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Disparities in COVID-19 Vaccination Booster Coverage among Healthcare Personnel (HCP) in Urban, Suburban, and Rural Long-Term Care Facilities (LTCF), National Healthcare Safety Network (NHSN), United States, January 2022 – March 2022

George E. Segovia

ABSTRACT

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By

George E. Segovia

May 2, 2023

As of March 2022, only 47% of healthcare personnel (HCP) in U.S. long-term care facilities (LTCFs) have received a COVID-19 booster dose, despite having access to the booster two months before the general population. The slower uptake of COVID-19 boosters among HCP may result from vaccine hesitancy and socioeconomic challenges, which are factors that vary across urbanicity. As previous studies have found lower completion of primary COVID-19 vaccine series among rural communities, it is important to examine if booster uptake vary among HCP, which could help inform where strategies to increase booster uptake are most needed. Using COVID-19 booster data from CDC's National Healthcare Safety Network (NHSN), we quantified the urbanicity (urban, suburban, rural) disparities of HCP booster coverage in LTCFs (n=14,380) between January and March 2022 and examined if these urbanicity disparities vary by proportions of uninsured individuals of the counties where LTCFs are located. A generalized estimating equations (GEE) model was used to obtain prevalence ratios (PR) and 95% confidence intervals (CI) for comparisons of the average percentage of HCP booster dose by urbanicity. Urban LTCFs had higher HCP booster coverage for all reporting weeks than rural LTCFs (PR: 1.24, 95% CI: 1.21, 1.26), with differences becoming larger across the study period. When stratified by county-level uninsured proportions, the urbanicity disparity persists among low and moderate strata. While there was no urbanicity disparity in HCP booster uptake found among LTCFs located in counties with high percentages of uninsured individuals, HCP booster coverage was lower than the national average for these facilities. With the end of the federal COVID-19 emergency declarations in May 2023, there may be additional barriers to accessing COVID-19 boosters for the uninsured, potentially worsening HCP booster uptake and widening coverage disparities if unaddressed. Initiatives to increase booster dose coverage should be highly prioritized among HCP in rural LTCFs and all LTCFs located in counties with high proportions of uninsured individuals to reduce booster disparities.

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APPROVAL PAGE

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Author's Statement Page

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Table of Contents

List of Tables

List of Figures

Chapter I - Introduction

Healthcare personnel (HCP) and residents of long-term care facilities (LTCFs) in the United States (U.S.) have been disproportionately affected by the COVID-19 pandemic. As of January 2022, LTCF residents and HCP constitute at least 23% of all COVID-19 deaths in the United States (Chidambaram, 2022). In September 2021, the U.S. Food and Drug Administration (FDA) authorized the first booster dose of COVID-19 vaccine to enhance protection against emerging COVID-19 variants after completion of primary series vaccination. High-risk individuals aged 65 years and older and individuals ages 18-64 years who experience frequent occupational exposure to COVID-19 were given precedence for booster dose vaccination (FDA, 2021b). Correspondingly, HCP in LTCFs were among the first groups eligible to receive a booster dose. Despite having earlier access to COVID-19 booster doses, booster uptake among HCP in LTCFs has been slower than that of the general population. Across approximately 14,700 U.S. LTCFs that report COVID-19 vaccination data to the Centers for Disease Control and Prevention (CDC), 47% of HCP have received a COVID-19 booster as of March 2022 (CDC, 2023c). For comparison, 46% of the general population have received a COVID-19 booster dose as of March 2022 (CDC, 2023a), despite having access to a COVID-19 booster dose two months after the HCP population on November 2021 (FDA, 2021c). The gradual increase in HCP COVID-19 booster dose coverage may reflect vaccine hesitancy patterns that have been documented among HCP (Pal et al., 2021). Moreover, as vaccination rates differ across the urban-rural spectrum in the general population (Sun & Monnat, 2021), little is known if these geographic disparities are also present in HCP booster dose coverage.

Historically, rural communities are at higher risk of morbidity and mortality from numerous illnesses and health conditions than urban communities (FDA, 2021a). One of the

contributors to urban-rural health disparities is health insurance enrollment, as rural residents are more likely to be uninsured and reluctant to seek medical services as a result (Ziller et al., 2012). Importantly with these existing differences, COVID-19 vaccination uptake has also been lower in rural areas. In a study that analyzed individuals ages five years and older who received their first dose of COVID-19 vaccine as of January 2022, those residing in rural counties had lower first-dose vaccination coverage (58.5%) than those residing in urban counties (75.4%) (Saelee et al., 2022). If not addressed, the urban-rural differences in COVID-19 primary series vaccination may persist and potentially widen as subsequent booster doses become available. Considering the slow COVID-19 booster dose uptake observed among HCP, it is imperative to examine whether booster dose uptake differs across urban, suburban, and rural LTCFs, which would be instrumental in informing where programs for improving vaccine uptake are most needed. Thus, this study aimed to quantify the urbanicity (urban, suburban, rural) disparities of HCP COVID-19 booster coverage in LTCFs over time and examine if these differences vary by proportions of uninsured individuals in the counties where LTCFs reside.

Chapter II - Literature Review

COVID-19 Transmission in LTCFs

The LTCF setting is critical in relation to COVID-19, as the virus can be easily transmitted in communities where individuals are unable to socially distance themselves. For example, nearly 94% of U.S. LTCFs experienced more than one COVID-19 outbreak between May 2020 and January 2021, with 85% of LTCFs experiencing an outbreak lasting five or more weeks (Li, 2022). A separate study that examined U.S. COVID-19 cases during the emergence of the Delta variant of COVID-19 found that cases among nursing homes increased by 440% (from 9,000 to 48,800), whereas cases among the general population increased by 224% (from 1.3 million to 4.2 million) between July and August 2021 (Chidambaram & Garfield, 2021). The drastic increase of COVID-19 cases in LTCFs compared to the general population is alarming, especially when considering the outbreaks that have disproportionally affected LTCFs. The rapid spread of COVID-19 underscores the need for increased prevention measures in LTCFs.

Low COVID-19 Vaccination Uptake among HCP in LTCFs

Vaccination against COVID-19 continues to be one of the most effective ways to prevent the spread of the virus, and is especially important for individuals who live in LTCFs (CDC, 2022b). However, even a few unvaccinated individuals in a congregate setting may pose a considerable risk of COVID-19 infection among the vaccinated. For instance, a LTCF in Kentucky experienced a COVID-19 outbreak due to transmission from an unvaccinated healthcare worker, despite 90.4% of residents having completed their primary vaccination series (Cavanaugh et al., 2021). Consequently, eighteen residents and four HCP who were fully vaccinated were infected with COVID-19. Any unvaccinated healthcare worker could pose COVID-19 transmission risk for all vaccinated residents and HCP as shown in this example,

which is a significant concern as only 52.6% of HCP in the Kentucky LTCF completed their COVID-19 primary vaccination series before the outbreak (Cavanaugh et al., 2021). While campaigns such as the Federal Pharmacy Partnership for Long-Term Care Facilities have helped to increase HCP primary series vaccination coverage, COVID-19 booster coverage among HCP in LTCFs is low (Gharpure, 2021). In a COVID-19 outbreak at a New Jersey LTCF where three residents died on January 2022, none of the HCP received a booster dose (Li, 2022). Faster transmission of emerging COVID-19 variants, compounded with the degree of close contact between HCP and residents, emphasizes the necessity to identify factors contributing to the low COVID-19 booster dose uptake among HCP in LTCFs.

Vaccine Hesitancy among HCP

Vaccine hesitancy is a prevalent issue well-documented in for contributing to the low COVID-19 vaccination coverage observed among HCP in LTCFs (Biswas et al., 2021) (Lee, 2021). A systematic review of 35 international studies found that 22.5% of the literature HCP (n=76,417) worldwide expressed hesitancy in receiving a COVID-19 vaccine (Biswas et al., 2021). The common reasons for vaccine hesitancy among HCP include safety and efficacy concerns, mistrust of the government, and the violation of personal rights (Peterson et al., 2022). Additionally, researchers have found an association between political affiliation and vaccine hesitancy among HCP. A study conducted in Chicago has found that 48.4% of HCP that identified with the Republican party did not intend to be vaccinated compared to 18.7% of HCP that identified with the Democratic party (Toth-Manikowski, 2022). Vaccine hesitancy has also been shown to differ between urban and rural communities. For instance, a survey from the Kaiser Family Foundation revealed that adults in rural areas were approximately twice as likely to report they will “definitely not” receive a COVID-19 vaccine than adults in urban areas

(Sparks, Hamel, et al., 2021). Ultimately, greater vaccine hesitancy in rural areas than urban areas may lead to important differences in HCP COVID-19 vaccine uptake. As studies have shown that HCP vaccine hesitancy toward primary COVID-19 vaccine series persists for booster doses (Farah et al., 2023), it is vital to understand if there is a geographic difference in HCP booster coverage among LTCFs for targeted outreach.

Urban vs. Rural Comparisons of COVID-19 Vaccination Uptake

Numerous studies have documented geographic location as a significant factor in health disparities, and a specific population of concern is the rural community (CDC, 2017). Rural populations frequently experience worse health events than urban populations due to higher rates of poverty, less access to healthcare, and less likelihood of having health insurance (CDC, 2017). As a result of these factors, studies have uncovered key differences in COVID-19 vaccination uptake when comparing urban and rural areas. A U.S. study conducted in August 2021 found that 45.8% of adults in rural counties were fully vaccinated compared to 59.8% of adults in urban counties (Sun & Monnat, 2021). A separate analysis conducted in January 2022 found that across U.S. counties, 48% of rural residents were fully vaccinated as opposed to 61% of urban counties (USDA, 2022). The urban-rural disparities in COVID-19 primary vaccine uptake present in the general population are concerning, as they may possibly present similar uptake patterns among HCP. Researchers have reported that HCP surrounded by COVID-19-vaccinated colleagues and community members are more willing to receive a vaccine due to increased confidence in the vaccine's safety and efficacy (Harrison et al., 2021). Accordingly, LTCFs in urban areas may have higher HCP COVID-19 booster dose coverage than LTCFs located in rural areas based on current vaccination uptake differences. However, no study to date has compared the urban and rural differences in COVID-19 vaccination booster coverage among HCP in the LTCF setting.

The limited studies that have assessed COVID-19 booster dose coverage among the general population have shown inconclusive results. A U.S. survey on November 2021 found that 14% of adults living in rural areas had received a COVID-19 booster dose compared to 18% of adults from urban areas (Sparks, Hamel, et al., 2021). Additionally, a study performed between December 2020 and January 2022 among the general population found similar booster vaccination uptake among urban (50.4%) and rural (49.7%) counties (Saelee et al., 2022). Notably, these studies were conducted around the time when the FDA authorized the first COVID-19 booster dose for all individuals 18 years and older (November 2021), therefore the data may have been limited due to the short period of time after the boosters became available (FDA, 2021c). As research has shown that vaccination disparities increase over time (Saelee et al., 2022), longitudinal studies that measure COVID-19 booster uptake are necessary.

The Need to Study COVID-19 Vaccination Uptake in Suburban Communities

Suburban areas are referred to as municipalities with more than 2,500 people in a Metropolitan Statistical Area (MSA) that are located outside of principal cities, although this definition has varied across research (Schnake-Mahl & Sommers, 2017). While much of the literature regarding COVID-19 disparities has focused on urban and rural populations, suburban populations are understudied. In general, suburban populations are often under-reported in the literature as they are typically grouped within urban categories. However, substantial statistics have emerged that warrant exploration of suburban communities independently from urban areas (Schnake-Mahl & Sommers, 2017). Due to the recent population shift in the U.S. where an increasing number of urban residents are relocating to suburban areas, an estimated 49% of the U.S. population lives in suburbia (L'Heureux Lewis-McCoy et al., 2023). With nearly half of Americans now living in suburban areas, poverty has emerged as a health threat in these

communities. According to the 2020 U.S. Census Bureau, 16.2 million individuals live below the federal poverty line in suburban neighborhoods, compared to 15.1 million in urban neighborhoods (Shrider et al., 2021).

Poverty has profound implications on health, especially on the availability of healthcare services. Evidence shows that after accounting for poverty rates, healthcare services and infrastructures primarily serving the low-income population are scarce in suburban areas (Schnake-Mahl & Sommers, 2017). Moreover, among affluent suburban communities with abundant healthcare services, research indicates that more physicians practicing in suburban areas are less willing to treat uninsured and Medicaid recipients than physicians practicing in urban areas (Felland et al., 2009). Poverty coupled with limited public transportation systems in suburban neighborhoods (Schnake-Mahl & Sommers, 2017) creates unique barriers to healthcare that require different solutions than urban and rural areas. The barriers to healthcare for persons experiencing poverty in suburban communities may have considerably limited the uptake of COVID-19 booster doses in this population and widened the booster coverage differences across the urban-rural spectrum. Nonetheless, little to no research provides insight into COVID-19 booster uptake in the suburban population. While poverty and insufficient access to healthcare may not be factors that affect HCP, measuring HCP COVID-19 booster coverage can provide an initial understanding of vaccine uptake among suburban communities and render a more extensive analysis of urbanicity disparities.

Accounting for Health Insurance in COVID-19 Vaccination Coverage Disparities

Although COVID-19 vaccines are free of charge to Americans, cumulative studies have shown that health insurance status is associated with COVID-19 vaccination rates. A national survey in May 2021 found that Americans under 65 without health insurance comprise 25% of

the COVID-19 unvaccinated population (Sparks et al., 2021). A separate study using data from the Household Pulse Survey between May and July 2021 revealed that 59.2% of uninsured individuals, compared to 80.8% of insured individuals, received at least one dose of the COVID-19 vaccine (Steege et al., 2022). The lower vaccination uptake observed among the uninsured has also persisted in COVID-19 booster doses, as a report found lower booster uptake among adults without health insurance (Lu et al., 2023). Surprisingly, a considerable amount of HCP were also found to be uninsured (approximately 600,000) based on a 2018 American Community Service (Price, 2020). Based on the presented evidence, the large number of uninsured HCP may have a significant role in the uptake of the COVID-19 booster dose.

Studies have also documented different health insurance coverage across U.S. geographic counties, which may be important to consider in describing urbanicity disparities of COVID-19 vaccination coverage. Researchers have found higher COVID-19 vaccination rates in U.S. counties with higher health insurance coverage among residents (Hu et al., 2022). Furthermore, studies have shown that there are higher proportions of uninsured individuals living in rural and suburban counties than urban counties (Schnake-Mahl & Sommers, 2017) (Murthy et al., 2021). Nonetheless, little is known whether health insurance impacts urban-rural disparities in COVID-19 vaccination coverage, especially among HCP in LTCFs. Therefore, to better comprehend the disparities in COVID-19 booster coverage across urban, suburban, and rural areas, there is a need to account for health insurance status.

Overall Study Objectives

The overarching objective of this study sought to describe the COVID-19 booster dose vaccination rate among HCP in LTCFs by urbanicity and by insurance status of the facility's

county to complement the current literature which mainly focuses on primary vaccination series. Our study had the following specific aims and corresponding hypotheses:

Aim 1: To compare the COVID-19 booster dose coverage among HCP in urban, suburban, and rural LTCFs and describe how they change over time.

Hypothesis 1: COVID-19 booster coverage among HCP will be lowest in rural LTCFs and highest in urban LTCFs throughout the study period, and urbanicity disparities in COVID-19 booster coverage among HCP will widen over time.

Aim 2: To examine the extent of differences between urban, suburban, or rural LTCFs regarding HCP booster dose uptake by the proportion of health insurance coverage in the LTCF's county of residence.

Hypothesis 2: Urbanicity differences in COVID-19 booster coverage among HCP will be most apparent in LTCFs located in counties with a high proportion of uninsured individuals, and the differences will be smaller in LTCFs located in counties with a low proportion of uninsured individuals.

Chapter III - Methods and Procedures

Data Source

Our study cohort was established using HCP COVID-19 vaccination data from CDC's National Healthcare Safety Network (NHSN) (CDC, 2022a). In December 2020, COVID-19 vaccination modules were introduced in NHSN to allow U.S. LTCFs to voluntarily report facility-level COVID-19 vaccination data on HCP. However, since May 2021, an interim final rule published by the Centers for Medicare and Medicaid Services (CMS) made it mandatory for CMS-certified LTCFs (n=15,382) to report weekly COVID-19 vaccination data to NHSN (Center for Clinical Standards and Quality/Quality, Safety & Oversight Group, 2021). LTCFs self-report cumulative weekly COVID-19 vaccination data on the following HCP: all staff employed directly by the facility, licensed independent practitioners (physicians, advanced practice nurses, and physician assistants), adult students/trainees and volunteers, and other contract personnel (CDC, 2022a).

Study Population

Our study considered all active CMS-certified LTCFs that were required to report weekly for inclusion. HCP were included in the study if they completed their primary COVID-19 vaccine series per the eligibility requirements to receive a booster dose. Complete COVID-19 primary series vaccination was defined as receiving dose 1 and dose 2 of COVID-19 vaccines requiring two doses for completion or one dose of COVID-19 vaccine requiring one dose of completion (CDC, 2022a). COVID-19 booster dose was defined as a dose of COVID-19 vaccine that is administered after completion of primary COVID-19 vaccine series. In addition, we only included HCP who worked at the LTCF for at least one day during a week of data collection.

Since the outcome of interest of this study is the HCP coverage of the first booster dose of COVID-19 vaccine among LTCFs authorized by the FDA in September 2021 (FDA, 2021b), the study period was restricted to January 3, 2022 to March 27, 2022 to prevent influences of the second booster dose approved by the FDA on March 29, 2022 (FDA, 2022a). Accordingly, each LTCF included in this study had twelve repeated measurements of the HCP percentage who received the first booster dose, corresponding to the twelve reporting weeks of the study period. We adopted the following exclusion criteria to ensure the reporting data quality during the study period. We first excluded LTCFs (n=195) that did not report any COVID-19 vaccine data for weeks in January through March 2022. Then, 584 LTCFs were excluded for not reporting COVID-19 vaccination data during all twelve weeks of the study. A total of 58 LTCFs were also excluded for reporting at least once that no HCP worked at the facility for a given reporting week. This exclusion criterion was established to remove any LTCFs that may skew the data due to temporary facility closures or other service interruptions. Moreover, the mean number of HCP that have worked at the facility across the twelve reporting weeks was calculated for each LTCF to use as a basis of comparison. If a LTCF reported a number of HCP who worked at the facility that was 50% less than or greater than the mean for more than one reporting week, they were excluded from the study. As a result, a total of 137 LTCFs were removed from the study. This exclusion aimed to remove the LTCFs that may have experienced a significant decrease in HCP due to staff shortages or a significant increase in HCP due to the assistance of temporary staff during medical surges. An additional 28 LTCFs located in Puerto Rico (5), Guam (1), Alaska (4), New York (1), Oregon (1), and Washington DC (16) were removed from the study as they did not have a corresponding county-level FIPS code in the NCHS Urban-Rural Classification Scheme or the CDC/ATSDR Social Vulnerability Index datasets. After all exclusions, there were

172,560 observations from 14,380 U.S. LTCFs in the final NHSN LTCF HCP dataset of this study. The study proposal was reviewed and approved by the Research Ethics Board of Georgia State University (appendices).

Exposure and Outcome Measurement

This study's main exposure of interest is urbanicity status according to the LTCF's location (urban vs. suburban vs. rural), which was obtained from the 2013 NCHS Urban-Rural Classification Scheme. The NCHS Urban-Rural Classification Scheme classifies all U.S. counties into six levels: four for metropolitan counties and two for nonmetropolitan counties (Ingram & Franco, 2014). Using county-level Federal Information Processing System (FIPS) codes, the Urban-Rural Classification Scheme dataset was merged with the NHSN LTCF HCP dataset, linking LTCFs to one of six categories from the Urban-Rural Classification Scheme based on their county of residence. We further categorized county-level urbanicity into three levels: urban (large central metropolitan and large fringe metropolitan counties), suburban (medium metropolitan and small metropolitan counties), and rural (micropolitan and non-core counties). Therefore, all LTCFs were assigned to either the urban, suburban, or rural category in the final dataset. The outcome of interest was defined as the percentage of staff that have received the first COVID-19 booster dose among HCP who have completing their primary COVID-19 vaccine series.

Covariates

The Social Vulnerability Index (SVI) provides county-level rankings using percentiles ranging from 0-1 that indicate a county’s relative social vulnerability for different demographic and socioeconomic variables (CDC/ATSDR, 2020). The SVI dataset was merged with the

NHSN LTCF HCP dataset by FIPS codes of the LTCF's county. Based on the literature, we identified four important variables from the SVI index: no health insurance (uninsured), living below the 150% federal poverty line, no high school (HS) diploma, and no household vehicle ownership. Each SVI variable was categorized into three levels based on tertiles calculated from the distribution of SVI ranking scores of the LTCFs: (1) No health insurance: LTCFs with a low percentile ranking (0.01-0.24) for the percentage of uninsured individuals in their residing county were assigned to the low uninsured vulnerability level, LTCFs with a moderate percentile ranking (0.25-0.56) were assigned to the moderate uninsured vulnerability level, and LTCFs with a high percentile ranking (0.57-0.99) were assigned to the high uninsured vulnerability level. (2) Living below the 150% Federal Poverty Line: Low Poverty Vulnerability Level (0.01-0.25); Moderate Poverty Vulnerability Level (0.26-0.53); High Poverty Vulnerability Level (0.54-0.99); (3) No HS Diploma: Low Absence of HS Education Vulnerability Level (0.01-0.30); Moderate Absence of HS Education Vulnerability (0.31-0.57); High Absence of HS Education Vulnerability (0.58-0.99). (4) No Vehicle: Low Absence of Transportation Vulnerability Level (0.01-0.46); Moderate Absence of Transportation Vulnerability Level (0.47-0.77); High Absence of Transportation Vulnerability Level (0.78-0.99). Correspondingly, all LTCFs were assigned to a vulnerability level for each SVI covariate according to the percentile ranking received by their county of residence.

Statistical Analyses

A descriptive analysis was conducted to first describe the characteristics of the LTCFs based on the urbanicity and the four SVI variables. The weekly average percentage of HCP that have received a booster dose was also calculated for urban, suburban, and rural LTCFs to describe the differences in booster dose coverage over time during the study period. A

generalized estimating equations (GEE) model was constructed to obtain prevalence ratios and 95% confidence intervals for all pairwise comparisons of the average percentage of HCP booster dose coverage by urbanicity (Suburban LTCFs vs. Rural LTCFs, Urban LTCFs vs. Rural LTCFs, and Urban LTCFs vs. Suburban LTCFs) (Zeger et al., 1988). A GEE model was chosen to consider the correlations among the twelve repeated measurements of the percentage of COVID-19-boosted HCP reported from the same LTCF.

The GEE model was specified with a negative binomial distribution, a log link function, and numbers of weekly eligible HCP as the offset to model the over-dispersed count outcome variable; the mean number of HCP that have received a COVID-19 booster dose was less than its variance. An autoregressive (AR1) correlation matrix structure was specified for the GEE model as measurements reported for consecutive weeks were more correlated than measurements reported several weeks apart. We further calculated the pairwise correlation coefficients among the three prespecified SVI variables (living below the 150% federal poverty line, no high school diploma, and no vehicle). High correlations were found among the three covariates; therefore, living below the 150% federal poverty level was the only covariate included in the GEE model. An adjusted GEE model that controlled for living below the 150% federal poverty line and reporting weeks was used to assess the interaction between urbanicity and the proportions of uninsured individuals. Adjusted prevalence ratios for all pairwise comparisons of the urbanicity variable were obtained for each uninsured vulnerability level to examine whether differences in HCP booster dose uptake across urban-suburban-rural LTCFs depend on uninsured vulnerability levels. All analyses were conducted using SAS statistical software (version 9.4; SAS Institute), and statistical significance was defined at an alpha level of 0.05 (two-tailed).

Chapter IV - Results

Among the 14,380 LTCFs included in the study, 41.5% of LTCFs were located in urban communities, 30.4% were in suburban communities, and 28.1% were in rural communities (Table 1). A majority of urban LTCFs were in counties with a low proportion of individuals living below the 150% federal poverty line, do not have a high school diploma, are uninsured, and in counties with a high proportion of households that do not own a vehicle. Most suburban LTCFs were in counties with a moderate proportion of individuals that do not have a high school diploma, are uninsured, and live in households that do not own a vehicle. Furthermore, suburban LTCFs were primarily in counties with a high proportion of individuals living below the 150% federal poverty line. In terms of rural LTCFs, most of them were located in counties with a high proportion of individuals that live below the 150% federal poverty line, do not have a high school diploma, are uninsured, and in counties with a low proportion of households that do not own a vehicle (Table 1).

Across all reporting weeks, HCP booster dose coverage was the highest for urban LTCFs and lowest for rural LTCFs. Weekly HCP booster dose coverage among suburban LTCFs was slightly higher than rural LTCFs but lower than urban LTCFs (Figure 1). Additionally, the differences in HCP booster dose coverage between urban, suburban, and rural LTCFs increased over time. At the first reporting week (January 3 – January 9, 2022), HCP booster coverage was similar among urban LTCFs (31.2%), suburban LTCFs (28.8%), and rural LTCFs (28.5%) (Table 2). However, during the last reporting week (March 21 – March 27, 2022), 52.4% of HCP had received a COVID-19 booster dose among urban LTCFs, followed by 44.2% of HCP among suburban LTCFs, and 39.5% of HCP among rural LTCFs. With small differences between urban and rural LTCFs (approximately 3%) early in the study period, the difference in HCP COVID-19

booster dose coverage between urban and rural LTCFs was nearly thirteen percent at the end of the study period (across twelve weeks), highlighting the widening urbanicity disparities over time.

Unadjusted Model

From the unadjusted GEE model that compared the average percentage of HCP booster dose coverage among urban, suburban, and rural LTCFs, all prevalence ratios (PR) were statistically significant (Table 3). Compared to the rural LTCFs, a 24% increase (PR: 1.24, 95% confidence interval (CI): 1.21, 1.26) and an 8% increase (PR: 1.08, 95% CI: 1.05, 1.10) in the average percentage of HCP that have received a booster dose were found in urban LTCFs and suburban LTCFs, respectively. Urban LTCFs showed higher booster dose coverage than suburban LTCFs (PR: 1.15, 95% CI: 1.12, 1.17).

Adjusted Model with Interaction

To further examine whether county-level uninsured proportions modified urbanicity disparities on HCP booster coverage, we included the interaction term between urbanicity and county-level uninsured proportions in a GEE model that also adjusted for county-level proportion of living below the 150% federal poverty line and reporting weeks. We found the interaction term was statistically significant ($p<.0001$).

Among LTCFs located in counties with a low proportion of uninsured individuals, compared to rural LTCFs, HCP booster dose coverage in suburban LTCFs (PR: 1.11, 95% CI: 1.07, 1.15) and urban LTCFs (PR: 1.14, 95% CI: 1.10, 1.18) were significantly higher. Among LTCFs located in counties with a moderate proportion of uninsured individuals, urban LTCFs have higher HCP booster dose coverage when compared to rural LTCFs (PR: 1.24, 95% CI: 1.20, 1.28) and suburban LTCFs (PR: 1.23, 95% CI: 1.19, 1.27), respectively. The HCP booster

dose coverages were similar and there were no statistically significant prevalence ratios for any urbanicity comparisons among the high uninsured proportion strata (Table 3). Figure 2 displays the weekly average HCP booster coverage by reporting weeks among urban, suburban, and rural LTCFs, stratified by county-level uninsured proportions. The extent of the urbanicity disparities in HCP booster dose coverage varied by county-level proportions of uninsured individuals across the entire study period.

Chapter V - Discussion

Our study found lower HCP booster dose coverage among suburban and rural LTCFs than urban LTCFs for all weeks between January and March 2022. The urbanicity disparities in HCP COVID-19 booster coverage also increased throughout the study. When stratified by county-level uninsured proportions, the urbanicity disparities persist among the low and moderate uninsured strata. No urbanicity disparities were found among LTCFs located in counties with high percentages of uninsured individuals; however, HCP booster coverage among these facilities was lower than the national HCP booster coverage among LTCFs. As emerging COVID-19 variants elevate the risk of COVID-19-related illness, it is imperative for HCP in LTCFs to receive COVID-19 boosters to protect the populations they serve.

The urban-rural differences in socioeconomic indicators presented in this study were consistent with the literature (CDC, 2017). Urban LTCFs were frequently located in counties with low proportions of individuals that live below the 150% poverty line, are without a school diploma, and are uninsured. The opposite was true for rural LTCFs, as they were primarily located in counties with high proportions of individuals who live below the 150% federal poverty line, have no high school diploma, and are uninsured. Although federal policies and strategies have been implemented in recent years to reduce the socioeconomic differences between urban and rural areas (Whitman et al., 2022), these discrepancies persist in the present, as shown by our study that analyzed more contemporary data. Our study results of low HCP COVID-19 booster coverage found among rural LTCFs also serve as an example of poor preventive health behaviors among rural communities that have been consistently documented in the literature. Throughout our study period, rural LTCFs had consistently lower HCP COVID-19 booster uptake than urban LTCFs, which is similar to the urban-rural disparities in primary COVID-19 vaccine series

among the general population. Since similar urban-rural differences in COVID-19 vaccine uptake were observed in both HCP and the general population, future studies are warranted to focus on examining if socioeconomic vulnerability can explain these urban-rural disparities.

A majority of suburban LTCFs were in counties with high proportions of individuals living below the 150% federal poverty level, supported by previous studies that have reported higher poverty rates among suburban communities (Shrider et al., 2021). Furthermore, our study contributes to the growing literature calling for the separation of suburban communities from urban communities in research (Schnake-Mahl & Sommers, 2017). There was an approximately eight percent difference in HCP booster dose coverage between urban and suburban LTCFs at the end of the study period. This distinct difference could have been masked if suburban areas were grouped with urban areas in the analyses. Thus, further exploration is needed to identify the factors that are contributing to lower COVID-19 booster uptake among suburban.

In addition to the socioeconomic disadvantages that rural communities encounter, vaccine hesitancy may be one of the possible reasons that explain the lower HCP COVID-19 booster coverage among rural LTCFs in this study. Researchers have suggested that the low COVID-19 vaccine uptake in rural areas may be explained by higher rates of vaccine hesitancy in rural areas (Kirzinger et al., 2021). Considering the high rates of COVID-19 vaccine hesitancy documented in the HCP population (Gu et al., 2022), it is likely that vaccine hesitancy has a role in the low HCP booster coverage observed among rural LTCFs. A previous study has found HCP who were hesitant to receive primary COVID-19 vaccination were just as reluctant to receive their COVID-19 booster dose (Farah et al., 2023). Although the current study did not measure vaccine hesitancy among HCP, the presented evidence alludes to the importance of exploring whether vaccine hesitancy results in the differing HCP booster coverage among urban-rural

LTCFs. One study reported increased trust in COVID-19 vaccines among HCP who work or interact with other vaccinated HCP (Harrison et al., 2021). Therefore, initiatives to reduce HCP booster dose differences across urban, suburban, and rural LTCFs should consider incorporating interaction with vaccinated HCP to help increase overall vaccine confidence among healthcare staff.

The urbanicity disparities of HCP COVID-19 booster coverage in LTCFs became wider as the study progressed, corroborating previous research that has also reported increasing urban-rural vaccination uptake differences over time (Saelee et al., 2022). Urban LTCFs had higher weekly increases in HCP COVID-19 vaccination coverage than suburban and rural LTCFs, resulting in widening disparities over time. While underlying urban-rural differences in socioeconomics and vaccine hesitancy may have important roles in COVID-19 vaccination disparities, mandates may also be one of the significant factors in the observed differences. Although the federal mandate detailed in the CMS interim final rule has required COVID-19 primary series vaccination for HCP in LTCFs, it has not been extended to include booster doses (Federal Register, 2021). Nonetheless, a Kaiser Family Foundation analysis from January through March 2022 found that there was a significant increase in HCP booster coverage after state mandates. The states of Connecticut, Massachusetts, New Jersey, New York, and California that mandated receipt of a booster dose among HCP reported a greater than 30 percentage point increase in HCP booster uptake among LTCFs between January and March 2022, compared to the national increase of 17 percent (Chidambaram & Musumeci, 2022). Of note, these five states have high proportions of their population living in urban areas (statistics in 2010, Iowa State University, n.d.). Researchers also found that employer-based mandates were more common in urban areas than rural areas (Sparks, Hamel, et al., 2021). Therefore, the higher increase in HCP

booster dose uptake among urban LTCFs observed in this study may reflect the impact from the HCP booster mandates. State leaders and employers should consider booster mandates for HCP in areas with a primarily suburban or rural population to increase booster uptake.

In counties with a high proportion of uninsured individuals, the effect of urbanicity on HCP booster dose coverage was not statistically significant. Although no urbanicity booster disparities were found among LTCFs residing in counties with high uninsured proportions, we should be aware that the HCP booster coverage among these facilities was lower than the mean of overall HCP booster coverage. By the end of March 2022, LTCFs located in counties with high proportions of uninsured individuals reported HCP booster coverage below 35%, much lower than the 47% reported across all CMS-certified LTCFs (CDC, 2023c). The low HCP booster coverage discovered among LTCFs in the high uninsured strata is alarming, as being uninsured has been shown to hinder the accessibility of healthcare services (CDC, 2017). A previous study also found associations between uninsured status and poor access to healthcare services across all urbanicity levels (Ziller et al., 2012). As a result, the low HCP booster coverage observed among counties with high proportions of uninsured individuals may allude to more difficulties in accessing COVID-19 booster doses, regardless of urbanicity. As many HCP are uninsured (Price, 2022), initiatives to increase booster dose accessibility for HCP should be highly prioritized among LTCFs residing in areas of high proportions of uninsured individuals.

Implications

The Biden administration has announced that the federal public health emergency declaration for COVID-19 will expire on May 11, 2023 (HHS, 2023). Consequently, the emergency federal funds used to purchase the COVID-19 vaccines and boosters that are offered free of charge to Americans are in jeopardy. If the current supply of federally purchased COVID-

19 vaccines is depleted without the necessary funds to replenish, the vaccines could become at risk of being commercialized (Kates et al., 2023). The commercialization of COVID-19 vaccines would have negative implications for the uninsured population, as it may leave them with no other options but to pay out-of-pocket to receive a COVID-19 booster dose. The cost would present an additional barrier to COVID-19 vaccination, potentially affecting millions of uninsured Americans. As a result, the urbanicity disparities and low HCP booster coverage found among the uninsured in this study may worsen and lead to increased susceptibility to future COVID-19 variants. The current administration has recently requested supplemental emergency funding to continue purchasing COVID-19 vaccine and booster doses (White House, 2022); however, Congress has yet to approve (Kates et al., 2023). The findings presented in this study can support public health leaders in advocating for the congressional support of supplemental federal funds to ensure COVID-19 vaccine equity for all Americans.

Although this study focused on identifying the urbanicity disparities of booster dose coverage among HCP, the findings may also have implications among the general population. HCP are leaders in the healthcare industry and are often among the limited reliable sources of health information for individuals. For instance, one study reported that 86% of rural residents trust their healthcare providers for reliable information on COVID-19 vaccines (Kirzinger et al., 2021). As such, HCP are among the most trusted sources of health information and have a critical role in vaccine acceptance among their community (Latkin et al., 2021). Researchers have documented higher rates of COVID-19 vaccine acceptance and uptake among individuals who received recommendations from healthcare workers (Finney Rutten et al., 2021). Due to HCP's influence on the opinions of COVID-19 vaccines, the urbanicity disparities and low booster coverage found among HCP may reflect current vaccine uptake patterns among the

general population. If HCP choose not to receive a COVID-19 booster, they are unlikely to recommend it to their patients, which can affect booster uptake among the community. As a result, booster disparities may already be prevalent among the general population due to the lower HCP COVID-19 booster uptake found among suburban and rural LTCFs. The HCP booster disparities observed among the uninsured may also lead to wider booster disparities in the broader population due to increased barriers to healthcare access. Therefore, increasing HCP booster uptake should be prioritized as a strategy that can also influence higher booster uptake and reduce disparities among the general population.

Limitations

This study is subject to several limitations. First, the number of HCP that have completed primary COVID-19 vaccine series and the number of HCP that have received a booster dose were self-reported weekly by LTCFs. Consequently, there may have been data entry errors or inaccurate counts that could have underestimated or overestimated the HCP booster dose coverage among LTCFs. Second, person-level data was unavailable as LTCFs only reported aggregate data weekly to NSHN. As a result, HCP that worked at multiple facilities in a given week may have been counted more than once in calculations for average HCP booster dose coverage among LTCFs. Third, the NHSN LTCF dataset does not distinguish HCP that received an additional COVID-19 primary dose from HCP that received a COVID-19 booster dose, which can affect the interpretation of these findings. As counts of booster doses and additional doses are combined into one variable in the NHSN dataset, accurate receipt of COVID-19 booster doses among HCP could not be discerned. Fourth, data on facility-specific COVID-19 booster mandates were unavailable, therefore, we were not able to account for their effect on HCP booster uptake in the analyses. Lastly, the NCHS Urban-Rural Classification Scheme dataset

used in this study was published in 2013. The counties classified as rural in 2013 may no longer be rural in 2023, which could have affected this study's urbanicity classification of LTCFs. An update of the NCHS Urban-Rural Classification Scheme dataset will be released in 2024, which can provide a more contemporary view of the urbanicity disparities in COVID-19 booster dose coverage.

Future Studies

The current study serves as a resource to guide the ongoing efforts that address COVID-19 vaccine disparities among the nation and as a foundation for future research. The HCP population was chosen to study the uptake of the first COVID-19 booster due to more available data resulting from their earlier access to the booster dose. Nonetheless, as time has passed and more data has been collected, it is also important to monitor COVID-19 booster uptake among the general population and assess if booster disparities are similar to those identified in this study. Furthermore, studies should continue to identify discrepancies in the uptake of future COVID-19 booster doses. At the time of writing, the bivalent COVID-19 booster doses are being recommended by public health officials to protect against the Omicron COVID-19 variant (FDA, 2022b). However, only 22% of HCP in LTCFs are up to date with COVID-19 vaccines as of April 2023, indicating that just one in five HCP in LTCFs have received a bivalent booster dose or completed primary series vaccination in the last two months (CDC, 2023b). Importantly, the COVID-19 bivalent booster uptake among HCP has plateaued near 22% for several months, signaling lower uptake of the bivalent booster dose than the first booster dose among HCP. Therefore, studies that aim to identify urbanicity disparities of bivalent booster coverage among HCP are urgently needed to help guide the implementation of strategies to increase bivalent booster uptake. Lastly, future studies should estimate how much of the observed urbanicity

disparities in HCP COVID-19 booster coverage can be explained by factors such as socioeconomics and vaccine hesitancy. Identifying the underlying sources that contribute to urbanicity disparities of HCP booster dose coverage can assist public health professionals in tailoring initiatives to address the most impactful factors. As the FDA has proposed a transition to annual COVID-19 booster doses in the near future (FDA, 2023), it is imperative to understand the sources of current booster differences so that action can be taken to prevent subsequent disparities from arising.

Conclusion

Addressing urbanicity disparities in HCP booster uptake is critical to achieving vaccine equity and decreasing COVID-19-related illness and death in LTCFs. As the threat of mutating COVID-19 variants places residents and communities at constant risk of disease, healthcare leaders need to remain up to date with the latest COVID-19 vaccine. The current study identified urbanicity disparities and low coverage of the first COVID-19 booster dose among HCP, which may allude to similar issues in subsequent booster doses if unaddressed. The findings of this study can help inform where efforts to increase HCP COVID-19 booster coverage are most needed to prevent further exacerbation of disparities and ensure communities remain protected against emerging variants.

References

Biswas, N., Mustapha, T., Khubchandani, J., & Price, J. H. (2021). The Nature and Extent of COVID-19 Vaccination Hesitancy in Healthcare Workers. *Journal of Community Health, 46*(6), 1244–1251. https://doi.org/10.1007/s10900-021-00984-3

Cavanaugh, A. M., Fortier, S., Lewis, P., Arora, V., Johnson, M., George, K., Tobias, J., Lunn, S., Miller, T., Thoroughman, D., & Spicer, K. B. (2021). COVID-19 Outbreak Associated with a SARS-CoV-2 R.1 Lineage Variant in a Skilled Nursing Facility After Vaccination Program - Kentucky, March 2021. *MMWR: Morbidity and Mortality Weekly Report, 70*(17), 639–643. https://doi.org/10.15585/mmwr.mm7017e2

Center for Clinical Standards and Quality/Quality, Safety & Oversight Group. (2021). *Interim Final Rule - COVID-19 Vaccine Immunization Requirements for Residents and Staff.* United States Department of Health and Human Services, Centers for Medicare & Medicaid Services. https://www.cms.gov/files/document/qso-21-19-nh.pdf

Centers for Disease Control and Prevention. (2017, August 2). *About Rural Health.* Center for Surveillance, Epidemiology, and Laboratory Services (CSELS). https://www.cdc.gov/ruralhealth/about.html

Centers for Disease Control and Prevention. (2022a). *The National Healthcare Safety Network (NHSN) Manual: COVID-19 Vaccination Protocol - Weekly COVID-19 Vaccination Module for Healthcare Personnel*. Division of Healthcare Quality Promotion, National Center for Emerging and Zoonotic Infectious Diseases. https://www.cdc.gov/nhsn/pdfs/hps/covidvax/protocol-hcp-508.pdf

Centers for Disease Control and Prevention. (2022b, September 12). *5 Reasons It Is Important for Adults to Get Vaccinated.* National Center for Immunization and Respiratory Diseases. https://www.cdc.gov/vaccines/adults/reasons-to-vaccinate.html

Centers for Disease Control and Prevention. (2023a). *COVID Data Tracker*. US Department of Health and Human Services. https://covid.cdc.gov/covid-data-tracker

Centers for Disease Control and Prevention. (2023b). *Percentage of Nursing Home Staff Who Are Up to Date with COVID-19 Vaccines, by State and Week – United States*. Centers for Disease Control and Prevention, National Healthcare Safety Network. https://www.cdc.gov/nhsn/covid19/ltc-vaccination-dashboard.html#26720

Centers for Disease Control and Prevention. (2023c). *Percentage of Nursing Home Staff with Complete COVID-19 Primary Series who Have Received Any Additional Primary or Booster Dose(s), by Week - United States*. Centers for Disease Control and Prevention, National Healthcare Safety Network. https://www.cdc.gov/nhsn/covid19/ltc-vaccination-dashboard.html#7

Centers for Disease Control and Prevention/Agency for Toxic Substances and Disease Registry/ Geospatial Research, Analysis, and Services Program. (2020). *2020 CDC/ATSDR Social Vulnerability Index US Database*. https://www.atsdr.cdc.gov/placeandhealth/svi/data_documentation_download.html

Chidambaram, P. (2022, February 3). *Over 200,000 Residents and Staff in Long-Term Care Facilities Have Died From Covid-19.* Kaiser Family Foundation. https://www.kff.org/policy-watch/over-200000-residents-and-staff-in-long-term-care-facilities-have-died-from-covid-19/

Chidambaram, P., Garfield, R. (2021, October 1). *Nursing Homes Experienced Steeper Increase in COVID-19 Cases and Deaths in August 2021 than the Rest of the Country.* Kaiser Family Foundation. https://www.kff.org/coronavirus-covid-19/issue-brief/nursing-homes-experienced-steeper-increase-in-covid-19-cases-and-deaths-in-august-2021-than-the-rest-of-the-country/

Chidambaram, P., Musumeci, M. (2022, May 16). *Nursing Facility Staff Vaccinations, Boosters, and Shortages After Vaccination Deadlines Passed.* https://www.kff.org/coronavirus-covid-19/issue-brief/nursing-facility-staff-vaccinations-boosters-and-shortages-after-vaccination-deadlines-passed/

Farah, W., Breeher, L. E., Hainy, C. M., Tommaso, C. P., & Swift, M. D. (2023). Who is getting boosted? Disparities in COVID-19 vaccine booster uptake among health care workers. *Vaccine: X, 13*, 100269. https://doi.org/10.1016/j.jvacx.2023.100269

Federal Register. (2021, November 5). *Rules and Regulations.* U.S. Government Publishing Office (GPO) Publications. https://www.govinfo.gov/content/pkg/FR-2021-11-05/pdf/2021-23831.pdf

Felland, L. E., Lauer, J. R., & Cunningham, P. J. (2009). Suburban Poverty and the Health Care Safety Net. *Research Brief*, (13), 1–12. https://www.issuelab.org/resources/11321/11321.pdf

Finney Rutten, L. J., Zhu, X., Leppin, A. L., Ridgeway, J. L., Swift, M. D., Griffin, J. M., St Sauver, J. L., Virk, A., & Jacobson, R. M. (2021). Evidence-Based Strategies for Clinical Organizations to Address COVID-19 Vaccine Hesitancy. *Mayo Clinic Proceedings, 96*(3), 699–707. https://doi.org/10.1016/j.mayocp.2020.12.024

Gharpure, R., Yi, S. H., Li, R., Jacobs Slifka, K. M., Tippins, A., Jaffe, A., Guo, A., Kent, A. G., Gouin, K. A., Whitworth, J. C., Vlachos, N., Patel, A., Stuckey, M. J., & Link-Gelles, R. (2021). COVID-19 Vaccine Uptake Among Residents and Staff Members of Assisted Living and Residential Care Communities-Pharmacy Partnership for Long-Term Care Program, December 2020-April 2021. *Journal of the American Medical Directors Association*, *22*(10), 2016–2020. https://doi.org/10.1016/j.jamda.2021.08.015

Gu, M., Taylor, B., Pollack, H. A., Schneider, J. A., Zaller, N. (2022). A pilot study on COVID-19 vaccine hesitancy among healthcare workers in the US. *PLoS ONE, 17*(6): e0269320. https://doi.org/10.1371/journal.pone.0269320

Harrison, J., Berry, S., Mor, V., & Gifford, D. (2021). "Somebody Like Me": Understanding COVID-19 Vaccine Hesitancy among Staff in Skilled Nursing Facilities. *Journal of the American Medical Directors Association, 22*(6), 1133–1137. https://doi.org/10.1016/j.jamda.2021.03.012

Hu, S., Xiong, C., Li, Q., Wang, Z., & Jiang, Y. (2022). COVID-19 Vaccine Hesitancy cannot Fully Explain Disparities in Vaccination Coverage Across the Contiguous United States. *Vaccine, 40*(37), 5471-5482. https://doi.org/10.1016/j.vaccine.2022.07.051

Ingram, D. D., & Franco, S. J. (2014). *2013 NCHS Urban–Rural Classification Scheme for Counties*. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics. https://www.cdc.gov/nchs/data/series/sr_02/sr02_166.pdf

Iowa State University. (n.d.). *Urban Percentage of the Population for States, Historical.* Iowa Community Indicators Program. https://www.icip.iastate.edu/tables/population/urban-pct-states

Kates, J., Cox, C., Cubanski, J., Tolbert, J., & Pollitz, K. (2023, February 13). *Commercialization of COVID-19 Vaccines, Treatments, and Tests: Implications for Access and Coverage.* Kaiser Family Foundation. https://www.kff.org/coronavirus-covid-19/issue-brief/commercialization-of-covid-19-vaccines-treatments-and-tests-implications-for-access-and-coverage/

Kirzinger, A., Muñana, C., & Brodie, M. (2021, January 7). *Vaccine Hestiancy in Rural America.* Kaiser Family Foundation. https://www.kff.org/coronavirus-covid-19/poll-finding/vaccine-hesitancy-in-rural-america/

Latkin, C. A., Dayton, L., Miller, J. R., Yi, G., Jaleel, A., Nwosu, C. C., Yang, C., & Falade-Nwulia, O. (2021). Behavioral and Attitudinal Correlates of Trusted Sources of COVID-19 Vaccine Information in the US. *Behavioral Sciences*, 11(4), 56. https://doi.org/10.3390/bs11040056

Lee, J. T., Althomsons, S. P., Hsiu Wu, Budnitz, D. S., Kalayil, E. J., Lindley, M. C., Pingali, C., Bridges, C. B., Geller, A. I., Fiebelkorn, A. P., Graitcer, S. B., Singleton, J. A., Patel, S. A., & Wu, H. (2021). Disparities in COVID-19 Vaccination Coverage Among Health Care Personnel Working in Long-Term Care Facilities, by Job Category, National Healthcare Safety Network - United States, March 2021. *MMWR: Morbidity & Mortality Weekly Report, 70*(30), 1036–1039. https://doi.org/10.15585/mmwr.mm7030a2

L'Heureux Lewis-McCoy, R., Warikoo, N., Matthews, S. A., & Foley, N. F. (2023). Resisting Amnesia: Renewing and Expanding the Study of Suburban Inequality. *RSF: The Russell Safe Foundation Journal of the Social Sciences, 9*(1), 1-24. https://doi.org/10.7758/RSF.2023.9.1.01

Li, J. (2022). Prevention is Key to Reducing the Spread of COVID-19 in Long-Term Care Facilities. *Infection and Drug Resistance*, *2022*(15), 6689-6693. https://doi.org/10.2147/IDR.S386429

Lu, P., Srivastav, A., Vashist, K., Black, C. L., Kriss, J. L., Mei-Chuan Hung, Lu Meng, Tianyi Zhou, Yankey, D., Masters, N. B., Fast, H. E., Razzaghi, H., & Singleton, J. A. (2023). COVID-19 Booster Dose Vaccination Coverage and Factors Associated with Booster Vaccination among Adults, United States, March 2022. *Emerging Infectious Diseases, 29*(1), 133–140. https://doi.org/10.3201/eid2901.221151

Murthy, B. P., Sterrett, N., Weller, D., Zell, E., Reynolds, L., Toblin, R. L., Murthy, N., Kriss, J., Rose, C., Cadwell, B., Wang, A., Ritchey, M. D., Gibbs-Scharf, L., Qualters, J. R., Shaw, L., Brookmeyer, K. A., Clayton, H., Eke, P., Adams, L., & Zajac, J. (2021). Disparities in COVID-19 Vaccination Coverage Between Urban and Rural Counties - United States, December 14, 2020-April 10, 2021. *MMWR: Morbidity & Mortality Weekly Report, 70*(20), 759–764. https://doi.org/10.15585/mmwr.mm7020e3

Pal, S., Shekhar, R., Kottewar, S., Upadhyay, S., Singh, M., Pathak, D., Kapuria, D., Barrett, E., & Sheikh, A. B. (2021). COVID-19 Vaccine Hesitancy and Attitude toward Booster Doses among US Healthcare Workers. *Vaccines*, *9*(11), 1358. https://doi.org/10.3390/vaccines9111358

Peterson, C. J., Lee, B., & Nugent, K. (2022). COVID-19 Vaccination Hesitancy among Healthcare Workers-A Review. *Vaccines, 10*(6), 948. https://doi.org/10.3390/vaccines10060948

Price, S. (2020, September 1). *Nearly 600,000 Health Care Workers On Frontlines of COVID-19 Don't Have Health Insurance*. Value Penguin. https://www.valuepenguin.com/health-care-worker-health-insurance

Saelee, R., Zell, E., Murthy, B. P., Castro-Roman, P., Fast, H., Lu Meng, Shaw, L., Gibbs-Scharf, L., Chorba, T., Harris, L. Q., Murthy, N., & Meng, L. (2022). Disparities in COVID-19 Vaccination Coverage Between Urban and Rural Counties - United States, December 14, 2020-January 31, 2022. *MMWR: Morbidity & Mortality Weekly Report, 71*(9), 335–340. https://doi.org/10.15585/mmwr.mm7109a2

Schnake-Mahl, A. S., & Sommers, B. D. (2017). Healthcare in the Suburbs: An Analysis of Suburban Poverty and Health Care Access. *Health Affairs, 36*(10), 1777-1785. https://doi.org/10.1377/hlthaff.2017.0545

Shrider, E. A., Kollar, M., Chan, F., & Semega, J. (2021). *Income and Poverty in the United States: 2020.* U.S. Census Bureau, Current Population Reports. https://www.census.gov/content/dam/Census/library/publications/2021/demo/p60-273.pdf

Sparks, G., Hamel, L., Kirzinger, A., Stokes, M., & Brodie, M. (2021, December 22). *KFF COVID-19 Vaccine Monitor: Differences in Vaccine Attitudes between Rural, Suburban, and Urban Areas.* Kaiser Family Foundation. https://www.kff.org/coronavirus-covid-19/poll-finding/kff-covid-19-vaccine-monitor-vaccine-attitudes-rural-suburban-urban/

Sparks, G., Kirzinger, A., & Brodie, M. (2021, June 11). *KFF COVID-19 Vaccine Monitor: Profile of the Unvaccinated.* Kaiser Family Foundation. https://www.kff.org/coronavirus-covid-19/poll-finding/kff-covid-19-vaccine-monitor-profile-of-the-unvaccinated/

Steege, A. L., Luckhaupt, S. E., Guerin, R. J., Okun, A. H., Hung, M.-C., Syamlal, G., Lu, P.-J., Santibanez, T. A., Groenewold, M. R., Billock, R., Singleton, J. A., & Sweeney, M. H. (2022). Characteristics Associated with a Previous COVID-19 Diagnosis, Vaccine Uptake, and Intention to Be Vaccinated Among Essential Workers in the US Household Pulse Survey. *American Journal of Public Health, 112*(11), 1599–1610. https://doi.org/10.2105/ajph.2022.307010

Sun, Y., & Monnat, S. M. (2022). Rural-urban and within-rural differences in COVID-19 vaccination rates. *The Journal of Rural Health: Official Journal of the American Rural Health Association and the National Rural Health Care Association*, *38*(4), 916–922. https://doi.org/10.1111/jrh.12625

Toth-Manikowski, S. M., Swirsky, E. S., Gandhi, R., & Piscitello, G. (2022). COVID-19 vaccination hesitancy among health care workers, communication, and policy-making. *American Journal of Infection Control, 50*(1), 20–25. https://doi.org/10.1016/j.ajic.2021.10.004

U.S. Department of Agriculture (USDA). (2022, January 21). *COVID-19 Vaccinations in Rural America.* Economic Research Service. https://www.ers.usda.gov/covid-19/rural-america/covid-19-vaccinations-in-rural-america/

U.S. Department of Health and Human Services (HHS). (2023, February 9). *Fact Sheet: COVID-19 Public Health Emergency Transition Roadmap.* HHS Press Office. https://www.hhs.gov/about/news/2023/02/09/fact-sheet-covid-19-public-health-emergency-transition-roadmap.html

U.S. Food and Drug Administration (FDA). (2021a, June 22). *Rural Health.* https://www.fda.gov/consumers/minority-health-and-health-equity-resources/rural-health

U.S. Food and Drug Administration. (2021b, September 22). *FDA Authorizes Booster Dose of Pfizer-BioNTech COVID-19 Vaccine for Certain Populations.* https://www.fda.gov/news-events/press-announcements/fda-authorizes-booster-dose-pfizer-biontech-covid-19-vaccine-certain-populations

U.S. Food and Drug Administration. (2021c, November 19). *Coronavirus (COVID-19) Update: FDA Expands Eligibility for COVID-19 Vaccine Boosters.* https://www.fda.gov/news-events/press-announcements/coronavirus-covid-19-update-fda-expands-eligibility-covid-19-vaccine-boosters

U.S. Food and Drug Administration. (2022a, March 29). *Coronavirus (COVID-19) Update: FDA Authorizes Second Booster Dose of Two COVID-19 Vaccines for Older and Immunocompromised Individuals.* https://www.fda.gov/news-events/press-announcements/coronavirus-covid-19-update-fda-authorizes-second-booster-dose-two-covid-19-vaccines-older-and

U.S. Food and Drug Administration. (2022b, August 31). *Coronavirus (COVID-19) Update: FDA Authorizes Moderna, Pfizer-BioNTech Bivalent COVID-19 Vaccines for Use as a Booster Dose.* https://www.fda.gov/news-events/press-announcements/coronavirus-covid-19-update-fda-authorizes-moderna-pfizer-biontech-bivalent-covid-19-vaccines-use

U.S. Food and Drug Administration. (2023, January 26). *FDA Briefing Document: Future Vaccination Regimens Addressing COVID-19.* https://www.fda.gov/media/164699/download

U.S. White House. (2022, September 2). *Summary of Funding Request to Meet Critical Needs.* https://www.whitehouse.gov/wp-content/uploads/2022/09/Summary-of-Funding-Request-to-Meet-Critical-Needs.pdf

Whitman, A., De Lew, N., Chappel, A., Asyola, V., Zuckerman, R., & Sommers, B. D. (2022, April 1). *Addressing Social Determinants of Health: Examples of Successful Evidence-Based Strategies and Current Federal Efforts.* Office of Health Policy, U.S. Department of Health & Human Services. https://aspe.hhs.gov/sites/default/files/documents/e2b650cd64cf84aae8ff0fae7474af82/SDOH-Evidence-Review.pdf

Zeger, S. L., Liang, K., Albert, P. S. (1988). Models for Longitudinal Data: A Generalized Estimating Equation Approach. *Biometrics, 44*(4), 1049-1060. https://doi.org/10.2307/2531734

Ziller, E. C., Lenardson, J. D., & Coburn, A. F. (2012). Health Care Access and Use Among the Rural Uninsured. *Journal of Health Care for the Poor and Underserved 23*(3), 1327-1345. https://doi.org/10.1353/hpu.2012.0100

Tables and Figures

Table 1. County-level SVI Characteristics of Long-Term Care Facilities by Urbanicity, United States, January – March 2022

SVI Characteristic N (%)	Overall	Urbanicity		
		Urban	Suburban	Rural
Overall	14,380	5,965 (41.5)	4,368 (30.4)	4,047 (28.1)
Living Below 150% FPL[a]				
Low Vulnerability	4,742 (33.0)	2,822 (47.3)	1,205 (27.6)	715 (17.7)
Moderate Vulnerability	4,822 (33.5)	2,099 (35.2)	1,492 (34.2)	1,231 (30.4)
High Vulnerability	4,816 (33.5)	1,044 (17.5)	1,671 (38.3)	2,101 (51.9)
No High School Diploma[b]				
Low Vulnerability	4,801 (33.4)	2,167 (36.3)	1,552 (35.5)	1,082 (26.7)
Moderate Vulnerability	4,777 (33.2)	1,917 (32.1)	1,742 (39.9)	1,118 (27.6)
High Vulnerability	4,802 (33.4)	1,881 (31.5)	1,074 (24.6)	1,847 (45.6)
Uninsured[c]				
Low Vulnerability	4,745 (33.0)	2,357 (39.5)	1,333 (30.5)	1,055 (26.1)
Moderate Vulnerability	4,809 (33.4)	1,933 (32.4)	1,590 (36.4)	1,286 (31.8)
High Vulnerability	4,826 (33.6)	1,675 (28.1)	1,445 (33.1)	1,706 (42.2)
No Vehicle[d]				
Low Vulnerability	4,892 (34.0)	1,913 (32.1)	1,347 (30.8)	1,632 (40.3)
Moderate Vulnerability	4,805 (33.4)	1,549 (26.0)	1,844 (42.2)	1,412 (34.9)
High Vulnerability	4,683 (32.6)	2,503 (42.0)	1,177 (27.0)	1,003 (24.8)

Abbreviations: SVI, Social Vulnerability Index;

[a] Low Vulnerability tertile: counties ranked between the 1st and 25th percentile for the percentage of individuals living below the 150% federal poverty level; Moderate: counties between 26th and 53rd percentile; High: counties between 54th and 99th percentile

[b] Low vulnerability tertile: counties ranked between the 1st and 30th percentile for the percentage of individuals with no high school diploma; Moderate: counties between 31st and 57th percentile; High: counties between 58th and 99th percentile

[c] Low vulnerability tertile: counties ranked between the 1st and 24th percentile for the percentage of uninsured individuals in total civilian noninstitutionalized population; Moderate: counties between 25th and 56th percentile; High: counties between 57th and 99th percentile

[d] Low vulnerability tertile: counties ranked between the 1st and 46th percentile for the percentage of households with no vehicle available; Moderate: counties between 47th and 77th percentile; High: counties between 78th and 99th percentile

Table 2. Average Weekly HCP Booster Dose Coverage, by Urbanicity, United States, January – March 2022

Reporting Week (%)	Overall (n = 14,380)	Urbanicity		
		Urban (n = 5,965)	Suburban (n = 4,368)	Rural (n = 4,047)
January 3 – January 9	29.7	31.2	28.8	28.5
January 10 – January 16	31.2	33.2	30.0	29.7
January 17 – January 23	32.7	34.8	31.6	30.8
January 24 – January 30	34.1	36.7	32.8	31.7
January 31 – February 6	35.5	38.6	33.8	32.6
February 7 – February 13	37.0	40.5	35.5	33.3
February 14 – February 20	40.0	44.4	38.4	35.4
February 21 – February 27	41.4	46.2	39.6	36.2
February 28 – March 6	42.6	48.2	40.7	36.5
March 7 – March 13	43.8	49.8	41.8	37.2
March 14 – March 20	44.9	50.9	42.9	38.0
March 21 – March 27	46.3	52.4	44.2	39.5

Abbreviations: HCP, Healthcare Personnel

Table 3. Prevalence of HCP COVID-19 Booster Dose Coverage, Comparisons among LTCFs located in Urban, Suburban, and Rural counties, Stratified by Uninsured Vulnerability Tertiles, United States, January – March 2022

Urban-Suburban-Rural Comparisons Stratified by Uninsured Vulnerability Tertiles	Prevalence Ratio	95% CI	p-value
Overall[a]			
Suburban vs. Rural	1.08	1.05, 1.10	<.0001*
Urban vs. Rural	1.24	1.21, 1.26	<.0001*
Urban vs. Suburban	1.15	1.12, 1.17	<.0001*
Low Uninsured Vulnerability[bc]			
Suburban vs. Rural	1.11	1.07, 1.15	<.0001*
Urban vs. Rural	1.14	1.10, 1.18	<.0001*
Urban vs. Suburban	1.03	1.00, 1.06	0.0803
Moderate Uninsured Vulnerability[bd]			
Suburban vs. Rural	1.01	0.97, 1.05	0.7047
Urban vs. Rural	1.24	1.20, 1.28	<.0001*
Urban vs. Suburban	1.23	1.19, 1.27	<.0001*
High Uninsured Vulnerability[be]			
Suburban vs. Rural	0.99	0.95, 1.03	0.5217
Urban vs. Rural	0.97	0.93, 1.01	0.1729
Urban vs. Suburban	0.99	0.94, 1.93	0.4919

Abbreviations: CI, Confidence Interval

[a] Unadjusted model

[b] Adjusted model controls for time effect (reporting week) and county-level proportions of individuals living below the 150% Federal Poverty Line

[c] Low uninsured vulnerability tertile: counties ranked between the 1st and 24th percentile for the percentage of uninsured individuals in the total civilian noninstitutionalized population

[d] Moderate uninsured vulnerability tertile: counties between the 25th and 56th percentile for the percentage of uninsured individuals in the total civilian noninstitutionalized population

[e] High uninsured vulnerability tertile: counties between the 57th and 99th percentile for the percentage of uninsured individuals in the total civilian noninstitutionalized population

* Statistically significant using 0.05 alpha level

Figure 1. Average percentage of HCP that have received a COVID-19 booster dose by reporting week among urban, suburban, and rural long-term care facilities, United States, January – March 2022.

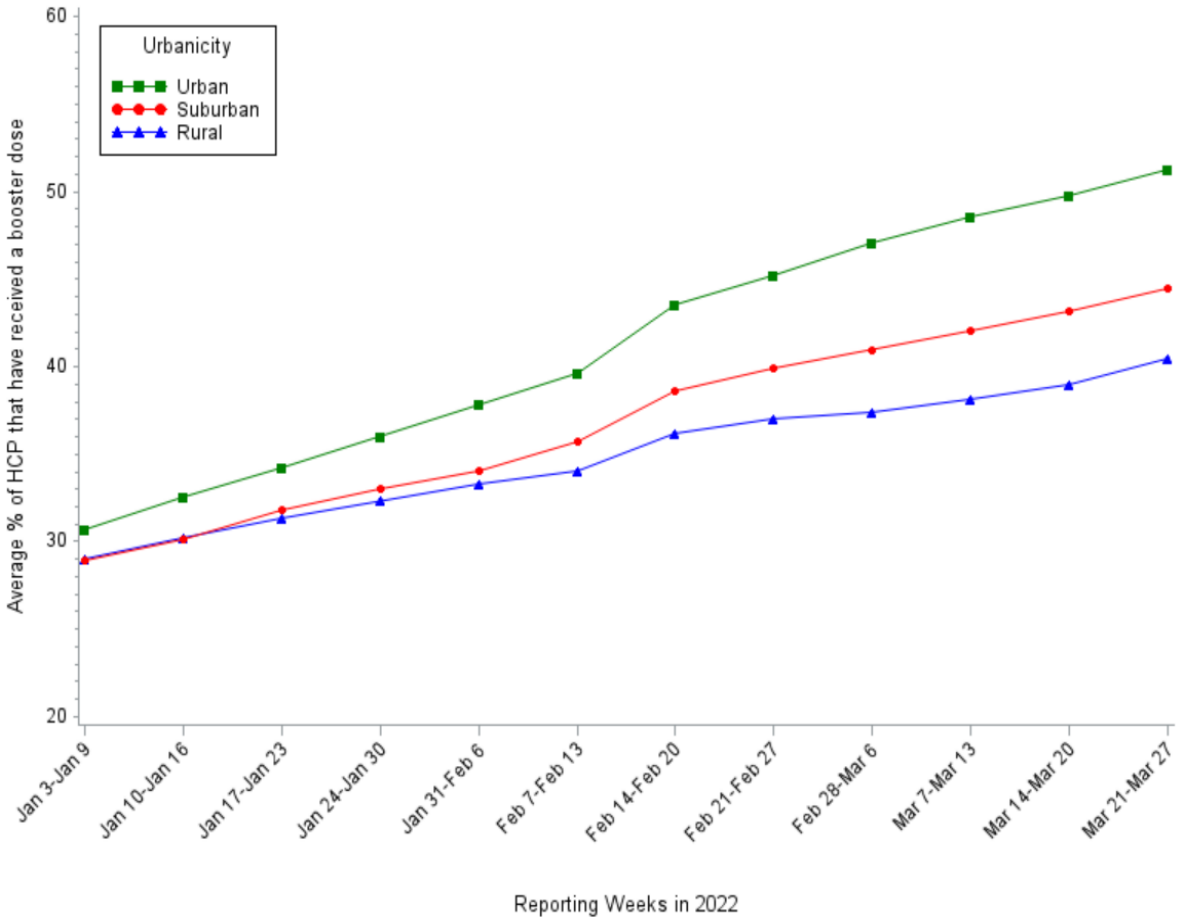
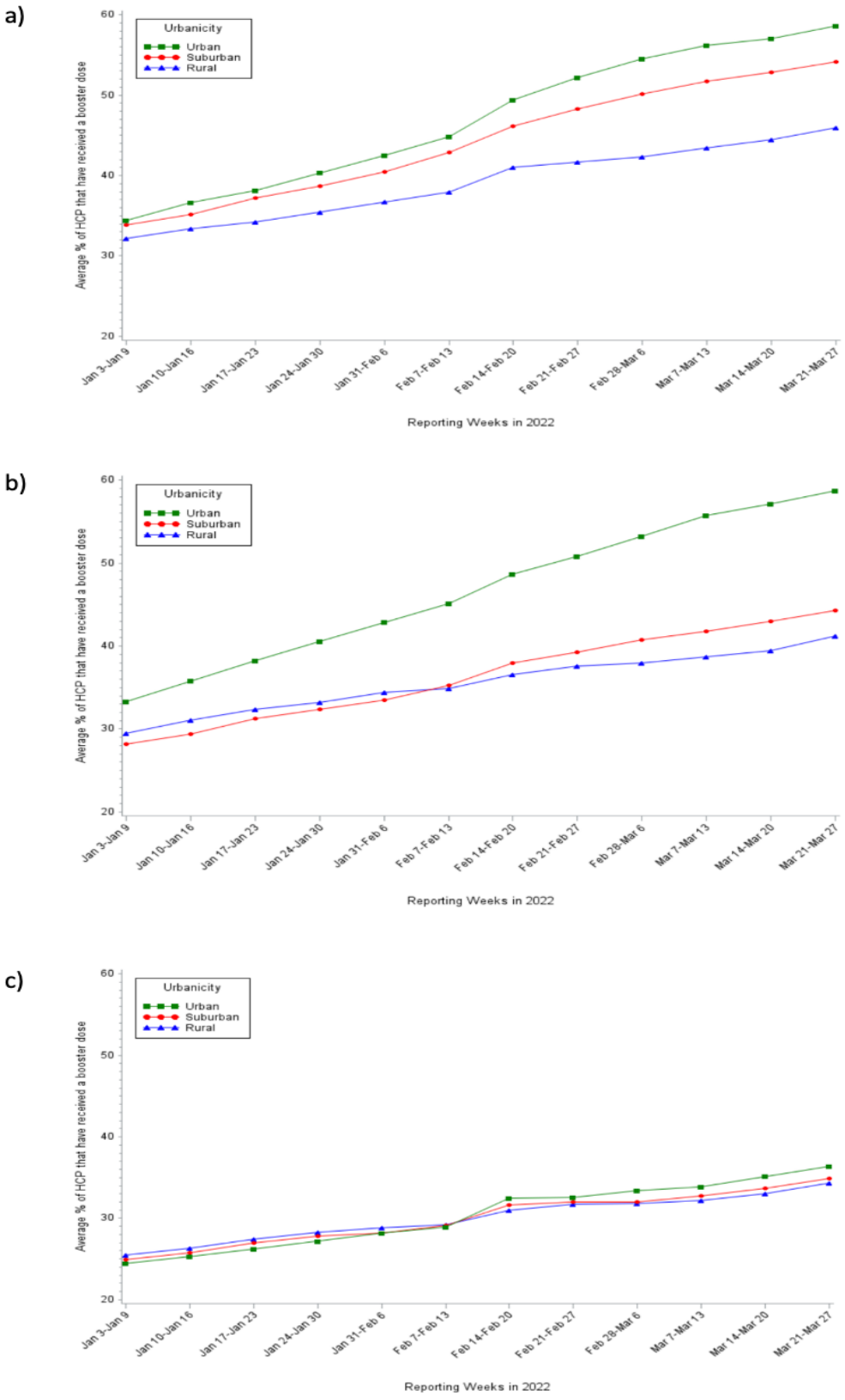


Figure 2. Average percentage of HCP that have received a COVID-19 booster dose by reporting week among urban, suburban, and rural long-term care facilities, stratified by county-level percentage of uninsured individuals, United States, January – March 2022. (a) low percentage of uninsured individuals; (b) moderate percentage of uninsured individuals; (c) high percentage of uninsured individuals.



Appendices

Georgia State University

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January 17, 2023

Principal Investigator: Ya-Hui Yu

Key Personnel: Segovia, George E; Yu, Ya-Hui

Study Department: School of Public Health

Study Title: Disparities in COVID-19 Vaccination Booster Coverage among Healthcare Personnel in Urban and Rural Long-Term Care Facilities, National Healthcare Safety Network (NHSN), United States, January 2022 – March 2022

Submission Type: Application for Designation of Not Human Subjects Research

IRB Number: H23349

Reference Number: 373289

Thank you for your Application for Designation of Not Human Subjects Research. Based on the information provided, this submission has been determined to be not human subjects research. This correspondence should be maintained with your records.

Please do not hesitate to contact the Office of Research Integrity at 404-413-3500 if you have any questions or concerns.

Sincerely,

Susan Vogtner

Susan Vogtner, IRB Co-Vice Chair