healthy Adults (Review). *Cochrane Database Sys Rev*. Retrieved November 18, 2020, from <https://www.cochranelibrary.com/cdsr/doi/10.1002/14651858.CD001269.pub6/epdf/full>.

FIGURE 2: FREQUENCY OF VACCINATION, AGE GROUPS, AND RISK FOR INFLUENZA-RELATED COMPLICATIONS GROUPS PRE- AND POST-MATCHING BY SEASON WITH COMPARISON TO U.S. GENERAL POPULATION

	2016-17		2017-18	
	ELIGIBLE STUDY POPULATION	MATCHED STUDY POPULATION	ELIGIBLE STUDY POPULATION	MATCHED STUDY POPULATION
Population	16,622,251	14,041,217	16,622,251	14,091,004
Vaccination Coverage	22.0%	25.0%	22.0%	25.0%
Age Group	0 to 4 years	4.0%	6.7%	2.8%
	5 to 17 years	19.2%	24.8%	18.7%
	18 to 64 years	73.7%	65.6%	74.9%
	65 years and older	3.1%	2.9%	3.6%
Risk for Influenza-related Complications	High	11.9%	16.2%	14.0%
	Low	88.1%	83.8%	86.0%

* See Methods section for definition. ** Average of 2016-17 and 2017-18 seasons.

UTILIZATION

Hospital inpatient utilization (per 1,000) for influenza was 15% (0.22 versus 0.26 per 1,000) and 19% (0.40 versus 0.49 per 1,000) lower among individuals vaccinated against influenza compared to those not vaccinated for the 2016-17 and 2017-18 seasons, respectively (Figure 3; Appendix Figures 2A and 2B). Reductions were consistently highest for ED followed by hospitalization with intensive care unit (ICU) utilization. Influenza-like illness utilization followed similar patterns; though the magnitudes were smaller, reductions were highest for hospitalizations with ICU, nearly doubling from the first to second season (Figure 1; Appendix Figures 2A and 2B). Office visits for influenza-like illness, on the other hand, were higher among those vaccinated in both seasons.

FIGURE 3: PERCENT REDUCTION IN INFLUENZA* UTILIZATION FOR VACCINATED INDIVIDUALS OVERALL AND AT HIGH-RISK FOR INFLUENZA-RELATED COMPLICATIONS* BY UTILIZATION CATEGORY AND SEASON

CATEGORY	2016-17		2017-18	
	OVERALL	HIGH-RISK FOR INFLUENZA-RELATED COMPLICATIONS	OVERALL	HIGH-RISK FOR INFLUENZA-RELATED COMPLICATIONS
Office Visits	10.9%	2.5%	7.6%	6.1%
Emergency Department Visits	36.2%	28.9%	32.2%	21.8%
Hospitalizations	14.9%	19.5%	19.1%	11.4%
Without Intensive Care Unit (ICU)	9.8%	11.4%	17.7%	9.8%
With ICU	32.5%	44.9%	23.3%	15.7%

* See Methods section for definition.

Findings were similar for influenza and influenza-like illness utilization among those at high-risk for influenza-related complications with two notable exceptions: for 2017-18, reductions in influenza hospitalization with ICU were higher than the year prior, and it was hospitalization with ICU, not ED, that had the highest reduction for influenza-like illness utilization compared to 2016-17 (Figures 1 and 3; Appendix Figures 2A and 2B).

COSTS

The average influenza vaccine allowed costs were \$21.79 for 2016-17 and \$25.23 for 2017-18. Influenza costs were \$20 (2016-17: \$31 versus \$11 and 2017-18: \$43 versus \$23) higher per vaccinated member per season (PMPY), which accounted for 0.67% and 0.55% of total allowed costs PMPY (Figure 4; Appendix Figures 2A and 2B; data not shown). These PMPY costs were nearly double and equal to the total influenza allowed costs PMPY for the two seasons studied, respectively (data not shown). The dollar amount of savings from reductions in influenza utilization was reasonably similar across major service categories for the first season, while reductions in hospital inpatient utilization comprised more than half of the savings during 2017-18. For influenza-like illness utilization, PMPY was \$15 higher (\$237 versus \$222) for 2016-17 and \$23 lower (\$280 versus \$303) for 2017-18, accounting for 0.52% and

FIGURE 4: SAVINGS IN INFLUENZA* ALLOWED COSTS FOR VACCINATED INDIVIDUALS OVERALL AND AT HIGH-RISK FOR INFLUENZA-RELATED COMPLICATIONS* BY UTILIZATION CATEGORY AND SEASON

CATEGORY	2016-17		2017-18	
	OVERALL	HIGH-RISK FOR INFLUENZA-RELATED COMPLICATIONS	OVERALL	HIGH-RISK FOR INFLUENZA-RELATED COMPLICATIONS
Office Visits	\$0.34	\$0.08	\$0.40	\$0.34
Outpatient Facility	\$0.20	\$0.22	\$0.62	\$1.39
Emergency Department Visits	\$0.50	\$0.56	\$0.84	\$0.67
Hospitalizations without ICU	\$0.43	\$0.48	\$2.23	\$5.03
Hospitalizations with ICU	\$0.61	\$2.73	\$1.26	\$4.49
Influenza Vaccination		\$21.79		\$25.23
Total	-\$19.72	-\$17.71	-\$19.89	-\$13.31

ICU = Intensive Care Unit. * See Methods section for definition. Vaccination and other prescription drug costs were not included. Column entries may not sum to totals due to rounding.

0.64% of total allowed costs PMPY and 7% and 8% of total influenza-like illness costs PMPY (Figure 1; Appendix Figures 2A and 2B; data not shown). Reductions in hospital inpatient utilization drove savings for both seasons.

Among those at high-risk for influenza-related complication(s), influenza vaccination was associated with influenza costs of \$18 (\$44 versus \$26) and \$13 (\$73 versus \$60) PMPY for 2016-17 and 2017-18, respectively, which accounted for 0.21% and 0.13% of total allowed costs PMPY, and 71% and 23% of total influenza allowed costs PMPY for these seasons (Figure 4; Appendix Figures 2A and 2B; data not shown). Reductions in influenza hospitalizations accounted for the majority of cost savings in both seasons. Influenza-like illness savings, driven by reductions in hospitalizations as well, were \$45 (\$611 versus \$656) PMPY, accounting for 0.54% of total allowed costs and 7.0% of influenza-like illness costs for 2016-17 (Figure 1; Appendix Figures 2A and 2B; data not shown). For 2017-18, savings were \$141 (\$771 versus \$912) PMPY, accounting for 1.34% of total allowed costs and 16% of influenza-like illness costs.

Costs of \$123 (\$3,062 versus \$2,939) and cost savings of \$67 (\$3,625 versus \$3,692) PMPY for the two seasons, respectively, were realized when no requirement for specific diagnoses to attribute utilization and costs was considered (Appendix Figures 2A and 2B). For pneumonia unrelated to influenza or influenza-like illness health care, costs of \$21 (\$26 versus \$5) and \$25 (\$30 versus \$5) PMPY were observed (Appendix Figures 2A and 2B).

Methods

We used administrative health care claims from Milliman Consolidated Research Databases (CHSD) and IBM® MarketScan® Research Databases for this retrospective cohort study to compare costs among those vaccinated and those not vaccinated against influenza for the 2016-17 and 2017-18 influenza seasons.

The CHSD database represents a sample of over 20 million individuals comprising several of Milliman's Health Cost Guidelines™ (HCG) data contributors and MarketScan® a sample of approximately 30 million individuals. Both data sources contain annual enrollment, and paid medical and pharmacy claims, for individuals covered by the benefit plans of large employers, health plans, and governmental and public organizations nationwide. The databases link paid claims and encounter data to detailed patient information across sites and types of providers. Member identification codes are consistent from year to year and allow for multiyear longitudinal studies. The databases contain diagnosis codes; procedure codes and diagnosis-related group codes; national drug codes; and site of service information and the amounts allowed and paid by commercial insurers.

The study population included commercially insured individuals that were continuously enrolled from September 1, 2015 through August 31, 2018. The study periods, or influenza seasons, ran from September 1st through August 31st of the following year. Vaccination against influenza was identified by the presence of a Current Procedural Terminology (CPT) code of 90630, 90653-8, 90660-4, 90666-8, 90672-3, 90685-9, G0008, G9141, G9142, and/or Q2033-8; or International Classification of Diseases, Tenth Revision, Procedure Coding System (ICS-10-PCS) code of 3E01340 and/or 3E02340; or prescription drug Generic Product Identifier (GPI) code that began with "17100020".

The baseline period encompassed 365 days prior to the start of each season, or September 1st through August 31st during which the following characteristics for the study population were measured:

- Age group (0 to 4, 5 to 17, 18 to 64, and 65 years and older) using age as of the start of the season (September 1st)
- Gender (female or male sex)
- U.S. Department of Health and Human Services (HHS) region⁷ based on enrollment data
- High-risk for influenza-related complications,⁸ as defined by age less than two or greater than 64 years at the start of the season, or at least one condition determined by the presence of at least two medical claims 30 days or more apart during the baseline period) of the following:
 - asthma: Clinical Classification Software⁹ (CCS) code 128
 - blood disorders: [coagulation deficiency, blood loss anemia, deficiency anemia]¹⁰
 - neurologic and neurodevelopment conditions: [rheumatoid arthritis / collagen vascular disease / rheumatic disease, paralysis, other neurological disorders]^{10,11}
 - chronic lung disease: [chronic pulmonary disease, pulmonary circulation disorders] + cystic fibrosis (ICD-10-Clinical Modification (CM) codes E84.11, E84.19, E84.8, E84.9, E84.0)
 - endocrine disorders: [diabetes]^{10,11}
 - heart disease: [myocardial infarction, congestive heart failure, valvular disease, cardiac arrhythmias]^{10,11}
 - kidney disorders: [renal failure / disease]^{10,11}
 - liver disorders: [mild / moderate or severe liver disease]^{10,11}
 - metabolic disorders: [hypothyroidism, weight loss, fluid and electrolyte disorders]¹⁰
 - obesity: [obesity]¹⁰
 - weakened immune system: [HIV and AIDS, lymphoma, metastatic cancer, solid tumor without metastasis, any malignancy]^{10,11}
 - [pregnancy: CCS⁹ codes 182-188, 190-196]
 - nursing home / long-term care residence: place of service of skilled nursing facility, nursing facility, or custodial care facility
- HHS silver plan risk score group
- Any health care utilization and total allowed costs
- Vaccination status
- Diagnosis of influenza

We estimated the likelihood for vaccination with a propensity score based on the baseline characteristics specified above with two exceptions: continuous variables for age and HHS silver plan risk score were used, and the conditions listed for high-risk for influenza-related complications were included as both individual and combined (presence of any) indicators. Three unvaccinated individuals were matched, with replacement, for every vaccinated individual on this score. The date of vaccination was used as the index date for those not vaccinated matched to ensure equivalent follow-up periods between the groups. We used standardized mean difference (SMD) and standardized difference (SD), calculated by dividing the difference in mean (or proportion for SD) effect by the pooled standard deviation (or proportion for SD) for which absolute values greater than 0.10 indicated statistically significant differences in

⁷ U.S. Department of Health & Human Services. Regional Offices. Retrieved November 18, 2020, from <https://www.hhs.gov/about/agencies/iea/regional-offices/index.html>.

⁸ CDC. People at High Risk for Flu Complications. Retrieved November 18, 2020, from <https://www.cdc.gov/flu/highrisk/index.htm>.

⁹ Agency for Healthcare Research Quality. Clinical Classifications Software Refined (CCSR). Retrieved November 19, 2020, from https://www.hcup-us.ahrq.gov/toolssoftware/ccsr/ccs_refined.jsp.

¹⁰ Table 1: ICD-9-CM and ICD-10 Coding Algorithms for Elixhauser Comorbidities. Retrieved November 18, 2020, from [http://mchp-appserv.cpe.umanitoba.ca/concept/Elixhauser Comorbidities - Coding Algorithms for ICD-9-CM and ICD-10.pdf](http://mchp-appserv.cpe.umanitoba.ca/concept/Elixhauser%20Comorbidities%20-%20Coding%20Algorithms%20for%20ICD-9-CM%20and%20ICD-10.pdf)

¹¹ Table 1. ICD-9-CM and ICD-10 Coding Algorithms for Charlson Comorbidities. Retrieved November 18, 2020, from [https://www.medschool.lsuhsu.edu/ortho/docs/Charlson Comorbidities - Coding Algorithms for ICD-9-CM and ICD-10.pdf](https://www.medschool.lsuhsu.edu/ortho/docs/Charlson%20Comorbidities%20-%20Coding%20Algorithms%20for%20ICD-9-CM%20and%20ICD-10.pdf).

continuous and categorical variables, respectively, to assess match quality between the vaccinated and unvaccinated groups.

The observation period during which specifically attributable health care utilization and costs for influenza, influenza-like illness, and pneumonia diagnoses as defined in Figure 5 were measured for the propensity-matched groups began two weeks after the index date and ended on August 31st for each season. Pneumonia unrelated to influenza or influenza-like illness served as a negative control of our assumption of association as differences should otherwise be unrelated to influenza vaccination in a predominantly young and healthy population. Individuals vaccinated within 15 days of the end of the season were excluded to allow for at least one day of follow-up. Individuals identified as pregnant during the study were also excluded. Utilization and allowed costs per member were calculated as the sum of utilization or allowed costs, respectively, during the observation period divided by the count of members for the following Milliman HCG-based categories that are defined using administrative codes:

- Office Visits, counted as visits to a physician's or other professional's office, visits to the insured's home or custodial facility, and visits to an urgent care center, excluding physical exams and pre- and post-surgical visits; costs include contracted amounts of the primary professional or the referral professional, as well as the costs of pulmonology, cardiovascular, diagnostic radiology, and laboratory services
- Outpatient Facility, measured for costs only and includes contracted amounts of diagnostic radiology, laboratory, cardiovascular, pulmonary, urgent care, observation, and other diagnostic services
- ED, measured as visits to the emergency area of a hospital outpatient facility for cases that do not result in an inpatient admission or observation case; costs include facility and professional contracted amounts associated with the visit
- Inpatient, non-ICU, counted as hospitalizations (admissions) without use of ICU; costs include all facility and professional contracted amounts associated with the stay
- Inpatient, ICU, counted as hospitalizations (admissions) with ICU use; costs include all facility and professional contracted amounts associated with the stay
- Vaccination, measured as the average cost for the CPTs listed previously for matched vaccinated individuals
- Total, measured for costs only, as a sum of Office Visits, Outpatient Facility, ED, Inpatient, non-ICU, inpatient, ICU, and vaccination costs

FIGURE 5: DEFINITIONS

CATEGORY	DEFINITION
Influenza	Any diagnosis of International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) J09, J10, J11
Influenza-like illness ¹²	Any diagnosis of ICD-10-CM J00, J01, J06.9, J09, J10, J11, J12.89, J12.9, J15.21, J18, J20.9, J40, B97.89, H66.9, R05, R50.9
Pneumonia, unrelated to influenza or influenza-like illness	Principal diagnosis of ICD-10-CM J13, J14, J12.0, J12.1, J12.3, J12.81, J15.0, J15.1, J15.29, J15.3, J15.4, J15.5, J15.6, J15.7, J15.8, J15.9, J16, J17

Differences in utilization and allowed costs PMPY between the vaccinated and unvaccinated groups were summarized overall and stratified by risk group for influenza-related complications.

Discussion

Findings from this retrospective, matched case-control claims-based study provide new evidence of reductions in influenza-related health care utilization attributable to vaccination against influenza. The study population was comprised of commercially insured, predominantly healthy adults at low-risk for influenza-related complications for whom up-to-date analyses are lacking. We found that the largest reductions associated with vaccination against influenza were for high acuity health care. Specifically, there were nearly 10% and 33% fewer influenza hospitalizations without and with ICU admission, respectively, in 2016-17, and 18% and 23% for 2017-18, respectively.

¹² Marsden-Haug N. et al. (February 2007). *Emerg Infect Dis*. Retrieved November 18, 2020, from <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2725845/>.

It is possible that the true burden of influenza infection is not fully ascertained when only influenza-specific diagnosis codes are used to identify related utilization, particularly if symptoms are non-specific, diagnostic testing is inconclusive or results are not available when the claim is coded, or coding practices vary by provider (or coder).¹² We therefore included the broader definition of influenza-like illness in order to capture situations in which administrative coding for a visit may not accurately reflect true illness. A slightly different pattern of differences between vaccinated and unvaccinated individuals emerged for influenza-like illness compared to influenza. The greater cost savings for influenza-like illness associated with influenza vaccination seemed to be driven most by different patterns in health care utilization: overall, rates for influenza-like illness office visits were 20 and 11 times; ED visits 12 and 7 times; and hospitalizations 19 and 12 times higher than for influenza during the two seasons, respectively. Notably, the only instance in which influenza or influenza-like illness utilization and costs were higher for vaccinated than unvaccinated individuals occurred for influenza-like illness office visits, which may be indicative of differences in the propensity for any healthcare use between the groups.

We observed consistently higher influenza-associated health care utilization and costs during the second season, and vaccination resulted in savings - driven by changes in hospital utilization - nearly twice as high as those during the first season. This is most likely explained by differences in seasonal severity as the CDC categorization of 2017-18 was more severe (due to higher illness burden, health care utilization, and mortality) than 2016-17.¹³ We did not observe increases of such magnitude for pneumonia unrelated to influenza or influenza-like illness, or any diagnoses, which further supports that the higher influenza-related utilization and costs observed in 2017-18 compared to the previous year cannot be entirely explained by secular utilization and cost trends.

Results from season to season depend not only on influenza virulence (severity) but also vaccine effectiveness, match to circulating strains, and coverage. While much remains to better understand and enhance for vaccine effectiveness and match, there is also opportunity to improve upon in vaccine coverage. The vaccination rate for our study population was lower than that of the U.S. general population and as self-reported by adults in Medicare and commercial plans; the former two differ from one of commercially insured individuals by age and risk for influenza-related complications, characteristics which are associated with propensity for vaccination (Figure 6).^{2,3} Nevertheless, with vaccine effectiveness of 40% and 38%, influenza's herd immunity threshold, the indirect protection from infectious disease that occurs when a large percentage of a population has become immune to an infection, whether through vaccination or previous infection(s), ranged from 42% to 71% and 44% to 75% for the two seasons studied.^{14,15} Among the comparisons presented in Figure 6, vaccine coverage surpassed the lower bound of the threshold range for the U.S. general population in 2016-17 only; thus, our findings for the less severe season of 2016-17 may best reflect the extent of savings that can be expected in similar scenarios, while those for 2017-18 may under-estimate the magnitude in a severe season where the herd immunity threshold is achieved. Furthermore, we found larger reductions in utilization and greater cost savings associated with vaccination in high-risk groups compared to those at low risk.

We found larger cost savings for members identified as at high-risk for influenza-related complications, a finding that aligns with studies that have demonstrated that the benefit of vaccination against influenza extends to other diagnoses. For example, influenza infection can lead to increased cardiovascular risk through the cascade of systemic infection and subsequent inflammation and may therefore trigger acute cardiovascular events.¹⁶ The development of new, or exacerbation of, symptoms of concomitant underlying health condition(s) during an illness resulting from infection of the influenza virus may result in sequela that require high(er) health care utilization for an

¹³ CDC. How CDC Classifies Flu Severity. Retrieved November 17, 2020, from <https://www.cdc.gov/flu/about/classifies-flu-severity.htm>.

¹⁴ CDC. Past Seasons Vaccine Effectiveness Estimates. Retrieved November 18, 2020, from <https://www.cdc.gov/flu/vaccines-work/past-seasons-estimates.html>.

¹⁵ Herd immunity threshold was calculated as $(1 - 1 / \text{basic reproduction number}) / \text{vaccine effectiveness}$ for a 1.2 lower and 1.4 upper bound of influenza's basic reproduction number [Biggerstaff, M. et al. (September 4, 2014). Estimates of the reproduction number for seasonal, pandemic, and zoonotic influenza: A systematic review of the literature. BMC Infect Dis. Retrieved November 17, 2020, from <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4169819/>.]

¹⁶ Clar C. et al. (2015). Influenza Vaccines for Preventing Cardiovascular Disease (Review). *Cochrane Database Sys Rev*. Retrieved November 18, 2020, from <https://www.cochranelibrary.com/cdsr/doi/10.1002/14651858.CD005050.pub3/epdf/full>.

FIGURE 6: VACCINE COVERAGE FOR STUDY POPULATION, NATIONAL COMMITTEE FOR QUALITY ASSURANCE (NCQA)², AND U.S. GENERAL POPULATION³ BY RISK FOR INFLUENZA-RELATED COMPLICATIONS*, AGE GROUP*, AND SEASON

RISK GROUP	AGE GROUP	2016-17			2017-18			U.S. GENERAL POPULATION	
		ELIGIBLE STUDY POPULATION	MATCHED STUDY POPULATION	NCQA	ELIGIBLE STUDY POPULATION	MATCHED STUDY POPULATION	NCQA		
High*	6 months to 4 years*	50.9%	34.4%	-	70.0%	49.6%	35.0%	-	67.8%
	5 to 17 years**	46.2%	27.6%	-	-	46.4%	28.7%	-	-
	18 to 64 years**	31.6%	24.4%	-	46.4%	30.2%	23.4%	-	38.8%
	65 years and older	20.3%	24.8%	H: 71.1% P: 73.4%	65.3%	21.7%	25.2%	H: 72.1% P: 74.0%	59.6%
Low	5 to 17 years	29.6%	26.4%	-	-	31.2%	28.9%	-	-
	18 to 64 years	16.9%	23.4%	-	34.9%	16.9%	22.9%	-	28.8%
Overall	5 to 17 years	30.1%	26.4%	-	55.3%	31.7%	28.9%	-	54.3%
	18 to 64 years	18.4%	23.5%	H: 48.1% P: 47.1%	37.5%	18.6%	23.0%	H: 50.5% P: 49.6%	31.1%
	All	22.0%	25.0%	-	46.8%	22.0%	25.0%	-	41.7%

H = Health Maintenance Organization. P = Preferred Provider Organization. * See Methods section for definition; the youngest age group is reported as less than four years instead of two to align with CDC reporting categories. ** With conditions listed in Methods section for high-risk for influenza-related complications. Individuals aged 65 years and older in the study population have commercial insurance coverage, likely through employment; any other coverage, such as through Centers for Medicare & Medicaid, for these individuals was not included in the analysis.

extended period following viral clearance. This underscores the rationale for vaccinating those at high-risk as these individuals have known characteristics, such as specific comorbidities, that can result in higher severity and/or prolonged illness.

The generalizability of our findings should be interpreted in the context of the study population and its characteristics, particularly vaccine coverage, as well as potential limitations of statistical power. We analyzed what is, to our knowledge, one of the largest analytical datasets comprised of a commercially insured population, with more than 14 million continuously enrolled members included from two data sources. Despite this breadth of information, the frequency of some outcomes, such as hospitalization with ICU for influenza, was comparatively rare. We note that prescription drugs costs were not included, nor were costs during the two-week vaccination response period, for both groups. Factors, such as time away from work due to illness and premature morbidity and/or mortality due to influenza-related complications, were not available in our data sources.⁴

Propensity score matching was used to control for confounding by indication, or vaccination against influenza, in this study.¹⁷ There are several advantages to this approach, including no restrictions on the number of measured confounders included, separating the study design from the outcome analysis, and less biased estimates as compared to stratification or covariate adjustment. Despite these, it is possible that alternative methods might produce different estimates. For example, we found statistically significant imbalances even after matching for some of the age groups (but not age) that might be indicative of a lack of adequate matches and/or measured confounders to explain the indication for vaccination against influenza.

We relied on administrative coding from health insurance claims for the identification of vaccination. This could have affected our findings via misclassification of vaccination status in which the member was vaccinated against influenza but a claim for the vaccination was not submitted and processed by the individual's (commercial) insurance. For example, we observed that vaccine coverage consistently decreased as age group increased among those identified as at high-risk for influenza-related complications, a population shown to have higher than average vaccination rates and for whom additional health insurance (e.g., Medicare) may be used to cover vaccination.^{2,3}

We similarly relied on administrative coding from health insurance claims for the measurement of condition-related health care utilization and costs and did not use antiviral medications, nor laboratory test results which are

¹⁷ Umberto, B. et al. (June 2018). Statistical Primer: Propensity Score Matching and its Alternatives, *European Journal of Cardio-Thoracic Surgery*. Retrieved January 18, 2021, from <https://academic.oup.com/ejcts/article/53/6/1112/4978231>.

unavailable in claims data, to identify possible infection due to influenza. The observed 19% lower hospital utilization accompanied by a diagnosis code of influenza for those vaccinated as compared to those not in the 2017-18 season is nearly double the 10% reduction in averted hospitalizations reported by Rolfes and colleagues.⁵ This variance may be explained by differences in methodologies as their study used laboratory results to confirm influenza-associated inpatient utilization. A diagnosis code may be reported on a claim(s) when an illness or condition is suspected at the time of the service but is later ruled out by additional follow-up such as diagnostic testing. In other cases, the specific infectious agent responsible for an acute illness may not be reported, either because no diagnostic testing is performed, or the agent is not detectable by the test. Feemster et al. reported that the use of administrative data to detect influenza cases among hospitalized pediatric patients was moderately sensitive, but highly specific; that is, using diagnostic coding was likely to miss some influenza cases, but the lack of a code reliably indicated the absence of laboratory-confirmed infection.¹⁸

Finally, the impact of vaccination can be challenging to interpret as relationships among various factors, some of which are not available in the data sources used for this study, can influence vaccination and the outcome(s) and may not have been adequately accounted for in the analysis. Although we attempted to account for factors associated with vaccination against influenza and infection from influenza as available in our research claims datasets, it is possible that unmeasured confounding may have affected our findings. For example, race and ethnicity were not available, and we excluded patients identified as pregnant during the study period (0.6% of the study population).

Our review of published research on this topic identified two relevant systematic reviews, one with a focus on vaccination against influenza in healthy adults and the other on the cost-effectiveness of adult vaccinations, including influenza.^{6,19} Both include results from a randomized controlled trial conducted more than twenty years ago which found influenza-like illness costs for physician visits (including co-pays) and hospitalizations were lower among individuals vaccinated as compared to those not for one of the two seasons studied (costs were \$15 higher for the vaccinated group in 1997-98 and nearly \$2 lower in 1998-99).²⁰ The matching algorithm we employed for our claims analysis attempted to balance measured confounding factors, while a randomized controlled trial accounts for both measured and unmeasured factors. Thus, that the magnitude of differences in costs between individuals vaccinated against influenza and individuals not vaccinated will vary by season align with those of a rigorous evaluation in a similar population is encouraging despite the limitations inherent to observational research.

Conclusion

This retrospective claims-based study demonstrated that vaccination against influenza is associated with lower health care utilization and costs due to influenza and influenza-like illness among a commercially insured population, even with low rates of vaccine coverage. Continued progress towards reaching the CDC vaccine recommendations is likely to reduce utilization and increase savings further.

Caveats and Limitations

This Milliman, Inc. report has been prepared for the specific purpose of estimating the effect of vaccination against influenza on utilization and costs among a commercially insured population. This information, including all input, calculations, and output, may not be appropriate, and should not be used, for any other purpose. Milliman does not intend to endorse any product or organization. If this report is reproduced, it should be reproduced in its entirety, as pieces taken out of context can be misleading. Milliman does not intend to benefit or create a legal duty to any third party recipient of this work. This work has been prepared for and funded by Aetna, Inc. Our analysis was performed under a Consulting Services Agreement with Aetna.

¹⁸ Feemster K.A. et al. (July 2, 2012). Use of Administrative Data for the Identification of Laboratory-Confirmed Influenza Infection: The Validity of Influenza-Specific ICD-9 Codes. *J Pediatr Infect Dis Soc.* Retrieved November 18, 2020, from <https://academic.oup.com/jpids/article/2/1/63/1084708>.

¹⁹ Leidner A.J. et al. (January 7, 2019.) Cost-effectiveness of adult vaccinations: A systematic review. *Vaccine* Retrieved January 8, 2021, from <https://pubmed.ncbi.nlm.nih.gov/30527660/>.

²⁰ Bridges C.B. et al. (October 4, 2000). Effectiveness and cost-benefit of influenza vaccination of healthy working adults, A randomized controlled trial. *JAMA.* Retrieved January 08, 2021, from <https://jamanetwork.com/journals/jama/fullarticle/193139>.

The results presented herein are estimates based on analysis performed using Milliman research datasets. We have reviewed the analytical inputs, calculations, and outputs for consistency, reasonableness, and appropriateness to the intended purpose. The results are dependent on the quality of the matching algorithm to provide for balanced confounders between the vaccinated and unvaccinated groups. As with any economic or actuarial analysis, it is not possible to capture all of the factors that may contribute to the propensity for vaccination; we account for those that can be measured and for which the adjustment methods chosen apply. Different member identification methods or case-control matching algorithms may produce different results.

Our analysis of patients who have been administered vaccine for influenza, their characteristics, and utilization of health care services and costs is based on historical utilization and costs which can be expected to change over time, especially during periods of disruptions in health care access. Future experience will vary from the estimates to the extent that actual experience deviates from the experience presented in this report for many reasons including random fluctuation; the geographic areas in which both vaccination and utilization of care occurs, as this affects both exposure to influenza viruses (for influenza-specific measures) and regional variation in consumption and cost of care; and/or specific health insurance benefit provisions and the effectiveness of vaccine targeting strategies given these provisions.

Appendix. Detailed Findings

FIGURE 1A: BASELINE CHARACTERISTICS PRE- AND POST-MATCHING BY VACCINATION STATUS FOR 2016-17

	PRE-MATCHING: N=16,622,251					POST-MATCHING: N=14,041,217				
	VACCINATED N	UNVACCINATED PCT	N	PCT	SMD	VACCINATED N	UNVACCINATED PCT	N	PCT	SMD
Total	3,649,702	100	12,972,549	100	-	3,510,298	100	10,530,919	100	-
Age (years)	mean / standard deviation									
	34	22	37	19	-0.16	34	22	34	20	0.00
	0 to 4	9.2	323,731	2.5	0.29	321,187	9.1	613,304	5.8	0.13
	5 to 17	26.3	2,232,566	17.2	0.22	919,587	26.2	2,559,513	24.3	0.04
	18 to 64	61.6	9,999,726	77.1	-0.34	2,167,782	61.8	7,049,310	66.9	-0.11
	65 and older	2.9	416,526	3.2	-0.02	101,742	2.9	308,792	2.9	0.00
Sex	Female									
	1,954,307	53.5	6,478,293	49.9	0.07	1,879,636	53.5	5,719,394	54.3	-0.02
	Male									
	1,695,395	46.5	6,494,256	50.1	-0.07	1,630,662	46.5	4,811,525	45.7	0.02
U.S. Department of Health and Human Services Region	1: CT, ME, MA, NH, RI, VT									
	147,897	4.1	446,545	3.4	0.03	147,312	4.2	450,221	4.3	0.00
	2: NJ, NY, PR, VI									
	530,648	14.5	1,619,891	12.5	0.06	529,297	15.1	1,568,678	14.9	0.01
	3: DE, DC, ME, PA, VA, WV									
	366,291	10.0	1,101,047	8.5	0.05	365,899	10.4	1,151,893	10.9	-0.02
	4: AL, FL, GA, KY, MI, NC, SC, TN									
	943,208	25.8	3,605,877	27.8	-0.04	942,011	26.8	2,742,215	26.0	0.02
	5: IL, IN, MI, MN, OH, WI									
	343,451	9.4	1,211,646	9.3	0.00	342,750	9.8	998,717	9.5	0.01
	6: AR, LA, NM, OK, TX									
	389,534	10.7	1,500,348	11.6	-0.03	389,032	11.1	1,213,266	11.5	-0.01
	7: IA, KS, MS, NE									
	148,789	4.1	444,846	3.4	0.03	147,728	4.2	416,416	4.0	0.01
	8: CO, MT, ND, SD, UT, WY									
	108,206	3.0	342,871	2.6	0.02	107,568	3.1	338,064	3.2	-0.01
	9: AZ, CA, HI, NV, AS, MP, FM, GU, MH, PW, UM									
	281,965	7.7	1,298,462	10.0	-0.08	281,056	8.0	872,139	8.3	-0.01
	10: AK, ID, OR, WA									
	257,770	7.1	952,073	7.3	-0.01	257,645	7.3	779,310	7.4	0.00
	Unknown									
	131,943	3.6	448,943	3.5	0.01	-	-	-	-	-
Morbidity	None									
	3,173,177	86.9	11,968,479	92.3	-0.17	3,050,764	86.9	9,117,339	86.6	0.01
	Any									
	476,525	13.1	1,004,070	7.7	0.17	459,534	13.1	1,413,580	13.4	-0.01
	Asthma									
	68,797	1.9	104,214	0.8	0.09	66,171	1.9	196,777	1.9	0.00
	Blood disorders									
	22,382	0.6	47,891	0.4	0.03	21,701	0.6	65,213	0.6	0.00
	Neurologic and neurodevelopmental conditions									
	50,515	1.4	105,089	0.8	0.06	48,780	1.4	146,617	1.4	0.00
	Chronic lung disease									
	92,651	2.5	149,528	1.2	0.10	89,090	2.5	266,301	2.5	0.00
	Endocrine disorders									
	172,821	4.7	331,633	2.6	0.12	166,651	4.7	515,050	4.9	-0.01
	Heart disease									
	45,114	1.2	103,505	0.8	0.04	43,451	1.2	132,277	1.3	0.00
	Kidney disorders									
	19,516	0.5	34,488	0.3	0.04	18,864	0.5	54,219	0.5	0.00
	Liver disorders									
	11,409	0.3	23,431	0.2	0.03	11,083	0.3	33,901	0.3	0.00
	Metabolic disorders									
	94,816	2.6	217,411	1.7	0.06	91,486	2.6	278,633	2.6	0.00
	Obesity									
	52,115	1.4	127,931	1.0	0.04	50,072	1.4	161,753	1.5	-0.01
	Weakened immune system									
	47,988	1.3	96,411	0.7	0.06	46,306	1.3	135,845	1.3	0.00
	Pregnancy									
	22,325	0.6	72,362	0.6	0.01	-	-	-	-	-
	Nursing home / long-term care facility residence									
	500	0.0	3,446	0.0	-0.01	483	0.0	1,272	0.0	0.00
Risk	Low									
	3,031,743	83.1	11,614,600	89.5	-0.19	2,915,550	83.1	8,847,824	84.0	-0.03
	High									
	617,959	16.9	1,357,949	10.5	0.19	594,748	16.9	1,683,095	16.0	0.03
U.S. Department of Health and Human Services Silver Plan Risk Score	mean / standard deviation									
	1.53	5.05	1.15	3.99	0.09	1.54	5.06	1.53	5.27	0.00
	0-2									
	3,143,433	86.1	11,651,572	89.8	-0.11	3,029,672	86.3	9,174,573	87.1	-0.02
	2-10									
	385,800	10.6	1,009,551	7.8	0.10	371,995	10.6	1,020,394	9.7	0.03
	10-20									
	68,265	1.9	170,656	1.3	0.04	65,819	1.9	195,495	1.9	0.00
	20+									
	44,374	1.2	101,828	0.8	0.04	42,812	1.2	140,457	1.3	-0.01
	Unknown									
	7,830	0.2	38,942	0.3	-0.02	-	-	-	-	-
Health Care Utilization per 1,000	Any									
	3,103,732	850.4	9,416,289	725.9	0.31	2,985,733	850.6	8,805,934	836.2	0.04
	Office Visits									
	3,077,650	843.3	9,223,576	711.0	0.32	2,960,105	843.3	8,684,125	824.6	0.05
	Emergency Department Visits									
	437,821	120.0	1,464,316	112.9	0.02	420,460	119.8	1,416,349	134.5	-0.04
	Hospitalizations without Intensive Care Unit									
	105,580	28.9	287,388	22.2	0.04	117,298	33.4	404,615	38.4	-0.03
	Hospitalizations with Intensive Care Unit									
	13,261	3.6	29,851	2.3	0.02	12,799	3.6	38,935	3.7	0.00
Influenza Vaccination	2,232,024									
	61.2	1,240,159	9.6	1.28	2,150,877	61.3	6,444,588	61.2	0.00	
Influenza	59,966									
	1.6	159,809	1.2	0.03	58,265	1.7	160,240	1.5	0.01	

PCT = Percent of total; SMD = Standardized (Mean) Difference; significant if >0.1 or <-0.1, text **bolded** accordingly; a value of - indicates exclusions applied prior to propensity score estimation

FIGURE 1B: BASELINE CHARACTERISTICS PRE- AND POST-MATCHING BY VACCINATION STATUS FOR 2017-18

	PRE-MATCHING: N=16,622,251					POST-MATCHING: N=14,041,217				
	VACCINATED N	UNVACCINATED PCT	UNVACCINATED N	UNVACCINATED PCT	SMD	VACCINATED N	UNVACCINATED PCT	UNVACCINATED N	UNVACCINATED PCT	SMD
Total	3,660,735	100	12,961,516	100	-	3,522,751	100	10,568,253	100	-
Age (years)	mean / standard deviation									
	35	22	38	19	-0.13	35	22	36	20	-0.02
	0 to 4	6.4	236,816	1.8	0.23	223,398	6.3	414,209	3.9	0.11
	5 to 17	26.9	2,119,636	16.4	0.26	944,014	26.8	2,319,439	21.9	0.11
	18 to 64	63.2	10,133,287	78.2	-0.33	2,230,193	63.3	7,462,660	70.6	-0.16
	65 and older	3.6	471,777	3.6	0.00	125,146	3.6	371,945	3.5	0.00
Sex	Female									
	1,956,290	53.4	6,476,310	50.0	0.07	1,882,355	53.4	5,730,407	54.2	-0.02
	Male									
	1,704,445	46.6	6,485,206	50.0	-0.07	1,640,396	46.6	4,837,846	45.8	0.02
U.S. Department of Health and Human Services Region	1: CT, ME, MA, NH, RI, VT									
	145,896	4.0	448,546	3.5	0.03	145,453	4.1	456,014	4.3	-0.01
	2: NJ, NY, PR, VI									
	541,340	14.8	1,609,199	12.4	0.07	540,173	15.3	1,596,662	15.1	0.01
	3: DE, DC, ME, PA, VA, WV									
	366,778	10.0	1,100,560	8.5	0.05	366,445	10.4	1,125,045	10.6	-0.01
	4: AL, FL, GA, KY, MI, NC, SC, TN									
	933,761	25.5	3,615,324	27.9	-0.05	932,817	26.5	2,755,278	26.1	0.01
	5: IL, IN, MI, MN, OH, WI									
	349,759	9.6	1,205,338	9.3	0.01	349,173	9.9	1,008,589	9.5	0.01
	6: AR, LA, NM, OK, TX									
	373,286	10.2	1,516,596	11.7	-0.05	372,832	10.6	1,199,166	11.3	-0.02
	7: IA, KS, MS, NE									
	155,388	4.2	438,247	3.4	0.05	154,407	4.4	442,981	4.2	0.01
	8: CO, MT, ND, SD, UT, WY									
	113,053	3.1	338,024	2.6	0.03	112,441	3.2	339,338	3.2	0.00
	9: AZ, CA, HI, NV, AS, MP, FM, GU, MH, PW, UM									
	293,481	8.0	1,286,946	9.9	-0.07	292,691	8.3	879,786	8.3	0.00
	10: AK, ID, OR, WA									
	256,388	7.0	953,455	7.4	-0.01	256,319	7.3	765,394	7.2	0.00
	Unknown									
	131,605	3.6	449,281	3.5	0.01	-	-	-	-	-
Morbidity	None									
	3,064,113	83.7	11,620,367	89.7	-0.18	2,948,249	83.7	8,729,969	82.6	0.03
	Any									
	596,622	16.3	1,341,149	10.3	0.18	574,502	16.3	1,838,284	17.4	-0.03
	Asthma									
	86,083	2.4	141,215	1.1	0.10	82,599	2.3	259,199	2.5	-0.01
	Blood disorders									
	30,830	0.8	69,467	0.5	0.04	29,865	0.8	93,031	0.9	0.00
	Neurologic and neurodevelopmental conditions									
	62,508	1.7	138,471	1.1	0.05	60,340	1.7	190,423	1.8	-0.01
	Chronic lung disease									
	116,442	3.2	203,349	1.6	0.11	111,733	3.2	353,504	3.3	-0.01
	Endocrine disorders									
	215,204	5.9	448,619	3.5	0.11	207,203	5.9	674,297	6.4	-0.02
	Heart disease									
	63,590	1.7	151,494	1.2	0.05	61,187	1.7	194,362	1.8	-0.01
	Kidney disorders									
	28,053	0.8	52,904	0.4	0.05	27,074	0.8	82,254	0.8	0.00
	Liver disorders									
	15,962	0.4	34,446	0.3	0.03	15,472	0.4	50,139	0.5	-0.01
	Metabolic disorders									
	128,097	3.5	306,707	2.4	0.07	123,612	3.5	390,192	3.7	-0.01
	Obesity									
	77,457	2.1	194,671	1.5	0.05	74,197	2.1	242,740	2.3	-0.01
	Weakened immune system									
	62,130	1.7	129,871	1.0	0.06	59,854	1.7	185,299	1.8	0.00
	Pregnancy									
	22,692	0.6	74,074	0.6	0.01	-	-	-	-	-
	Nursing home / long-term care facility residence									
	755	0.0	5,357	0.0	-0.01	726	0.0	1,985	0.0	0.00
Risk	Low									
	2,991,089	81.7	11,310,749	87.3	-0.15	2,878,324	81.7	8,539,695	80.8	0.02
	High									
	669,646	18.3	1,650,767	12.7	0.15	644,427	18.3	2,028,558	19.2	-0.02
U.S. Department of Health and Human Services Silver Plan Risk Score	mean / standard deviation									
	1.58	5.21	1.13	3.92	0.10	1.58	5.22	1.63	5.52	-0.01
	0-2									
	3,144,798	85.9	11,650,207	89.9	-0.12	3,031,773	86.1	9,127,279	86.4	-0.01
	2-10									
	392,281	10.7	1,003,070	7.7	0.10	378,266	10.7	1,080,643	10.2	0.02
	10-20									
	69,460	1.9	169,461	1.3	0.05	66,913	1.9	208,694	2.0	-0.01
	20+									
	47,467	1.3	98,735	0.8	0.05	45,799	1.3	151,637	1.4	-0.01
	Unknown									
	6,729	0.2	40,043	0.3	-0.03	-	-	-	-	-
Health Care Utilization per 1,000	Any									
	3,114,904	850.9	9,474,132	730.9	0.30	2,996,733	850.7	8,855,171	837.9	0.04
	Office Visits									
	3,088,388	843.7	9,278,220	715.8	0.31	2,971,119	843.4	8,732,044	826.3	0.05
	Emergency Department Visits									
	435,010	118.8	1,481,780	114.3	0.01	417,993	118.7	1,416,702	134.1	-0.05
	Hospitalizations without Intensive Care Unit									
	105,426	28.8	306,955	23.7	0.03	111,510	31.7	410,009	38.8	-0.04
	Hospitalizations with Intensive Care Unit									
	21,834	6.0	54,714	4.2	0.02	21,104	6.0	69,411	6.6	-0.01
Influenza Vaccination	2,295,956									
	62.7	62.7	1,353,746	10.4	1.29	2,208,680	62.7	6,620,795	62.6	0.00
Influenza	102,345									
	2.8	2.8	258,814	2.0	0.05	98,135	2.8	271,051	2.6	0.01

PCT = Percent of total; SMD = Standardized (Mean) Difference; significant if >0.1 or <-0.1, text bolded accordingly; a value of - indicates exclusions applied prior to propensity score estimation

FIGURE 2A: UTILIZATION PER 1,000 INDIVIDUALS AND ALLOWED COST PER MEMBER PER SEASON (PMPY) BY VACCINATION STATUS, RISK GROUP, DIAGNOSIS CODE ON CLAIMS, AND UTILIZATION CATEGORY FOR 2016-17

RISK GROUP	DIAGNOSIS	UTILIZATION CATEGORY	VACCINATED		UNVACCINATED		DIFFERENCE	
			UTILIZATION PER 1,000	ALLOWED COSTS PMPY	UTILIZATION PER 1,000	ALLOWED COSTS PMPY	UTILIZATION PER 1,000	ALLOWED COSTS PMPY
All	Influenza	Office Visits	20.78	\$2.92	23.33	\$3.26	2.54	\$0.34
		Outpatient Facility	-	\$0.69	-	\$0.89	-	\$0.20
		ED Visits	0.93	\$1.28	1.45	\$1.77	0.53	\$0.50
		Hospitalizations without ICU	0.18	\$2.75	0.20	\$3.18	0.02	\$0.43
		Hospitalizations with ICU	0.04	\$1.38	0.06	\$1.98	0.02	\$0.61
	Total	-	\$30.81	-	\$11.09	-	-\$19.72	
	Influenza-like illness	Office Visits	481.39	\$59.66	399.56	\$49.96	-81.83	-\$9.69
		Outpatient Facility	-	\$13.63	-	\$14.39	-	\$0.76
		ED Visits	13.90	\$18.47	15.29	\$19.59	1.39	\$1.12
		Hospitalizations without ICU	3.52	\$77.39	3.60	\$84.25	0.08	\$6.87
		Hospitalizations with ICU	0.91	\$46.10	1.03	\$53.53	0.12	\$7.44
	Total	-	\$237.03	-	\$221.74	-	-\$15.30	
	Pneumonia unrelated to influenza or influenza-like illness	Office Visits	1.81	\$0.23	1.33	\$0.17	-0.48	-\$0.06
		Outpatient Facility	-	\$0.20	-	\$0.16	-	-\$0.04
		ED Visits	0.11	\$0.21	0.13	\$0.22	0.02	\$0.01
Hospitalizations without ICU		0.12	\$1.82	0.10	\$2.68	-0.02	\$0.86	
Hospitalizations with ICU		0.03	\$1.25	0.03	\$1.39	0.00	\$0.14	
Total	-	\$25.50	-	\$4.63	-	-\$20.87		
Any	Office Visits	4,660.65	\$873.23	3,931.67	\$752.37	-728.99	-\$120.86	
	Outpatient Facility	-	\$410.08	-	\$373.17	-	-\$36.91	
	ED Visits	169.06	\$239.79	184.21	\$259.59	15.15	\$19.80	
	Hospitalizations without ICU	50.74	\$1,051.96	50.12	\$1,075.81	-0.63	\$23.85	
	Hospitalizations with ICU	8.52	\$465.48	9.30	\$478.71	0.77	\$13.23	
Total	-	\$3,062.34	-	\$2,939.66	-	-\$122.68		
High	Influenza	Office Visits	21.42	\$3.01	21.97	\$3.09	0.54	\$0.08
		Outpatient Facility	-	\$1.78	-	\$2.00	-	\$0.22
		ED Visits	1.59	\$2.46	2.23	\$3.02	0.64	\$0.56
		Hospitalizations without ICU	0.68	\$11.08	0.76	\$11.56	0.09	\$0.48
		Hospitalizations with ICU	0.13	\$3.76	0.24	\$6.49	0.11	\$2.73
	Total	-	\$43.88	-	\$26.16	-	-\$17.71	
	Influenza-like illness	Office Visits	724.22	\$91.52	577.85	\$74.08	-146.37	-\$17.44
		Outpatient Facility	-	\$35.03	-	\$37.63	-	\$2.61
		ED Visits	28.48	\$40.20	28.97	\$40.14	0.49	-\$0.06
		Hospitalizations without ICU	11.83	\$261.23	12.77	\$304.25	0.93	\$43.01
		Hospitalizations with ICU	3.37	\$161.60	4.03	\$200.18	0.66	\$38.58
	Total	-	\$611.37	-	\$656.28	-	\$44.91	
	Pneumonia unrelated to influenza or influenza-like illness	Office Visits	2.65	\$0.38	1.95	\$0.27	-0.70	-\$0.10
		Outpatient Facility	-	\$0.53	-	\$0.54	-	\$0.01
		ED Visits	0.25	\$0.57	0.29	\$0.58	0.04	\$0.01
Hospitalizations without ICU		0.38	\$6.23	0.35	\$12.88	-0.03	\$6.65	
Hospitalizations with ICU		0.10	\$4.91	0.11	\$6.31	0.02	\$1.40	
Total	-	\$34.42	-	\$20.59	-	-\$13.83		
Any	Office Visits	9,532.33	\$1,841.25	8,616.53	\$1,686.64	-915.81	-\$154.61	
	Outpatient Facility	-	\$1,095.92	-	\$1,053.07	-	-\$42.86	
	ED Visits	338.85	\$502.13	379.27	\$563.79	40.42	\$61.67	
	Hospitalizations without ICU	140.46	\$3,123.31	159.20	\$3,457.24	18.74	\$333.94	
	Hospitalizations with ICU	29.84	\$1,554.86	35.72	\$1,709.61	5.88	\$154.75	
Total	-	\$8,139.25	-	\$8,470.35	-	\$331.10		
Low	Influenza	Office Visits	20.65	\$2.90	23.59	\$3.29	2.93	\$0.39
		Outpatient Facility	-	\$0.47	-	\$0.68	-	\$0.21
		ED Visits	0.79	\$1.04	1.31	\$1.54	0.51	\$0.50
		Hospitalizations without ICU	0.08	\$1.05	0.10	\$1.58	0.01	\$0.53
		Hospitalizations with ICU	0.02	\$0.89	0.02	\$1.13	0.00	\$0.24
	Total	-	\$28.15	-	\$8.22	-	-\$19.93	
	Influenza-like illness	Office Visits	431.85	\$53.16	365.64	\$45.38	-66.21	-\$7.78
		Outpatient Facility	-	\$9.27	-	\$9.97	-	\$0.70
		ED Visits	10.93	\$14.04	12.69	\$15.68	1.76	\$1.65
		Hospitalizations without ICU	1.82	\$39.88	1.85	\$42.41	0.03	\$2.52
		Hospitalizations with ICU	0.41	\$22.53	0.46	\$25.64	0.05	\$3.11
	Total	-	\$160.67	-	\$139.07	-	-\$21.60	
	Pneumonia unrelated to influenza or influenza-like illness	Office Visits	1.65	\$0.20	1.21	\$0.15	-0.43	-\$0.05
		Outpatient Facility	-	\$0.13	-	\$0.09	-	-\$0.04
		ED Visits	0.08	\$0.14	0.10	\$0.16	0.02	\$0.02
Hospitalizations without ICU		0.07	\$0.92	0.06	\$0.74	-0.01	-\$0.18	
Hospitalizations with ICU		0.01	\$0.50	0.01	\$0.45	0.00	-\$0.05	
Total	-	\$23.68	-	\$1.59	-	-\$22.09		
Any	Office Visits	3,666.87	\$675.77	3,040.48	\$574.65	-626.39	-\$101.12	
	Outpatient Facility	-	\$270.17	-	\$243.84	-	-\$26.34	
	ED Visits	134.43	\$186.28	147.11	\$201.72	12.68	\$15.45	
	Hospitalizations without ICU	32.44	\$629.43	29.36	\$622.80	-3.08	-\$6.62	
	Hospitalizations with ICU	4.17	\$243.26	4.27	\$244.56	0.10	\$1.30	
Total	-	\$2,026.69	-	\$1,887.57	-	-\$139.12		

ED = Emergency Department; ICU = Intensive Care Unit. Prescription drug costs were not included. Negative values indicate higher utilization and costs (instead of savings) among vaccinated members. Column entries may not sum to totals due to rounding.

FIGURE 2B: UTILIZATION PER 1,000 INDIVIDUALS AND ALLOWED COST PER MEMBER PER SEASON (PMPY) BY VACCINATION STATUS, RISK GROUP, DIAGNOSIS CODE ON CLAIMS, AND UTILIZATION CATEGORY FOR 2017-18

RISK GROUP	DIAGNOSIS	UTILIZATION CATEGORY	VACCINATED		UNVACCINATED		DIFFERENCE	
			UTILIZATION PER 1,000	ALLOWED COSTS PMPY	UTILIZATION PER 1,000	ALLOWED COSTS PMPY	UTILIZATION PER 1,000	ALLOWED COSTS PMPY
All	Influenza	Office Visits	35.28	\$5.06	38.18	\$5.45	2.90	\$0.40
		Outpatient Facility	-	\$1.26	-	\$1.88	-	\$0.62
		ED Visits	1.74	\$2.33	2.56	\$3.17	0.82	\$0.84
		Hospitalizations without ICU	0.31	\$5.31	0.37	\$7.54	0.07	\$2.23
		Hospitalizations with ICU	0.09	\$3.62	0.12	\$4.87	0.03	\$1.26
	Total	-	\$42.80	-	\$22.91	-	-\$19.89	
	Influenza-like illness	Office Visits	446.94	\$58.54	391.69	\$51.48	-55.24	-\$7.06
		Outpatient Facility	-	\$14.96	-	\$17.68	-	\$2.72
		ED Visits	13.51	\$19.07	15.99	\$21.94	2.48	\$2.87
		Hospitalizations without ICU	3.88	\$99.03	4.31	\$123.71	0.43	\$24.68
		Hospitalizations with ICU	1.21	\$63.10	1.52	\$88.55	0.31	\$25.45
	Total	-	\$279.93	-	\$303.36	-	\$23.43	
	Pneumonia unrelated to influenza or influenza-like illness	Office Visits	1.45	\$0.19	1.05	\$0.14	-0.39	-\$0.05
		Outpatient Facility	-	\$0.19	-	\$0.15	-	-\$0.04
		ED Visits	0.09	\$0.18	0.08	\$0.18	-0.01	\$0.00
		Hospitalizations without ICU	0.13	\$2.74	0.12	\$2.66	-0.01	-\$0.08
		Hospitalizations with ICU	0.04	\$1.81	0.04	\$2.52	-0.01	\$0.71
	Total	-	\$30.34	-	\$5.64	-	-\$24.70	
	Any	Office Visits	4,706.23	\$920.78	4,140.79	\$823.48	-565.45	-\$97.29
		Outpatient Facility	-	\$465.90	-	\$428.95	-	-\$36.95
		ED Visits	168.05	\$257.29	188.39	\$284.86	20.34	\$27.56
Hospitalizations without ICU		53.95	\$1,324.95	56.52	\$1,423.64	2.57	\$98.69	
Hospitalizations with ICU		11.28	\$631.39	13.00	\$731.38	1.72	\$99.98	
Total	-	\$3,625.54	-	\$3,692.31	-	\$66.76		
High	Influenza	Office Visits	34.64	\$4.96	36.88	\$5.30	2.23	\$0.34
		Outpatient Facility	-	\$3.43	-	\$4.82	-	\$1.39
		ED Visits	2.94	\$4.41	3.76	\$5.08	0.82	\$0.67
		Hospitalizations without ICU	1.16	\$21.75	1.28	\$26.78	0.13	\$5.03
		Hospitalizations with ICU	0.38	\$14.73	0.46	\$19.22	0.07	\$4.49
	Total	-	\$74.51	-	\$61.19	-	-\$13.31	
	Influenza-like illness	Office Visits	578.31	\$79.47	531.71	\$72.52	-46.61	-\$6.95
		Outpatient Facility	-	\$39.23	-	\$46.65	-	\$7.42
		ED Visits	24.20	\$38.38	28.18	\$43.59	3.98	\$5.21
		Hospitalizations without ICU	13.43	\$354.37	14.97	\$441.86	1.54	\$87.49
		Hospitalizations with ICU	4.67	\$234.50	5.70	\$307.71	1.03	\$73.21
	Total	-	\$771.18	-	\$912.33	-	\$141.15	
	Pneumonia unrelated to influenza or influenza-like illness	Office Visits	1.87	\$0.28	1.65	\$0.25	-0.21	-\$0.03
		Outpatient Facility	-	\$0.77	-	\$0.45	-	-\$0.32
		ED Visits	0.19	\$0.43	0.19	\$0.42	0.00	-\$0.01
		Hospitalizations without ICU	0.46	\$10.66	0.46	\$10.53	0.01	-\$0.13
		Hospitalizations with ICU	0.17	\$6.85	0.14	\$7.39	-0.03	\$0.54
	Total	-	\$44.23	-	\$19.04	-	-\$25.18	
	Any	Office Visits	9,936.34	\$2,044.97	8,925.92	\$1,831.56	-1,010.42	-\$213.42
		Outpatient Facility	-	\$1,335.51	-	\$1,193.82	-	-\$141.69
		ED Visits	345.87	\$565.43	382.19	\$611.77	36.32	\$46.34
Hospitalizations without ICU		163.05	\$4,249.01	173.95	\$4,565.23	10.90	\$316.22	
Hospitalizations with ICU		42.58	\$2,285.49	47.81	\$2,517.65	5.23	\$232.16	
Total	-	\$10,505.64	-	\$10,720.03	-	\$214.39		
Low	Influenza	Office Visits	35.43	\$5.08	38.49	\$5.49	3.07	\$0.41
		Outpatient Facility	-	\$0.78	-	\$1.18	-	\$0.40
		ED Visits	1.47	\$1.86	2.28	\$2.71	0.81	\$0.85
		Hospitalizations without ICU	0.11	\$1.63	0.15	\$2.96	0.04	\$1.34
		Hospitalizations with ICU	0.03	\$1.13	0.04	\$1.46	0.01	\$0.34
	Total	-	\$35.70	-	\$13.81	-	-\$21.89	
	Influenza-like illness	Office Visits	417.52	\$53.85	358.43	\$46.48	-59.09	-\$7.37
		Outpatient Facility	-	\$9.52	-	\$10.80	-	\$1.27
		ED Visits	11.12	\$14.75	13.09	\$16.79	1.98	\$2.05
		Hospitalizations without ICU	1.75	\$41.86	1.78	\$48.14	0.03	\$6.28
		Hospitalizations with ICU	0.43	\$24.73	0.53	\$36.49	0.10	\$11.76
	Total	-	\$169.94	-	\$158.70	-	-\$11.24	
	Pneumonia unrelated to influenza or influenza-like illness	Office Visits	1.35	\$0.17	0.91	\$0.12	-0.44	-\$0.05
		Outpatient Facility	-	\$0.06	-	\$0.08	-	\$0.02
		ED Visits	0.07	\$0.13	0.06	\$0.12	-0.01	-\$0.01
		Hospitalizations without ICU	0.06	\$0.97	0.04	\$0.78	-0.02	-\$0.18
		Hospitalizations with ICU	0.02	\$0.68	0.02	\$1.36	0.00	\$0.68
	Total	-	\$27.23	-	\$2.46	-	-\$24.78	
	Any	Office Visits	3,535.27	\$669.08	3,004.11	\$584.02	-531.16	-\$85.06
		Outpatient Facility	-	\$271.20	-	\$247.26	-	-\$23.95
		ED Visits	128.23	\$188.31	142.35	\$207.20	14.12	\$18.90
Hospitalizations without ICU		29.52	\$670.28	28.63	\$677.37	-0.89	\$7.09	
Hospitalizations with ICU		4.27	\$261.06	4.73	\$307.06	0.46	\$46.00	
Total	-	\$2,085.16	-	\$2,022.91	-	-\$62.25		

ED = Emergency Department; ICU = Intensive Care Unit. Prescription drug costs were not included. Negative values indicate higher utilization and costs (instead of savings) among vaccinated members. Column entries may not sum to totals due to rounding.



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