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RESEARCH PAPER

The role of social determinants in timely herpes zoster vaccination among older American adults

Sohul Shuvo[a], Tracy Hagemann[b], Kenneth Hohmeier[b], Chi-Yang Chiu[c], Sujith Ramachandran[d], and Justin Gatwood[b]

[a]College of Graduate Health Sciences, University of Tennessee Health Science Center, Memphis, TN, USA; [b]College of Pharmacy, University of Tennessee, Nashville, TN, USA; [c]College of Preventive Medicine, University of Tennessee Health Science Center, Memphis, TN, USA; [d]School of Pharmacy, University of Mississippi, Oxford, MS, USA

ABSTRACT

CDC recommends that U.S. adults ≥50 years receive the herpes zoster (HZ) vaccine; but few are vaccinated at the recommended age. Little is known about how social determinants of health (SDH) influence timely vaccination. This retrospective observational study included U.S. adults aged ≥50 years who were vaccinated against HZ between 2014 and 2016 from IBM MarketScan commercial claims and Medicare supplemental databases. The cohort was classified into three groups based on age of vaccination: earlier (50–59 years), timely (60–64 years), and later (65+ years). Select SDH data from publicly-available sources were linked and included in multinomial logistic regression assessing the impact of SDH on timely vaccination. The final cohort comprised 549,544 individuals, 49.5% of whom were vaccinated at the age of 60–64. Odds of later HZ vaccination increased with higher poverty (OR: 1.035, 95% CI: 1.031–1.038), more democratic voters (OR: 1.011, 95% CI: 1.010–1.012), and lack of Internet access (OR: 1.028, 95% CI: 1.024–1.032), but decreased with higher health literacy (OR: 0.971, 95% CI: 0.970–0.973). Conversely, higher health literacy and lower poverty were associated with higher odds of earlier vaccination. Being male, not receiving a seasonal influenza vaccine, and higher healthcare utilization were associated with later vaccination. Individuals on an EPO/PPO vs. HMO plan, or who resided in regions other than the Northeast were more likely to receive the vaccine earlier. This study demonstrates the influence of SDH on time of HZ vaccination, but further research is needed to fully understand the impact of SDH on vaccination.

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Adult vaccination; social determinants; herpes zoster; preventive medicine; vaccine hesitancy

Introduction

Receipt of a herpes zoster vaccine helps reduce the risk of debilitating viral complications in adults, such as shingles and postherpetic neuralgia, particularly among those aged 50 years and older.[1] In 2008, the Advisory Committee on Immunization Practices (ACIP) of the US Centers for Disease Control and Prevention (CDC) provided an initial recommendation for adults aged 60 years and older to receive the herpes zoster (HZ) or shingles vaccine.[2] In conjunction with the availability of a recombinant zoster vaccine, ACIP updated its guidance in 2017, lowering the recommended age to 50 years and older.[3] However, despite the availability of two effective vaccines, rates of herpes zoster vaccination remain conspicuously low in the US. As of 2017, approximately one-third of adults 60 years and older had received the vaccine.[4] While this figure is above the established Healthy People 2020 goal for this vaccine, there remains a significant portion of the US population that is at-risk of being impacted by herpes zoster, a condition that is associated with approximately 2.4 billion USD in direct and indirect costs annually.[5]

A key challenge in promoting vaccination against herpes zoster and other vaccines is perceived or actual hesitancy and resistance toward immunization. The rise of vaccine hesitancy has been particularly pronounced in recent years due to the increased skepticism perpetuated by misinformation spread through social media.[6] However, most of the attention studying the effects of this skepticism has been focused online at vaccination of children and adolescents, where the beliefs and attitudes of parents influence the extent to which younger Americans are vaccinated. Arguably, it is equally important to interpret vaccine-seeking behavior in adults, observations of which could help guide policymakers and providers in approaching efforts to encourage appropriate vaccination in older Americans. Initial investigations into predictors of herpes zoster vaccination in adults have suggested that the odds of vaccination are higher among females, adults with more education, those with higher incomes, rural areas residents, "dual-eligible" adults (i.e., having both Medicare and Medicaid coverage), and non-Hispanic Whites.[7–9]

While these initial studies provided important guidance on the likelihood of certain adults to seek herpes zoster vaccination, elements beyond the healthcare system have seldom been the focus of investigations thus far. Such "social determinants of health" (SDH) are being increasingly recognized for their potentially important role in health-seeking behavior. The World Health Organization (WHO) defines social determinants of health as the "conditions in which people are born, grow, work, live, and age,

CONTACT Sohul Shuvo sshuvo@uthsc.edu University of Tennessee Health Science Center, Memphis, TN 38163.
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and the wider set of forces and systems shaping the conditions of daily life."[10] Arguably, multiple elements of this framework overlap with the vaccine hesitancy determinants matrix, also proposed by WHO. This matrix categorizes influencers on vaccine-seeking behavior by contextual, individual/group, and vaccine-specific factors that may contribute to whether an individual is vaccinated.-[11] In supporting such a framework, WHO outlines for researchers a path forward in identifying the factors that may be at play when individuals are making vaccine-related decisions.

In spite of WHO guidance, the role of SDH in adult vaccination has received limited research attention; importantly, recent results suggest the potential presence of localized factors as evidenced by geographic variation in adherence to age-appropriate herpes zoster vaccination.[7] Using a nationwide claims database, the objective of this study was to determine the extent to which select social determinants were related with age-appropriate herpes zoster vaccination across regions of the country. In doing so, analyses will provide initial guidance on whether certain environmental factors are related with herpes zoster vaccination at the recommended age in adults, providing guidance to a range of stakeholders involved with appropriately promoting immunizations in older adults.

Methods

Study design and data source

This retrospective observational study used data from 2013 to 2016 within two IBM MarketScan® databases: the Commercial Claims and Encounters database and Medicare Supplemental and Coordination of Benefits database. These databases include information on patient demographic, health plan, diagnosis, procedures, and healthcare utilization of a nationwide convenience sample of U.S. residents with private health insurance. The databases are de-identified and compliant with the Health Insurance Portability and Accountability Act of 1996. This study was determined to be non-human subjects research by the Institutional Review Board of the University of Tennessee Health Science Center.

Participant selection and measures

Eligible individuals included those aged 50 years or older in any of the years between 2014 and 2016 who had received the HZ vaccine anytime in that period. Despite the recommendation being for adults aged 60 years or older during the study period, 50 or above subjects were included as these population were found to benefit from the vaccine,[1] and to identify predictors of early vaccine-seeking behavior. Subjects were required to be continuously enrolled at least the year before and of vaccination. Those who resided outside a metropolitan statistical area (MSA) were excluded as SDH data were available for only those living in MSAs. Eligible patients were divided into three age groups: earlier vaccination (50–59 years), timely vaccination (60–64 years), and later vaccination (65 years and above) based on 2008 ACIP recommendation for HZ vaccination.[2]

Vaccination was assessed for each participant by evaluating National Drug Codes from their pharmacy claims and Current Procedural Terminology codes from their inpatient and outpatient claims. If multiple HZ vaccination records existed for any patient, only the first vaccination record was retained. Standard demographic characteristics were extracted for comparison and included age, gender, region of residence, and health plan type. Other factors derived from claims included immunocompetency status (diagnosis codes listed in Appendix), influenza vaccine receipt in the year of HZ vaccination, and health resource utilization (e.g., number of inpatient admissions, emergency visits, outpatient visits, and pharmacy visits) in the year prior to the year the patient received the HZ vaccine. Multiple SDH factors were derived from several external sources and used as primary predictors for this study. Earlier research by WHO suggested that a matrix of factors influences vaccine-seeking behavior including contextual, individual/group, and vaccine-specific factors.[7] However, using the WHO matrix to predict individual behavior remains a challenge due to the lack of individual-level data on these factors; consequently, we identified suitable proxies for several factors within the matrix from external, publicly-available sources. The proxy factors included MSA-level estimates for health literacy, presidential election voting records (as a percent of democratic voters), the percent of residents living in poverty, the percent of computer owners, and the percent of residents who lack the Internet access. These SDH data were collected from the University of North Carolina (health literacy), county-level election data compiled by MIT for the 2012 presidential election (voting records by political party), and the American Community Survey (poverty, Internet, and computer ownership).[12–14] The values were originally at census tract or county levels and were averaged across the individual's metropolitan statistical area (MSA) of residence. Such use of geographic proxies to identify the burden of SDH on health outcomes has been applied similarly elsewhere.[15]

Statistical analysis

Descriptive statistics (frequencies and percentages for categorical variables and means and standard deviations for continuous variables) were provided on patient characteristics and three vaccinated groups were compared using t-tests and ANOVA. Multinomial logistic regression provided the odds of earlier and later HZ vaccination using SDH variables as primary predictors and controlling for other covariates. A p-value < 0.05 was set a priori as the threshold for statistical significance. The multinomial logistic regression model was used to determine and plot predicted probabilities of vaccination by age group against each SDH variable. Predicted probabilities provided the assessment of change in preference of age of vaccination with respect to change in the SDH factors keeping control variables fixed at the reference level or mean. All data analyses were conducted in 2020 using SAS, version 9.4 (Cary, NC).

Results

A total of 549,544 individuals met all the inclusion-exclusion criteria and had complete data (Figure 1). Nearly half of the

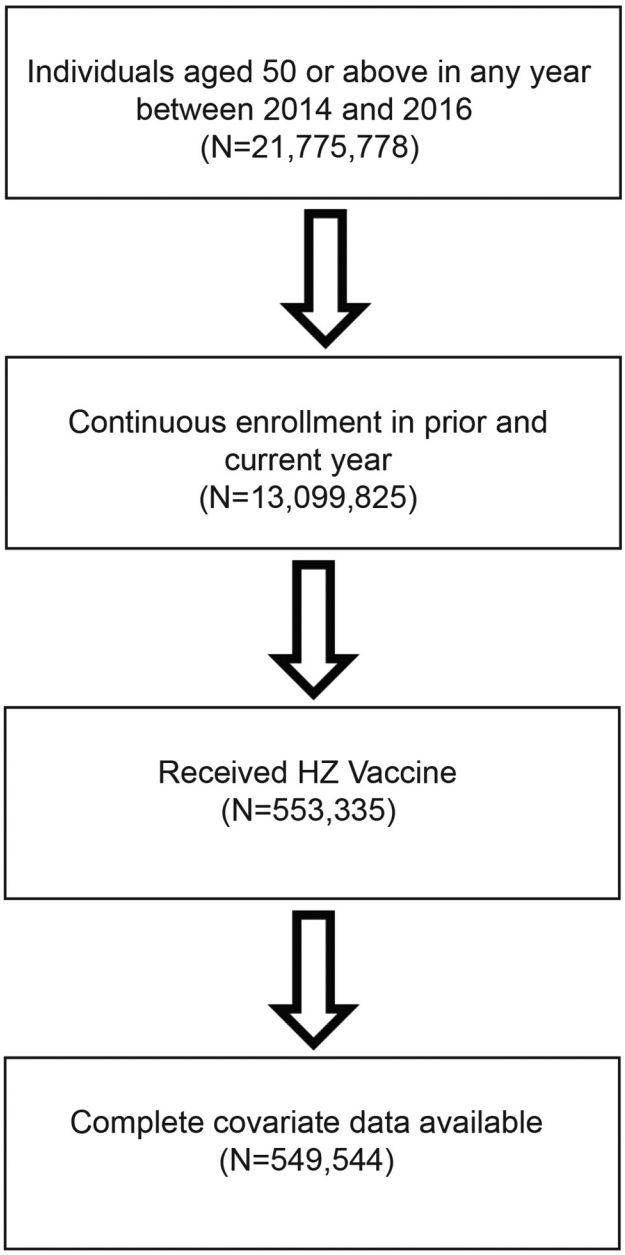

Figure 1. Participant selection.

population (49.5%) belonged to the timely vaccination group (i.e., 60–64 years) (Table 1). A majority of the population across all three groups were female (52–58%) and immunocompetent (75–84%). Approximately half of the earlier and timely vaccination groups received the influenza vaccine in the year of HZ vaccination, but less than one-fourth of those among the later vaccination group had done so over the same time period (Table 1). Compared to the earlier and timely groups, the later vaccination group had higher average pharmacy visits (18.9 vs. 14.1 and 14.1, respectively, $p < .0001$), outpatient visits (16.1 vs. 12.7 and 12.3, respectively, $p < .0001$), inpatient admissions (0.15 vs. 0.06 and 0.07, respectively, $p < .0001$), and emergency visits (0.25 vs. 0.15 and 0.15, respectively, $p < .0001$) (Table 1).

Multinomial logistic regression determined that the odds of later HZ vaccination increased with higher poverty rates (OR: 1.035, 95% CI: 1.031–1.038) and in communities with more democratic voters (OR: 1.011, 95% CI: 1.010–1.012) but decreased with higher estimates of health literacy (OR: 0.971, 95% CI: 0.970–-0.973) in the MSA (Table 2). People with access to technology were less prone to later vaccination as computer ownership had lower odds (OR: 0.986, 95% CI: 0.982–0.989) and lack of internet access had higher odds (OR: 1.028, 95% CI: 1.024–1.032) of later vaccination. Males, those identified as immunocompromised, and adults with no record of influenza vaccination in the year of HZ vaccination were associated with higher odds of later vaccination (Table 2). Higher utilization of any health resource was associated with higher odds of later vaccination.

The odds of earlier HZ vaccination slightly increased with increases in heath literacy (OR: 1.002, 95% CI: 1.000–1.004) but decreased slightly with increases in poverty (OR: 0.992, 95% CI: 0.989–0.995), the proportion of democratic voters (OR: 0.999, 95% CI: 0.998–0.999), and lower proportion of internet access (OR: 0.983, 95% CI: 0.980–0.987) in the MSA. Factors associated with lower odds of earlier vaccination were not being vaccinated against seasonal influenza in the same year (OR: 0.871, 95% CI: 0.859–-0.882), and having more inpatient admissions (OR: 0.870, 95% CI: 0.850–0.890) and pharmacy visits (OR: 0.998, 95% CI: 0.997–-0.998) (Table 2).

Predicted probabilities were obtained to assess the change in preference of time for HZ vaccination with change in SDH values. These probabilities were estimated keeping covariates constant at the reference level (for categorical variables) or at the mean (for continuous variables), i.e. the findings in Figure 2 are for a female living in the Northeast who is on an HMO health plan, is immunocompetent, had received the influenza vaccine in the baseline year, and had average number of pharmacy, outpatient, inpatient, and emergency visits. From Figure 2a, 60–64 years was the most preferred age group for HZ vaccination at any health literacy level and the preference increased with increases in health literacy in the MSA. Age 65 and above was the preferred group over 50–59 years age group until health literacy level of approximately 228, after which the preference flipped. A health literacy level of 228 can be translated to an intermediate health literacy skill as per the National Assessment of Adult Literacy (NAAL),[16] indicating that those with at least intermediate health literacy skills were more likely to vaccinate earlier. The most preferred age group for vaccination was 60–64 at any poverty level although the preference declined as percentage of poverty increased (Figure 2b). In MSAs with up to 28% population living in poverty, earlier vaccination was preferred over later vaccination, but beyond that percent of poverty, later vaccination becomes more preferable. A similar relationship was seen between earlier and later vaccination preference with change in percent population living with lack of Internet access. In MSAs where more than 21% of the population lived with no internet access, later vaccination was more preferable than earlier vaccination, and 60–64 years remained the overall preferred age for vaccination (Figure 2d). Regardless of political view, 60–64 years was the most preferred group for vaccination (Figure 2c). However, the preference for 60–64 and 50–59 groups declined and 65 + group increased with an increase in the percent of the democratic vote in the MSA.

Table 1. Patient population.

Characteristic	Earlier vaccination: 50–59 years (N = 147,355)	Timely vaccination: 60–64 years (N = 272,085)	Later vaccination: 65+ years (N = 130,104)	p-value
Gender				<.0001
Male	61,707 (41.9)	124,273 (45.7)	62,280 (47.9)	
Female	85,648 (58.1)	147,812 (54.3)	67,824 (52.1)	
Region				<.0001
Northeast	23,738 (16.1)	52,046 (19.1)	34,845 (26.8)	
North Central	31,329 (21.3)	57,423 (21.1)	38,343 (29.5)	
South	64,120 (43.5)	111,331 (40.9)	40,496 (31.1)	
West	28,168 (19.1)	51,285 (18.9)	16,420 (12.6)	
Health Plan Type				<.0001
EPO/PPO*	88,776 (60.3)	79,376 (29.2)	53,150 (40.9)	
HMO	16,777 (11.4)	161,143 (59.2)	62,521 (48.1)	
Other¥	41,802 (28.4)	31,566 (11.6)	14,433 (11.1)	
Influenza Vaccination				<.0001
Yes	74,277 (50.4)	128,013 (47.1)	31,078 (23.9)	
No	73,078 (49.6)	144,072 (53.0)	99,026 (76.1)	
Resource Utilization in Baseline Year†				
Outpatient visits	12.7 (13.7)	12.3 (13.1)	16.1 (15.0)	<.0001
Pharmacy visits	14.1 (14.2)	14.1 (13.7)	18.9 (14.8)	<.0001
Inpatient admissions	0.06 (0.31)	0.07 (0.33)	0.15 (0.45)	<.0001
Emergency visits	0.15 (0.57)	0.15 (0.53)	0.25 (0.74)	<.0001
Immunity Status				<.0001
Immunocompetent	124,066 (84.2)	227,951 (83.8)	97,297 (74.8)	
Immunocompromised	23,289 (15.8)	44,134 (16.2)	32,807 (25.2)	

Values are count (% across categories i.e. column %) unless otherwise noted. *P*-value < 0.05 indicates significant difference among the groups.
* EPO = Exclusive Provider Organization, PPO = Preferred Provider Organization
¥ Other group consists of comprehensive, point of service, basic or major medical, and high-deductible health plans
†Mean (SD)

Table 2. Odds of earlier and later herpes zoster vaccination.

	Earlier Vaccination (50–59 years)		Later Vaccination (65+ years)	
Characteristic	Odds Ratio (95% CI)	P-value	Odds Ratio (95% CI)	P-value
Gender				
Male	0.864 (0.852–0.875)	<.0001	1.141 (1.125–1.157)	<.0001
Female	REF		REF	
Region				
North Central	1.256 (1.228–1.285)	<.0001	0.931 (0.910–0.952)	<.0001
South	1.351 (1.321–1.382)	<.0001	0.445 (0.434–0.456)	<.0001
West	1.232 (1.204–1.262)	<.0001	0.469 (0.457–0.481)	<.0001
Northeast	REF		REF	
Health Plan Type				
EPO/PPO	1.029 (1.008–1.051)	.0072	0.795 (0.776–0.813)	<.0001
Other	0.979 (0.957–1.001)	.0612	1.360 (1.327–1.393)	<.0001
HMO	REF		REF	
Immunity Status				
Immunocompromised	0.954 (0.938–0.972)	<.0001	1.537 (1.510–1.565)	<.0001
Immunocompetent	REF		REF	
Health Resource Utilization				
Inpatient Admissions	0.870 (0.850–0.890)	<.0001	1.214 (1.191–1.237)	<.0001
Emergency Visits	1.000 (0.986–1.013)	.9512	1.094 (1.080–1.107)	<.0001
Outpatient Visits	1.004 (1.003–1.004)	<.0001	1.006 (1.006–1.007)	<.0001
Pharmacy Visits	0.998 (0.997–0.998)	<.0001	1.021 (1.021–1.022)	<.0001
Influenza vaccination				
No	0.871 (0.859–0.882)	<.0001	3.090 (3.042–3.138)	<.0001
Yes	REF		REF	
Social Determinants				
Health Literacy	1.002 (1.000–1.004)	.0062	0.971 (0.970–0.973)	<.0001
Poverty	0.992 (0.989–0.995)	<.0001	1.035 (1.031–1.038)	<.0001
Democratic Voters	0.999 (0.998–0.999)	.0005	1.011 (1.010–1.012)	<.0001
Computer Ownership	1.000 (0.997–1.004)	.8317	0.986 (0.982–0.989)	<.0001
No Internet Access	0.983 (0.980–0.987)	<.0001	1.028 (1.024–1.032)	<.0001

Timely vaccination (60–64 years) was used as the reference group.

Discussion

Vaccine hesitancy is a growing worldwide concern.[11] While much of the focus has been toward the outcomes and consequences of hesitancy related to pediatric vaccination, less attention has been paid to vaccine hesitancy in adults.[17,18] This study examined the impact of select social determinants of

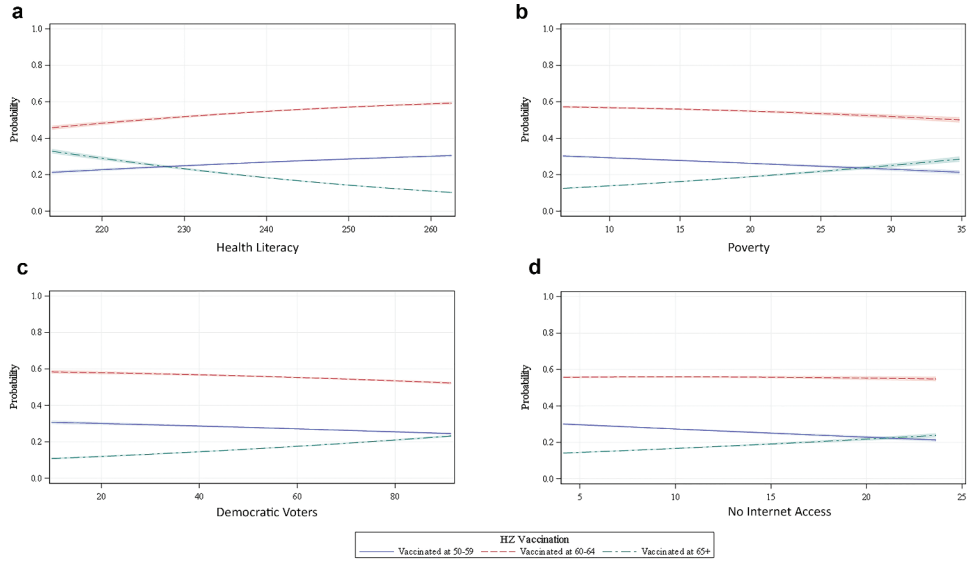

Figure shows change in preference of time for HZ vaccination with change in social determinants of health- 2A) with change in health literacy estimates in the MSA; 2B) with change in percent population living in poverty in the MSA; 2C) with change in percent of democratic voters in the MSA and; 2D) with change in percent population in the MSA who lack internet access.

Figure 2. Predicted probabilities for HZ vaccination by social determinants of health.

health on shingles vaccination across age groups and areas of the country as a means to help in developing effective means to counter adult vaccine hesitancy.

This study adds to only a handful of others which explored herpes zoster vaccine-seeking behavior and hesitancy in the U.S. and abroad. A 2009 survey in the Netherlands found that determinants of vaccine hesitancy included the lack of a formal recommendation by a provider and a patient's perception of a low risk of contracting shingles.[19] Similarly, a 2014 survey in U.S. community pharmacies found that patients were unaware that they needed the vaccine, although the perceived risk of shingles occurrence was only seen in a small minority as opposed to the Netherlands survey.[20] Lastly, in a 2019 survey in the United Kingdom, quality provider recommendation and a perceived risk of shingles were found to be positively associated with zoster vaccination.[21] Of note, the survey sample in the Netherlands perceived disease risk among the eligible population as low and consequently it was a major determinant of vaccine hesitancy, whereas the 2019 U.K. survey found that higher perceived risk was associated with vaccination and highlights the importance of this factor. This may explain in part why differences in vaccine-seeking behaviors across genders became less profound as age increased. Men had a higher probability of becoming vaccinated "later" while women were more likely to be vaccinated "earlier." However, this effect waned as men approached the age of 65. In general, men are less likely to accept preventative care recommendations and vaccine recommendations in particular.[22–25] The waning effect seen here may be related to the increasing incidence of shingles occurrence with age, and it stands to reason that as one ages the chances of first-hand knowledge of someone diagnosed with shingles may also increase.[26]

The importance of provider recommendations is further emphasized in the present study. Vaccination was associated with more frequent visits to the pharmacy and medical offices, most likely due to a higher likelihood of vaccine recommendations being made. Given that pharmacy visits are more frequent than other provider settings, the role of the pharmacist in making quality zoster recommendations on a routine basis may have a large impact on overall zoster vaccination rates.[20,27] ACIP and other professional organizations recommend combining vaccine recommendations to improve vaccine hesitancy (e.g., seasonal influenza vaccination and pneumococcal vaccinations concomitantly administered).[28] Results from the present study support this practice as it leads to earlier vaccination.

Social determinants of health were also found to be significantly linked to vaccination. This is an important finding as limited research has been done linking SDH to vaccinations. The work that has been done has demonstrated that SDH factors such as education, income, and location (underserved areas) negatively impact vaccine status.[29] The present study adds to this, as it was found that poverty, health literacy, living in an area with a majority democrat voter affiliation, computer ownership, and internet access were significant predictors of zoster vaccination. The current study shed light on the cutoff values for each SDH variable where individual's vaccine-seeking behavior alters and helps identify social parameters to consider when designing vaccination policies. For instance, those with health literacy below the intermediate level, or who live in areas where over 28% of the population live below the poverty level or over 21% do not have Internet access are more likely to delay vaccination and may need additional assistance or convincing to seek vaccination in time. These findings also help target and drive vaccination interventions for public health efforts and health plan quality improvements. This is similar to SDH impact on pneumococcal and influenza vaccination. In a recent observational study, individuals residing in high health literacy or democratic voter-rich areas were found to be more likely to receive pneumococcal vaccination.[30] In a recent systematic review of quantitative and qualitative studies on seasonal influenza vaccination, factors including age, gender, sources of information, and social influence were

found to be determinants of vaccination status.[31] Interestingly in the current study, internet access was positively correlated with earlier vaccination and negatively correlated with later vaccination. Computer access did not impact earlier vaccination, but negatively impacted later vaccination. This phenomenon calls for further exploration in future studies, especially in light of the established impact of perceived risk on zoster vaccination, and the current era of social media and post-truth politics.

This study has a few limitations. First, it consisted of only privately insured populations who are either working or have worked and, therefore, the findings may not be generalizable to beneficiaries who are not working or have other or no insurance. Furthermore, rural residents could not be studied as SDH data were not available for them. Also, other social determinants including but not limited to race, employment status, availability of transportation, physical environment etc. could influence HZ vaccination but could not be studied due to unavailability. Cost-sharing components were not controlled which may have influenced vaccine-seeking behavior. Moreover, the SDH factors incorporated are generalized at the MSA level but, the impact of these factors at the patient level may vary. This study aimed to demonstrate a high-level signal first that can be further studied with a deeper level analysis using more granular data. Finally, being an observational study, the current study cannot establish causal relationships between SDH and HZ vaccination. As the recommendation for receiving the vaccine has changed to 50 years of age, the magnitude of the impact of SDH factors may change; although, the direction should not alter.

In conclusion, many Americans receive the HZ vaccine at an older age than recommended or do not receive it at all. Policies focused at improving care for individuals with substandard social determinants of health such as low health literacy, high poverty, and poor access to internet have potential to be effective in mitigating vaccine hesitancy and encouraging early vaccine-seeking behavior. Patients with high healthcare utilization suffer delay in receiving the HZ vaccine, indicating strong advocacy from physicians and pharmacists at every opportunity can significantly improve vaccination. Combining recommendation for HZ vaccine with more widely used vaccines e.g. influenza can greatly improve the timely use of HZ vaccination. Further research is needed for more comprehensive understanding of the impact of social determinants on vaccination.

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ORCID

Sohul Shuvo http://orcid.org/0000-0002-8510-6829
Tracy Hagemann http://orcid.org/0000-0002-5715-9173
Kenneth Hohmeier http://orcid.org/0000-0002-0060-4643
Sujith Ramachandran http://orcid.org/0000-0002-8792-4307
Justin Gatwood http://orcid.org/0000-0002-4801-8555

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