Influenza vaccination rates and hospitalizations among Medicaid enrollees with and without sickle cell disease, 2009–2015

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Abstract

Background: Personswith sickle cell disease (SCD) face increased risks for pulmonary and infection-related complications. This study examines influenza vaccination coverage and estimates influenza-related morbidity among Medicaid enrollees with and without SCD.

Procedure: Influenza vaccination coverage and hospitalizations related to influenza and pneumonia/acute chest syndrome (ACS) during each influenza season from 2009–2010 to 2014–2015 were assessed among enrollees in the IBM MarketScan® Multi-State Medicaid Database. Enrollees with SCD were identified as enrollees with greater than or equal to three claims listing SCD within a 5-year period during 2003–2017. Vaccinations were identified in outpatient claims. Hospitalizations associated with influenza or pneumonia/ACS were identified using inpatient claims. This study includes a series of cross-sectional assessments by season.

Results: From 2009–2010 through 2014–2015 seasons, the SCD sample ranged from 5044 to 8651 enrollees; the non-SCD sample ranged from 1,841,756 to 3,796,337 enrollees. Influenza vaccination coverage was higher among enrollees with SCD compared with enrollees without SCD for all seasons (24.5%–33.6% and 18.2%–22.0%, respectively). Age-standardized rates of influenza-related hospitalizations were 20–42 times higher among SCD enrollees compared with non-SCD enrollees, and ACS/pneumonia hospitalizations were 18–29 times higher. Among enrollees with SCD, influenza-related hospitalization rates were highest among children aged 0–9 years. Among enrollees without SCD, influenza-related hospitalization rates were highest among adults aged 40–64 years.

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Conclusions: Although vaccine coverage was higher in persons with versus without SCD, efforts to increase influenza coverage further are warranted for this high-risk group, who experienced markedly higher rates of influenza and ACS/pneumonia hospitalizations during each season.

1 | INTRODUCTION

Sickle cell disease (SCD) is an inherited hemoglobinopathy estimated to affect over 100,000 persons in the United States.[1] In SCD, a pathogenic variant in the beta hemoglobin gene leads to production of abnormal hemoglobin that polymerizes under low oxygen conditions. As a result, red blood cells (RBCs) of individuals with SCD become rigid, deform into a sickle shape, and occlude the microvasculature.[2] SCD affects nearly every organ system and is associated with increased risk of early death.[3,4]

Pulmonary complications are a leading cause of SCD-related death.[5] SCD pulmonary complications include acute chest syndrome (ACS), a pneumonia-like illness defined by presence of acute respiratory clinical findings associated with new infiltrates on chest X-ray. Approximately a third of ACS events are idiopathic, a third are attributable to fat embolism, and a third are attributed to bacterial or viral infections.[6] Because bacterial and viral infections are associated with poor outcomes, such as ACS, individuals with SCD or their caregivers are instructed to seek immediate medical attention in the event of fever.[7] Further, strategies to prevent bacterial infections, notably penicillin prophylaxis[8] and vaccination schedules that include conjugated[9–11] and polysaccharide pneumococcal vaccines,[12] have been effective in reducing infection-related morbidity and mortality among persons with SCD, particularly among the very young, and hydroxyurea therapy has been shown to reduce risk of ACS in both children[13] and adults.[14] Nonetheless, infection remains among the most common reasons for hospitalization[15] and is still a leading cause of death[5] in persons with SCD.

Previous studies have shown that viral infections, such as influenza, are a significant source of increased morbidity and mortality among persons with SCD, although the reasons are not clearly defined.[16,17] Persons with SCD have been reported to be more likely to be hospitalized due to influenza virus infection than the general population,[16] although a lower threshold for admission may contribute to higher hospitalization rates among persons with SCD. However, measures of the immune response to influenza vaccination in persons with SCD have varied among studies.[18–21] Additionally, differences in vaccination coverage between persons with SCD and persons with other underlying conditions increasing the risk for influenza morbidity have been noted, with persons with SCD being less likely to be vaccinated.[22–26]

Further research can improve understanding of the burden of influenza among persons with SCD, identification of factors contributing to burden, and the effectiveness of vaccination in reducing severe influenza outcomes, such as hospitalization. Understanding

influenza infections in persons with SCD compared with the general population may guide better prevention, treatment, and allocation of resources. Furthermore, randomized trials to examine vaccine effects in orphan diseases such as SCD are often not possible, yet observational studies pose significant challenges.[27] Better understanding of factors related to both vaccination and influenza hospitalization (i.e., confounders in vaccine effectiveness studies) may help in the design of more reliable observational studies. This study examines trends over six influenza seasons in both influenza vaccination rates and hospitalizations related to influenza and pneumonia/ACS among persons with and without SCD using a multi-state Medicaid claims database and provides more comprehensive data regarding the burden of influenza in the US population living with SCD.

2 | METHODS

2.1 | Study population

Trends in influenza vaccination coverage and hospitalizations related to influenza and pneumonia/ACS during each influenza season from 2009 to 2015 were assessed among enrollees in the IBM MarketScan® Multi-State Medicaid Database. The database contains Medicaid and, in some states, Children's Health Insurance Program (CHIP) claims data. During the study period, data came from 10–13 states. The data are provided in separate files for outpatient services, inpatient admissions and services, and outpatient pharmacy claims as well as enrollment data for children, adolescents, and adults enrolled in Medicaid or CHIP from participating states or managed care plans. Medicaid claims data are frequently used for health services research on SCD, as most persons hospitalized with SCD have public health insurance as the expected payer.[15] In particular, many persons with SCD automatically qualify for Medicaid through receipt of disability benefits through the Supplemental Security Income (SSI) program.[28] The data that support the findings of this study are available from IBM®. Restrictions apply to the availability of these data, which were used under license for this study.

Influenza seasons were defined as beginning August 1 of one year through July 31 of the following year, from 2009–2010 through 2014–2015. Persons who were continuously enrolled for 12 months before and 12 months after the start of the influenza season were included in that season's study population. For each season, persons 65 years of age or older at the start of the season were excluded, because they are automatically covered by Medicare, and the MarketScan Medicaid database does not contain information regarding Medicare claims.

Enrollees with SCD were identified based on claims records in the MarketScan Medicaid database recorded in calendar years 2003 through 2017 (the last year data were available at the time of analysis). Participants with three or more claims with International Classification of Disease (ICD) versions 9 or 10 diagnosis Clinical Modification (CM) codes for SCD on different service dates within any 5-year period were considered to have SCD (see Table S1 for list of ICD-9/10-CM codes).[29,30] For consistency in coding for influenza, seasons were limited to those prior to the nationwide introduction of ICD-10-CM in US health care in late 2015. All others not meeting the SCD criteria were considered not to have SCD.

2.2 | Vaccination coverage

Evidence of vaccination was determined using claims recorded in the outpatient services file. To be considered vaccinated during a season, enrollees must have a claim indicating receipt of an influenza vaccine during that season. ICD-9-CM, Healthcare Common Procedure Coding System (HCPCS), and Current Procedural Terminology (CPT) codes used to identify influenza vaccinations are detailed in Table S2.

2.3 | Hospitalizations

Hospitalizations associated with influenza or pneumonia/ACS were identified using ICD-9-CM codes recorded in any field in the inpatient services file. ICD-9-CM codes used to identify influenza and pneumonia/ACS-related hospitalizations are detailed in Table S3. Because a diagnosis of ACS is rare among persons without SCD and it is difficult to reliably separate hospitalizations related to pneumonia from hospitalizations related to ACS using medical claims data, inpatient records with claims for either diagnosis were included as hospitalizations related to pneumonia/ACS.

2.4 | Health care utilization

To assess regular health care encounters among persons with SCD, we examined rate of emergency department (ED) visits, receipt of age-based recommended[7] preventive care procedures such as transcranial Doppler (TCD) screening, eye examination, and receipt of need-based procedures such as heart echocardiogram, as these can serve as a set of characteristics related to health care access that might have led to increased opportunity for receipt of influenza vaccine. Evidence of ED visits and receipt of procedures was determined using claims recorded in the outpatient record file during the influenza season in question (see Table S4 for list of procedure codes).

2.5 | Analysis

This study was conducted as a series of cross-sectional assessments in which we selected and compared persons with and without SCD who were continuously enrolled in the MarketScan Medicaid database before and during an influenza season. We describe both the SCD and general Medicaid population samples for each influenza season according to their distributions by age, race, gender, and whether disability was the basis of Medicaid eligibility. Persons eligible for Medicaid based on disability have low household income and have severe underlying medical conditions or disabling functional limitations that qualify them for SSI disability benefits from the Social Security Administration. Five-year age groups were used for ages 0–39, in line with age-based categorization used by the US Census Bureau. Persons aged 40–64 were grouped due to relatively small group sizes in older age groups among persons with SCD. For presentation purposes, we grouped age groups 0–4 and 5–9 years; 10–14 and 15—19 years; and 20–24, 25–29, 30–34, and 35–39 years when trends were similar among age groups.

Vaccination coverage was estimated for each season by dividing the number of persons with an influenza vaccination claim by the total number of enrollees meeting the inclusion criteria for that season. Vaccination coverage among enrollees with SCD was compared with coverage among enrollees without SCD by calculating the ratio of vaccination coverage

among enrollees with SCD to the coverage among enrollees without SCD. The 95% confidence interval around this estimate was obtained, assuming a log-binomial distribution.

Rates of influenza and pneumonia/ACS hospitalizations for both SCD and general Medicaid samples were calculated by dividing the number of influenza or pneumonia/ACS hospitalizations occurring in a season by the number of eligible enrollees in that season, that is, with 24 months continuous enrollment. Rates are reported as per 10,000 person-seasons. Overall rates for the SCD sample were age-standardized based on the non-SCD Medicaid sample using direct standardization.[31] The effect of SCD on rates of hospitalizations related to influenza and pneumonia/ACS was estimated by calculating the rate ratio and associated 95% confidence interval of the standardized rates among enrollees with SCD to those among enrollees without SCD.

3 | RESULTS

3.1 | Sample characteristics

Characteristics of the SCD and non-SCD samples captured in the MarketScan Medicaid data are outlined in Table S5 by influenza season. The total SCD sample ranged from 5044 enrollees during the 2009–2010 season to 8651 during the 2013–2014 season. The non-SCD sample ranged from 1,841,756 enrollees during the 2009–2010 season to 3,796,337 during the 2013–2014 season. The age distributions differed in that the SCD sample had a larger proportion of adolescent and young adult enrollees across all seasons. The distribution differed by race and gender, with the SCD sample having proportionately more Black enrollees and females. Additionally, basis of Medicaid eligibility for SCD enrollees was more likely to have been receipt of disability benefits compared with the non-SCD sample.

3.2 | Vaccination coverage

Regardless of SCD status, vaccination coverage varied by season, age group, and basis of Medicaid eligibility (Table 1). Coverage was highest in the 2013–2014 season (33.6% and 22.0% among enrollees with SCD and without SCD, respectively) and lowest in the 2010–2011 season (24.5% and 18.2% among enrollees with SCD and without SCD, respectively). Across all seasons coverage was notably higher among those aged 0–19 years than those aged 20–64 years, with the highest coverage rates among children 0–4 years of age. Coverage rates reached a low point at age 20–24 years among non-SCD enrollees and then increased slightly with increasing age, while for SCD enrollees, coverage rates reached a low point at a slightly older age (variable by season, from 25–29 to 35–39 years). Enrollees eligible for Medicaid because of disability had lower vaccination coverage than enrollees eligible for other reasons, across all seasons and regardless of SCD status.

Influenza vaccination coverage was higher among SCD enrollees compared with enrollees without SCD for all age and Medicaid eligibility groups (Figure 1). Comparing the average across all seasons of the ratio of vaccination coverage among enrollees with SCD to the vaccination coverage among enrollees without SCD (Figure 2), the greatest SCD versus non-SCD vaccination coverage differential was observed among the older adolescent and young adult age groups (ratios at or above 2.0). Additionally, the vaccination coverage

differential was higher among those eligible for Medicaid because of a disability compared with those eligible for another reason.

Among enrollees with SCD, vaccination coverage differed by several characteristics, including rate of ED visits, and receipt of preventive services (Figure 3). In general, coverage was higher among enrollees with more contact with the health care system. For example, coverage was higher among enrollees with more than three ED visits per year. Additionally, for all age groups, coverage was higher among enrollees receiving TCD screening, echocardiogram, and eye examination.

3.3 | Hospitalizations

Age-standardized rates of influenza and ACS/pneumonia-related hospitalizations for SCD enrollees compared with non-SCD enrollees by season are presented in Table 2. Both influenza and ACS/pneumonia hospitalization rates were substantially higher in SCD than non-SCD enrollees. The age-standardized rate of influenza hospitalizations was 20–42 times higher and the age-standardized rate of ACS/pneumonia hospitalizations was 18–29 times higher among SCD enrollees compared with non-SCD enrollees. Patterns of seasonal variation in influenza hospitalization rates were similar for the SCD and non-SCD groups. For both groups, influenza-related hospitalization rates were lowest during the 2011–2012 season (43.4/10,000 among SCD enrollees and 2.1/10,000 among non-SCD enrollees) and highest during the 2009–2010 season (297.4/10,000 among SCD enrollees and 9.6/10,000 among non-SCD enrollees). ACS/pneumonia-related hospitalization rates were lowest during the 2010–2011 season among enrollees with SCD (1827.4/10,000) and during the 2014–2015 season among enrollees without SCD (66.6/10,000). For both groups, ACS/pneumonia-related hospitalization rates were highest during the 2009–2010 season (2153.9/10,000 among enrollees with SCD and 108.7/10,000 among enrollees without SCD).

Variation in influenza and ACS/pneumonia hospitalizations by age group was markedly different for SCD versus non-SCD groups (Tables S6 and S7). Influenza hospitalization rates among SCD enrollees were highest for those of 0–9 years of age and decreased with increasing age, reaching a nadir among those aged 40–64 years. ACS/pneumonia hospitalization rates among SCD enrollees were highest for those aged 20–39 years. Influenza and ACS/pneumonia hospitalization rates among non-SCD enrollees increased with increasing age, with the highest rates observed among those aged 40–64 years.

Stratification by basis of Medicaid eligibility showed that among both SCD and non-SCD groups that met Medicaid eligibility because of a disability had higher influenza and ACS/pneumonia hospitalization rates than those who met Medicaid eligibility for other reasons, most commonly low income (Tables S6 and S7). Additionally, among those eligible because of disability, the pattern of influenza hospitalization by age no longer diverged between SCD and non-SCD groups: for both groups, rates were highest among those 0–9 years of age. However, this is not true for ACS/pneumonia hospitalization rates: rates were highest among persons aged 20–39 years in the SCD group and among those 40–64 years in the non-SCD group when limiting to those eligible for Medicaid because of disability.

4 | DISCUSSION

Although Medicaid enrollees with SCD had 1.3–1.6 times higher influenza vaccination coverage compared with enrollees without SCD, they were still 18–42 times more likely to be hospitalized due to complications related to influenza or ACS/pneumonia. The findings confirm that influenza poses a substantial risk for morbidity among people living with SCD.

Annual influenza vaccination among Medicaid enrollees was less than 34% in each year, which is less than half the Healthy People 2020 population target of 70% coverage[32] or the World Health Organization goal of 75% coverage.[33]

Reported influenza vaccination coverage estimates among persons with SCD vary by geographic location, season, and age group. A recent report from pediatric departments of Marseille University Hospitals in France indicated vaccination rates among persons with SCD averaged 86%, higher than coverage rates among persons with other underlying conditions.[34] However, US investigators have reported lower coverage estimates. A single-center evaluation in Louisville, KY in 2017 indicated 52% of children with SCD adhered to influenza vaccination recommendations.[35] Similarly, an investigation among children with SCD referred to services in Indiana between 2009 and 2017 found that although 60% of children received at least one influenza vaccination, the annual proportion declined over time and was 33% by the end of the study period.[36] Among persons with SCD enrolled in Medicaid in Wisconsin during 2003–2007, adherence rates among persons at least 18 years of age were 12% and 30% among persons less than 18 years of age.[22]

In this analysis, coverage varied by season regardless of SCD status, with the lowest coverage noted during the 2010–2011 season and highest during the 2013–2014 season. Coverage rates also differed by age group, with the lowest coverage among young adults and highest coverage among young children. Coverage among children may be higher compared with adults for multiple reasons. First, young children may be relatively compliant to parental and provider requests in general, and young adults may be less likely to adhere to recommendations. Second, through the Vaccines for Children (VFC) program, children through 18 years of age are eligible to receive the influenza vaccine at no cost if they meet criteria such as Medicaid eligibility.[37] Third, lower coverage among young adults compared with children may also suggest structural barriers to care among the adult population. Elements of coordinated health care delivery to alleviate these structural barriers to care have been explored,[38] and adoption of a coordinated care model may serve to increase vaccine coverage among adults with SCD.

Rates of vaccination were higher among enrollees with SCD compared to enrollees without SCD across all seasons and age groups. Rates of vaccination were highest among enrollees with SCD with more frequent health care contacts, including those who received recommended preventive services, such as TCD screening, eye examination, and echocardiography, or those who had a higher rate of ED visits. These descriptive findings can inform specification of hypotheses to be tested in future influenza vaccine uptake and vaccine effectiveness studies.

Higher influenza-related and ACS/pneumonia-related hospitalization rates among Medicaid enrollees with SCD compared with enrollees without SCD are consistent with previous findings. An analysis of hospital discharge records during two influenza seasons (2003–2005) in four states estimated that pediatric hospitalizations with SCD code are 56 times more likely to also have codes for influenza-related complications than other pediatric hospitalizations.[16] Among adults admitted with influenza to a community hospital during the H1N1 pandemic, patients with SCD were overrepresented.[39,40] This highlights the increased burden of influenza-related illness among persons with SCD, particularly in the setting of influenza strains associated with severe disease. Other studies conducted during that period reported that children with SCD were particularly likely to be symptomatic and admitted as inpatients. A survey of eight UK hospitals[41] identified 21 children with SCD and confirmed influenza virus infection: 19 (90%) were admitted and 10/17 (59%) had evidence of ACS. Similarly, 29 children with SCD admitted to Johns Hopkins hospital were significantly more likely to be diagnosed with ACS (34%) and be admitted to intensive care (17%) or placed on mechanical ventilation (10%) compared with 94 patients with seasonal influenza in the prior season.[42]

Possible explanations for the higher influenza hospitalization rates among Medicaid enrollees with SCD compared with enrollees without SCD include a greater risk for serious influenza complications among the SCD group and decreased vaccine effectiveness. Markedly higher influenza-related morbidity among persons with SCD is consistent with the known pathophysiology of this condition, which includes elevated risk for pulmonary complications. There is also some evidence suggesting that vaccine effectiveness could be lower among persons with SCD. Although several studies have indicated adequate serologic response to vaccination among persons with SCD, responses may be lower than in persons without SCD.[18,20,43] Furthermore, serologic response among persons with SCD may wane more rapidly over time,[20] and the magnitude and duration of response may be affected by use of chronic transfusion therapy[21,44] and splenic function.[45] One single-center study indicated vaccine effectiveness among children with SCD ranged between −6% and 40%.[46] However, it is also possible that clinicians who encounter persons with SCD may have a lower threshold to admit patients with influenza compared with the general population. Indicators of severity of influenza viral infection could be included in future studies comparing admissions of patients with SCD to those from the general population.

Although our study is the largest and most comprehensive study to date estimating influenza vaccination coverage and rates of hospitalization in the SCD population, it has several limitations. First, the study uses a database designed to capture medical encounters for which a Medicaid program or managed care plan was financially responsible and a specified set of criteria to identify encounters of interest; it is not a comprehensive record of care. For example, vaccinations received at free health clinics and not billed to the Medicaid program are not captured in these data nor are costs covered by other health plan providers (e.g., Medicare). Second, the identities of the states submitting data to the MarketScan database are unknown to the investigators. Also, as the number of states contributing data changed over time, decreasing from 13 states in 2009 to 10 states from 2011 through 2015, the validity of assessments of trends over time could be affected. Third, the cross-sectional study design for this descriptive analysis of influenza vaccination coverage and

hospitalizations does not enable the estimation of vaccine effectiveness in reducing severe influenza outcomes, such as hospitalization, as the timing of hospitalization and vaccination are not addressed. Estimation of vaccine effectiveness would require controlling for timing of vaccine administration relative to hospitalization as well as correction for factors that might influence both likelihood of vaccine receipt and hospitalization, such as disease severity and propensity to seek care. Similarly, we cannot comment on differences between severity measures traditionally associated with severe influenza and/or respiratory illness between SCD and non-SCD patients (e.g., hospital length of stay, admission to intensive care unit, intubation, and death). Fourth, while the definition used to identify Medicaid enrollees with SCD has been validated for use in administrative data,[29] some enrollees with SCD might have been erroneously classified as not having SCD. However, because SCD is a rare condition within the overall Medicaid population, any misclassification should have little effect on the results. Fifth, misclassification may extend to definitions of outcomes as well. For example, ACS is a pneumonia-like illness defined by presence of new-onset respiratory clinical findings associated with new infiltrates on chest X-ray. Because of the pneumonia-like presentation of ACS, it is likely some ACS events were recorded as "pneumonia" in the Medicaid claims data. For this reason, a composite outcome of ACS/pneumonia was used to investigate the rates of ACS. Sixth, our study design used Medicaid enrollees without SCD as a comparison group. This does not allow comparison of influenza vaccination coverage or influenza-related hospitalization rates among persons with SCD to that of other conditions that involve immunosuppression, which might help to identify the extent to which SCD-specific factors influence influenza vaccination coverage and hospitalization rates. Finally, the Medicaid data used in this analysis may not represent the broader population with SCD, although the majority of US residents with SCD are enrolled in Medicaid or Medicare.[15]

Further investigations regarding influenza vaccine effectiveness in the SCD population are warranted. Nevertheless, low vaccination coverage among Medicaid enrollees with SCD represents an opportunity to reduce influenza-related morbidity and mortality by implementing efforts to increase seasonal influenza vaccination in this population.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

ACKNOWLEDGMENTS

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from IBM. Restrictions apply to the availability of these data, which were used under license for this study.

Abbreviations:

ACS	acute chest syndrome
CHIP	Children's Health Insurance Program
ED	emergency department
ICD-CM	International Classification of Disease – Clinical Modification
SCD	sickle cell disease
SSI	Supplemental Security Income
TCD	transcranial Doppler.

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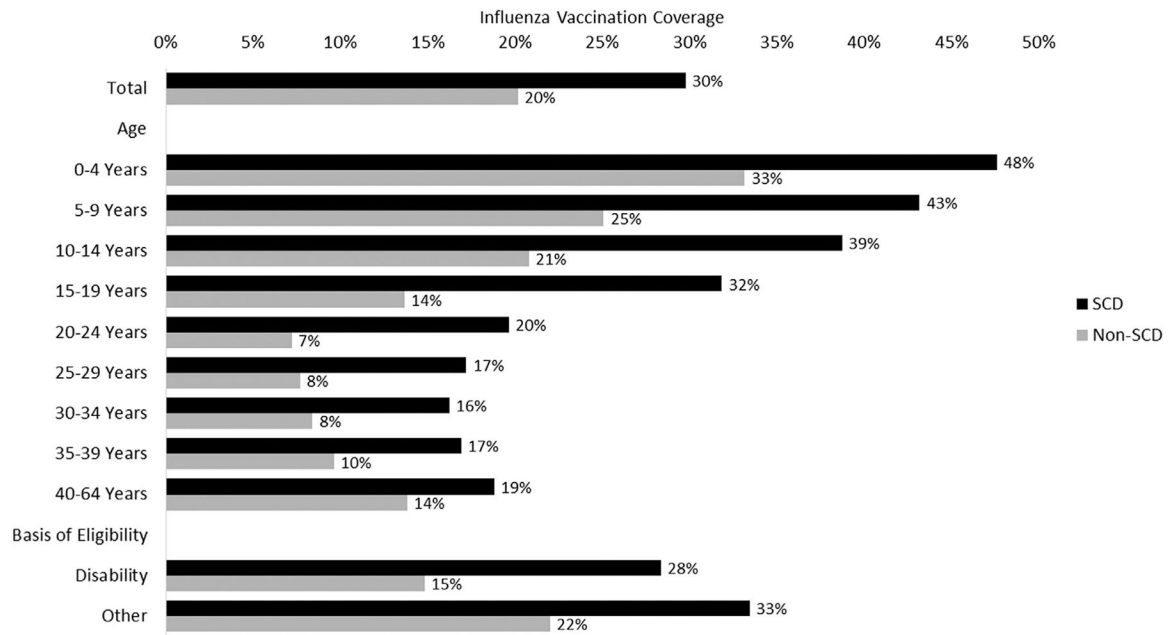
FIGURE 1.
Estimates of influenza vaccination coverage among enrollees in the IBM MarketScan®
Multi-State Medicaid Database with and without sickle cell disease (SCD), overall and by
age group and basis of Medicaid eligibility across influenza seasons 2009–2010 through
2014–2015. SCD: Sickle cell disease; enrollees in the MarketScan Multi-State Medicaid
database with three or more codes for SCD in a 5-year period. Non-SCD: Enrollees in the
MarketScan Multi-State Medicaid database that did not meet the criteria for SCD. Eligibility
for inclusion determined per season based on continuous enrollment 12 months before and
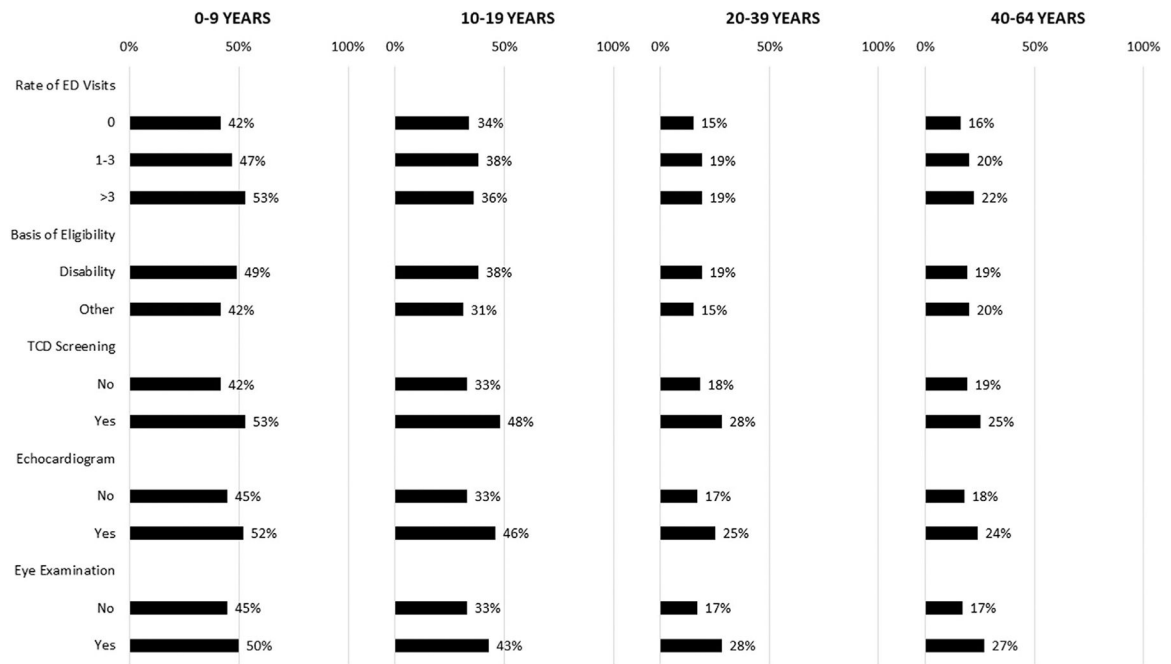12 months after the start of the influenza season
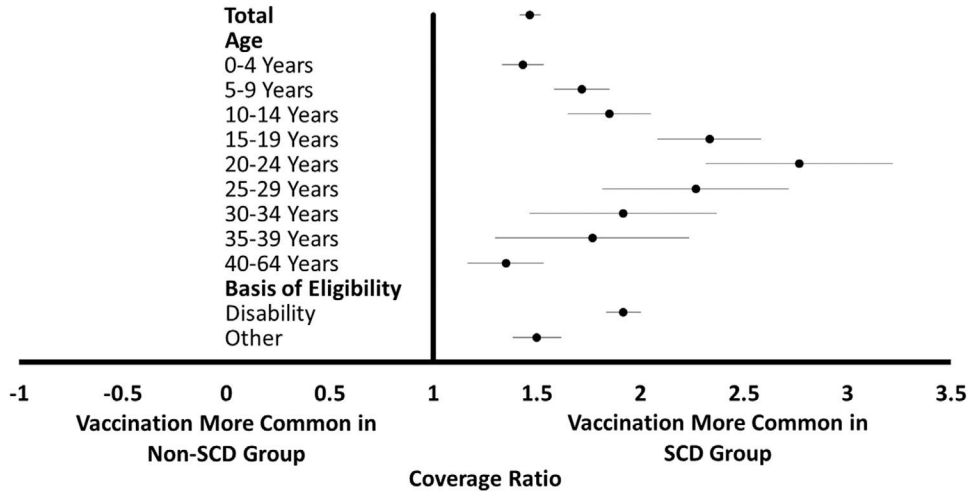
FIGURE 2.

Comparison of influenza vaccination coverage among enrollees in the IBM MarketScan®
Multi-State Medicaid database with and without sickle cell disease (SCD), overall and by
age group and basis of Medicaid eligibility across influenza seasons 2009–2010 through
2014–2015. SCD: Sickle cell disease; enrollees in the MarketScan Multi-State Medicaid
database with three or more codes for SCD in a 5-year period. Non-SCD: Enrollees in the
MarketScan Multi-State Medicaid database that did not meet the criteria for SCD. Eligibility
for inclusion determined per season based on continuous enrollment 12 months before and
12 months after the start of the influenza season. Coverage ratio: Average across all seasons
of the ratio of vaccination coverage among enrollees with SCD to the vaccination coverage
among enrollees without SCD

FIGURE 3.

Differences in vaccination coverage among persons with sickle cell disease (SCD) enrolled in the IBM® MarketScan® Multi-State Medicaid database by markers of care across influenza seasons 2009–2010 through 2014–2015. SCD: Sickle cell disease; enrollees in the MarketScan Multi-State Medicaid database with three or more codes for SCD in a 5-year period. Non-SCD: Enrollees in the MarketScan Multi-State Medicaid database that did not meet the criteria for SCD. Eligibility for inclusion determined per season based on continuous enrollment 12 months before and 12 months after the start of the influenza season

TABLE 1

Season-specific influenza vaccination coverage estimates among enrollees in the IBM MarketScan Multi-State Medicaid database with and without SCD, overall and by patient age and basis of Medicaid eligibility for influenza seasons 2009–2010 through 2014–2015

	2009–2010		2010–2011		2011–2012		2012–2013		2013–2014		2014–2015	
	SCD (%)	Non-SCD (%)	SCD (%)	Non-SCD (%)	SCD (%)	Non-SCD (%)	SCD (%)	Non-SCD (%)	SCD (%)	Non-SCD (%)	SCD (%)	Non-SCD (%)
Total	28.4	20.7	24.5	18.2	30.8	18.8	29.1	21.1	33.6	22.0	32.2	20.4
Age												
0–4 years	46.8	35.5	38.9	30.8	52.7	32.0	48.0	34.5	52.6	35.2	46.6	31.0
5–9 years	42.1	26.4	34.1	21.6	44.9	22.6	42.6	26.5	48.2	27.8	47.2	25.6
10–14 years	35.4	20.0	27.9	17.3	42.4	18.7	41.0	22.2	44.1	24.1	41.6	22.6
15–19 years	29.9	13.1	26.4	11.8	30.5	12.6	30.3	14.6	38.0	15.9	36.0	14.2
20–24 years	19.0	8.3	16.5	7.0	18.2	6.8	18.3	7.3	22.8	7.6	23.2	6.4
25–29 years	17.6	8.8	16.0	7.6	17.4	7.4	16.6	7.7	18.1	7.6	17.6	7.1
30–34 years	14.5	8.8	14.3	8.4	17.2	8.0	14.6	8.5	19.0	8.6	17.9	8.1
35–39 years	17.9	10.2	16.2	9.3	17.8	9.4	13.4	9.7	19.4	9.9	16.8	9.4
40–64 years	16.5	13.4	17.1	13.2	18.0	13.2	18.5	13.9	21.5	14.5	21.3	14.8
Basis of eligibility												
Disability	27.1	13.7	22.5	13.5	29.8	14.1	27.6	15.2	32.2	16.5	30.9	16.0
Other	31.2	22.6	30.4	19.6	34.1	20.4	33.3	23.1	37.5	24.5	34.1	21.8

Note: SCD: Enrollees in the MarketScan Multi-State Medicaid database with three or more codes for SCD in a 5-year period. Non-SCD: Enrollees in the MarketScan Multi-State Medicaid database that did not meet the criteria for SCD. Eligibility for inclusion determined per season based on continuous enrollment 12 months before and 12 months after the start of the influenza season.

Abbreviation: SCD, sickle cell disease.

TABLE 2

Age-standardized rates of hospitalizations for influenza and ACS/pneumonia per 10,000 persons among persons with SCD compared to that of without SCD in the MarketScan Multi-State Medicaid database by influenza season, 2009–2010 through 2014–2015

	Influenza			ACS/pneumonia		
	SCD rate (95% CI)	Non-SCD rate (95% CI)	Rate ratio (95% CI)	SCD rate (95% CI)	Non-SCD rate (95% CI)	Rate ratio (95% CI)
2009–2010	297.4(243.0–351.8)	9.6(9.2–10.1)	31.0 (25.6–37.4)	2153.9(2016.4–2291.4)	108.7 (107.2–110.2)	19.8 (18.6–21.2)
2010–2011	146.7(108.9–184.4)	4.6 (4.3–4.9)	31.8 (24.4–41.5)	1827.4(1708.7–1946.1)	99.2(97.9–100.5)	18.4(17.2–19.7)
2011–2012	43.4 (24.0–62.8)	2.1 (2.0–2.3)	20.3 (12.9–32.0)	1897.9(1779.4–2016.4)	89.1 (87.8–90.3)	21.3(20.0–22.7)
2012–2013	204.5 (163.5–245.5)	6.4 (6.1–6.8)	31.7(25.8–39.0)	2114.8(1992.2–2237.4)	91.6(90.4–92.8)	23.1(21.8–24.5)
2013–2014	115.0 (89.8–140.1)	5.8 (5.5–6.0)	20.0(16.0–25.0)	1935.5 (1838.4–2032.6)	79.2 (78.3–80.1)	24.4 (23.2–25.7)
2014–2015	234.7(197.1–272.2)	5.6 (5.4–5.9)	41.7(35.3–49.2)	1912.0(1811.6–2012.4)	66.6(65.7–67.4)	28.7(27.2–30.3)

Note: SCD: Enrollees in the MarketScan Multi-State Medicaid database with three or more codes for SCD in a 5-year period. Non-SCD: Enrollees in the MarketScan Multi-State Medicaid database that did not meet the criteria for SCD. Eligibility for inclusion determined per season based on continuous enrollment 12 months before and 12 months after the start of the influenza season. SCD rate age-standardized to non-SCD population.

Abbreviations: ACS, acute chest syndrome; SCD, sickle cell disease.