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Highest Risk Groups and the Distribution of COVID-19 Vaccine in Milwaukee County, Wisconsin: A Census Tract Level Evaluation

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Abstract

Introduction: COVID-19 vaccinations are the most effective approach to COVID-19 control. The vaccine deployment was designed to support the at-risk individuals and reduce COVID-19 mortality. This study asked, "Were vaccine doses successfully administered to Milwaukee County Wisconsin census tracts with the highest at-risk populations?"

Methods: This ecological study was performed using census tract level data on 1) vaccine doses given through June 2021, 2) Crude COVID-19 Death Rates (CDR) from March 2020 through May 2021, 3) mean individual COVID-19 highest risk chronic conditions percentages, 4) mean age, and percentages of poverty and People of Color (POC), and 5) and social vulnerability scales (SVI). Linear regressions for total second vaccine doses (a completed course as of June 2020) and percent of second vaccine dose and these individual factors and a multiple regression with chronic conditions were performed. The analysis was performed in R.

Results: Milwaukee county census tract second COVID-19 vaccine doses and percentage of second vaccine doses were statistically more common with increasing census tract age and were statistically less common in census tracts with 1) greater COVID-19 crude death rates, 2) higher values of the chronic conditions, 3) greater percentages of POC and in poverty, 4) higher SVI scores. The results were all $p<0.001$ at 95% alpha.

Discussion: This study indicates COVID-19 vaccine distribution success in Milwaukee county Wisconsin census tracts was variable. Tracts with older populations completed more second vaccination doses. Those tracts with the other highest risk factors for poor COVID-19 outcomes and mortality achieved lower vaccination percentages.

Conclusion: The COVID-19 vaccine distribution can be seen as an important part of the emergency response to a pandemic. The large datasets collected on demographics and health outcomes can provide guidance for focused emergency management. Implementation of emergency COVID-19 measures may have provided lessons for future pandemics.

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Introduction

SARS-CoV2 produces a clinical syndrome of COVID 19 including respiratory failure [1]. Age race and several medical conditions predispose individuals to severe acute disease and death. Those conditions included Chronic Renal Failure (CRD), Coronary Heart Disease (CHD), Obstructive Pulmonary Disease (COPD), Chronic Asthma (CASM), Hypertension (HTN), Diabetes Mellitus (DM), and Obesity (OBS) [2]. Individual characteristics, specifically age and race significantly increase mortality rates [3].

Early strategies for mitigation of COVID-19 were designed to control the pandemic spread prior to a vaccine development and deployment to avoid catastrophic mortality [4]. Recommendations included effective masking, handwashing, and distancing to reduce the viral particle dispersal. These measures likely resulted in far fewer deaths than was predicted in their absence [5].

The individual risk factors were also reflected in geographical frequencies of COVID 19 mortality [6]. The worst COVID-19 outcomes were seen in census tracts with higher frequencies of the individual risk factors, people of color and poverty. These higher risk geographical areas provided a potential target for strategic immunization promotion by public health services [7].

The rapid vaccine development over the year 2020 reduced vulnerability to severe disease in the vaccinated [8]. Vaccine release and application was based on a phased process based upon those individual risk factors, with age most prominently featured. The initial recommendations were controversial, creating inequities worldwide and disparities in high income countries [9,10]. Technology, socioeconomic inequities, gender, and structural racism were identified as contributing to a maldistribution of vaccine availability [11-15]. Vaccine hesitancy, specifically in disparate minority populations, were identified as a contributor to the challenge of COVID-19 control and requiring specific strategies to accomplish vaccination goals [16,17].

Milwaukee county Wisconsin represents a frequency variation in COVID-19 relevant demographics and health conditions. These variations, by census tract, increase mortality rates from COVID-19 in Milwaukee county with weak correlations with age, and correlated with higher frequencies of those coexisting conditions placing individuals at high risk of COVID-19 death [18]. The identified risk differences for these census tracts could allow for a focus of vaccine promotion at the census tract level containing only a few thousand residents, versus hundreds of thousands in a city or tens of thousands in a zip code.

The deployment objective of COVID-19 vaccination would be to potentially reduce severe outcomes and COVID-19 deaths if vaccinations were targeted to areas with higher concentrations of individuals with coexisting conditions based on prior publications.

This research project asked the question: Do vaccines for COVID-19 reach those census tracts at greatest risk for severe COVID-19 disease and death?

The aims and objectives of this project were to identify vaccine administration of first and second doses with 1) crude death rates for COVID-19, comorbid conditions associated with severe population illness frequency and mortality, 2) demographics including mean age, percentage people of color and poverty, and 3) social vulnerability index.

Methodology

Study description

The population of the 296 census tracts of Milwaukee county Wisconsin contain over 963,000 individuals. This research protocol is an ecological study of factors associated with SARS-CoV-2 vaccine administration in Milwaukee county Wisconsin.

Data sources

Health prevalence data: The 500 Cities Project, as described by the CDC, "provided city- and census tract-level small area estimates for chronic condition risk factors, health outcomes, and clinical preventive services use for the largest 500 cities in the United States [19]. These small area estimates allowed cities and local health departments to better understand the burden and geographic distribution of health-related variables in their jurisdictions and assisted them in planning public health interventions". CPRs are estimates created from data collected in the CDC's Behavioral Risk Factor Surveillance Survey (BRFSS). The BRFSS responses allow mean percentage estimates for survey responses within census tracts. These mean prevalence rate estimates include health outcomes, prevention, and unhealthy behavior prevalence rates for adults (i.e., ≥18 years of age). Health outcome prevalence rates included Chronic Renal Failure (CRD), Coronary Heart Disease (CHD), Obstructive Pulmonary Disease (COPD), Chronic Asthma (CASM), Hypertension (HTN), diabetes mellitus (DM), and obesity (OBS). Prevalence rates were obtained from the CDC website for these health outcomes of interest. The dataset was downloaded containing the relevant census tract-level mean prevalence rates (in percentages) and was reduced to the 7 conditions listed above. The population of each tract, deaths from COVID-19, and these 7 CPRs were arranged into columns in an Excel spreadsheet (Microsoft Corp.) for the 296 census tracts of Milwaukee county.

Demographic data: The demographic predictors of mean age, percentage of People of Color (POC), and percentage of persons in the poverty level were accessed from census.gov for each of the 296 census tracts and arranged in 3 additional columns to the spreadsheet [20].

COVID-19 mortality data: Deaths occurring in Milwaukee County from COVID-19 were tracked and provided at public request from the Milwaukee County Medical Examiner's Office. This fatality dataset contains the last known address of residents from March 2020 through May 2021. The coroner's office collects these data as part of reporting to the Wisconsin Department of Health for the National Bureau of Vital Statistics. In May 2021, the Medical Examiner's office provided the residences of persons identified as experiencing COVID-19 death. Census tracts were obtained for these addresses by submitting the file list to census.gov. Unidentified addresses were confirmed to not represent residential addresses in Milwaukee County. Deaths were assessed for residences in Milwaukee County and residences in the census tracts. Autopsies reported outside of Milwaukee County were not classifiable by census tracts in Milwaukee County, and deaths in commercial residences (nursing homes and other extended care facilities) were not included due to those reflecting nonpermanent residents of the recorded census tract. The COVID-19 crude death rate (CDR) was expressed as assessable deaths per 100,000 for each of the 296 census tracts. The number of deaths and the crude death rate were added as an additional two columns to the spreadsheet.

Social vulnerability index: Social vulnerability indexes were downloaded from CDC/ATSDR Social Vulnerability Index (SVI) | Place and Health website for Milwaukee County census tracts and added to the spreadsheet [21].

Vaccinations: Vaccination data for Milwaukee County was available on the Wisconsin Department of Health Website [22].

This information was downloaded as an Excel file and the county of Milwaukee's 296 census tracts isolated and imported to an Excel spreadsheet (Microsoft Corp). These data included total first and second vaccine doses and are the last two columns added to the spreadsheet. The second vaccine dose percentage was calculated from the second vaccine dose totals divided by the total population.

Data management

Milwaukee County census tract data were reduced to a file containing the tract 1) the 296 census tract identifiers, 2) population, 3) COVID-19 deaths, 4) the 7 relevant mean condition prevalence rates (CASM, CHD, COPD, CRD, DM, HTN, OBS), 5) the mean age, percentage of non-White residents, and percentage in poverty 6) SVI score, and 6) first and second vaccine dose totals.

Analysis of these data were combined into a single Excel (.csv) file and imported for analysis into the open-source statistical package R (R Foundation for Statistical Computing). The mean prevalence rate values and their first and third quartiles were calculated to verify a normal distribution for applying a linear regression analysis. The assumptions of linearity, variance, independence, and normality were established by reviewing the data prior to its inclusion in the analysis. Data were reviewed in a scatter plot, with residuals reviewed for variance and distribution. The alpha value was set at 0.05. All analysis was conducted in R version 3.6.3, with base R statistical packages. The R^2 statistic, as a measure of how well the parameters predicted the outcome, was calculated.

Results

Demographic data

The demographic and health outcome data for the census tracts is provided in tables 1A and 1B. There is considerable variation in all of these factors across Milwaukee County, Wisconsin. The unusual range for vaccination percentage is due to 2 outliers where a second dose is present in more than the total population. These 2 outliers were included in the analysis and data presented.

COVID-19 mortality data

The Milwaukee County Medical Examiner, which also provides autopsies for surrounding counties as an accredited office, reported 1129 deaths from COVID-19 from March 2020 to June 2021. Deaths were provided by the last known residence. Some addresses were in surrounding counties, and some were in non-residences (nursing homes, rehabilitation units, other extended care facilities). The COVID-19 related deaths included in the final assessment was 898. Deaths excluded from the analysis included a) those not part of Milwaukee County census tracts (n=132), and b) those recorded as nonresidents of the tract (n=174). Some exclusions belonged to both groups (n=75). The mean CDR for census tracts was 94 deaths/100,000 (range: 0-443/100,000; first quartile: 33/100,000; third quartile: 134/100,000).

Vaccination data

The first dose number per census tract was 1484 (range 326-6180) within Milwaukee County Wisconsin. The second dose number per Census tract was 1397 (range 283-5977). The percentage of residents receiving a second dose, consider full vaccination in June of 2021, was 49 (range 21-117).

Linear regression analysis

Factors associated with first dose in each census tract were CDR, the condition model, mean age, percent people of color, and percent people in poverty which can be found in Table 2. The crude death rate for COVID-19 was not a significant factor associated with first vaccination, but the age was positively associated with first dose while the condition model, POC and poverty percentage and SVI were negatively associated with first COVID-19 vaccination doses in a census tract. The R^2 value suggested that the condition model and percentage of POC were most suggestive of the likelihood not to be vaccinated in each census tract.

Factors associated with a second dose and second dose fraction, considered up to date coverage in June 2021, was positively associated with age and negatively with the model, mean percentage people of color and people in poverty and utilizing all 3 demographics as found in Tables 3 and 4. The R^2 value suggested that the demographics of mean age, parentage of POC and in poverty most contributory to a reduced likelihood of second vaccination in census tract.

Census tracts with the highest CDR were not associated with a high degree of second dose fractions and census tracts with higher second dose fractions did not have lower CDRs.

Crude death rates at the census tract level were weekly associated with the SVI. The condition model showed an association with the social vulnerability index with a high degree of predictability.

Table 1

The mean frequencies (as percentages) for factors in the analysis.

Table 1a: Condition mean frequencies in Milwaukee County census tracts.

Condition	CRD	CHD	COPD	CASM	HTN	DM	OBS
Mean	3.2	6.1	6.7	11.1	31.1	11.1	37.2
Range	1.2-6.8	2.0-12.3	2.3-12.3	7.9-16.3	11.8-51.0	3.0-25.0	23.0-53.7

Table 1b: Demographic and second vaccination rate in Milwaukee County census tracts.

Factor	Tract population	POC percentages	Poverty percentages	Mean age	Second dose percentage
Mean	3201	34.9	52.5	34.9	49
Range	1066-9582	4-100	1.1-77.8	19.9-54.0	21-1.17

Table 2: Factors associated with First CoVID-19 vaccination dose.

Factor	Estimate	p-value	R^2
COVID CDR	-0.00	0.63	0.42
Condition Model Sum	-20.10	<0.001	0.27
Mean Age	61.15	<0.001	0.19
POC Percentage	-16.22	<0.001	0.30
Poverty Percentage	-15.65	<0.001	0.06
SVI	-0.00	<0.002	0.20

Table 3: Factors associated with second COVID-19 vaccination dose.

Factor	Estimate	p-value	R^2
COVID CDR	0.0	<0.001	0.08
Condition Model	-20.1	<0.001	0.28
Mean Age	129.9	<0.001	0.32
POC Percentage	-145.6	<0.001	0.33
Poverty Percentage	-75.7	<0.001	0.33
Mean Age + POC + Poverty	-83.0	<0.001	0.65
SVI	-10.9	<0.001	0.56

Table 4: Factors associated with second COVID-19 vaccination dose fraction.

Factor	Estimate	p-value	R^2
COVID CDR	0.0	0.16	0.01
Condition Model	0.0	<0.001	0.74
Mean Age	0.1	<0.001	0.26
POC Percentage	0.0	<0.001	0.63
Poverty Percentage	-0.0	<0.01	0.02
Mean Age + POC + Poverty	-19.1	<0.001	0.64
SVI	-0.0	<0.001	0.20

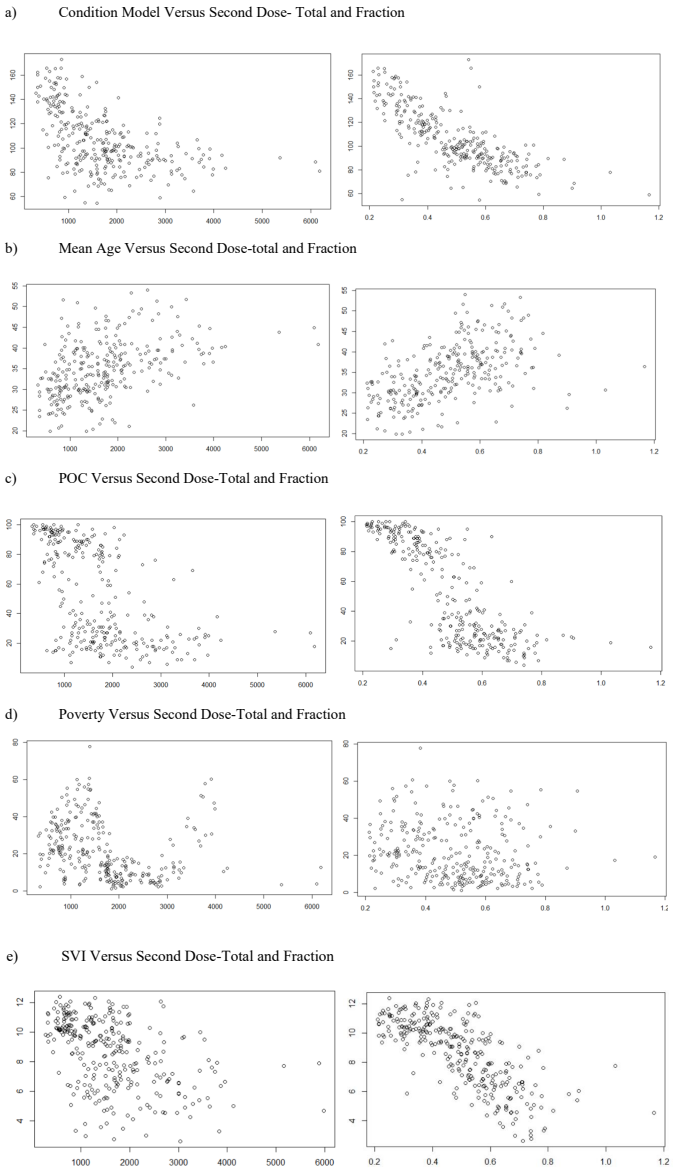

Figure 1 a-e: Scatter Plots of census tracts results-Total COVID-19 Vaccines on left and the Fraction of the Population with Second Vaccination 9Conisdered complete in 2021.

Discussion

It is an accepted fact that place matters in health and the place you are born, live, and age in influences your life outcome. This analysis confirmed that fewer COVID-19 vaccine doses were given in census tracts with 1) high-grade death rates from COVID-19, 2) greater condition frequencies associated with individual COVID poor outcome risk, and 3) poorer, more socially vulnerable and more POC populations. Second COVID-19 vaccine dose frequencies (then considered a complete vaccination course) were also highly negatively associated with the same conditions, census tract demographics and health outcomes. Mean age in census tracts was associated with greater COVID-19 vaccine doses and fractions. These associations indicate the lack of success in providing COVID-19 vaccine protection in Milwaukee County Wisconsin. The result of this disparity can potentially be disparities in COVID-19 deaths and the long-term effects of COVID-19. There are several potential reasons why the greatest at-risk groups may have not received COVID-19 vaccinations and several potential limitations to creating a causal link regarding these disparities.

Medical services access is a known potential disparity for populations of POC, people in poverty, and those with social vulnerabilities before, during and since the COVID-19 pandemic. The fair COVID-19 vaccine prioritization is an ethical issue previously addressed and some of those concerns may be reflected in these results [9,23]. Several authors called for a review of the social determinants of health in the outcome of the COVID-19 pandemic [24-27].

Several authors have pointed to the geographically targeting benefits. Levy et al used socioeconomic inequality measures to identify higher COVID-19 infection rates [28]. Barry et al focused on the Social Vulnerability Index in their 2021 report suggesting how personal agency impacts health utilization [29]. Wrigley-Field et al pointed to the potential to avert more COVID-19 death with geographically targeted vaccinations [30]. These authors correctly assert the need for improving the health promotion and communication in these higher risk locations.

Vaccinations were available throughout these areas through the work of the Milwaukee Health Department in collaborations with community organizations, but this approach was not effective in reducing the disparities in these census tracts [31]. Reports of significant wait times at testing and vaccination centers potentially limited access. Paradoxically, by mid-May vac-

cine centers were closing due to low attendance [32]. Despite these issues, there was a strong correlation with older mean age tracts and vaccine status. Goldstein et al reported such outcomes should produce the best outcomes which may be the result in Milwaukee Country [33].

Significant misinformation was a potential factor in the population's willingness to access vaccine administration. This misinformation took the form of erroneous efficacy and aggerated adverse effects. This misinformation was widely disseminated. Zhao performed a systematic review identifying low educational and economic enhance misbeliefs on misinformation [34]. Zimmerman et al made the critical point that vaccine hesitancy and misinformation are not simple parts of a cause-and-effect process [35]. They suggest they require engaging experts in managing misinformation. George et al do take that next step to analyze the themes including rationalization, identity, beliefs and potential modifiers, emotional responses, and information sources [36].

Limitations

Limitations in this study include the source of data coming from different years, the accuracy of vaccine locations, the timing of the availability of vaccine to distinct groups, and whether associations provide useful information that leads to disparity resolution. Year-to-year variations in residence make urban areas variable which introduces some imprecision. The presence of tracts with more vaccine doses than residents illustrate the potential for migration in the county to create some error. The vaccine was not available to every adult till shortly before the report data was gathered. There may have been a lag that additional months might have altered but the vaccine had been available to all group but the time of the data collection. Finally, the causal link between these factors and the vaccine distribution cannot be established here. A strong model result does not create proof of causality.

Conclusion

COVID-19 mitigation is dependent on the effective distribution and use of vaccines. Early identified risk factors could be used effectively to identify geographic locations for promotion and distribution of vaccine. This strategy was possible in the county of Milwaukee based upon small units of geographic measure called census tracts for focused delivery based on individual risk factors that also predict population crude death rates. The COVID-19 pandemic highlighted the health disparities in Milwaukee County neighborhoods. The higher rates of health outcome disparities and the additional risk factors of race resulted in an ineffective distribution of vaccine. Preparation for future pandemics should consider eliminating these disparities to eliminate disparities in pandemic fatalities.

References

1. Wiersinga WJ, Rhodes A, Cheng AC, Peacock SJ, Prescott HC. Pathophysiology, Transmission, Diagnosis, and Treatment of Coronavirus Disease 2019 (COVID-19): A Review. JAMA. 2020; 324: 782-793.
2. Wortham JM, Lee JT, Althomsons S, Latash J, Davidson A, et al. Characteristics of Persons Who Died with COVID-19 - United States, February 12-May 18, 2020. MMWR Morb Mortal Wkly Rep. 2020; 69: 923-929.
3. Hooper MW, Nápoles AM, Pérez-Stable EJ. COVID-19 and racial/ethnic disparities. Jama. 2020; 323: 2466-2467.
4. Ferguson N, Laydon D, Nedjati-Gilani G, Imai N, Ainslie K, et al. Report 9: Impact of non-pharmaceutical interventions (NPIs) to reduce COVID19 mortality and healthcare demand. Imperial College London. 2020; 10: 491-497.
5. Zheng C, Shao W, Chen X, Zhang B, Wang G. Real-world effectiveness of COVID-19 vaccines: A literature review and meta-analysis. International Journal of Infectious Diseases. 2022; 114: pp.252-260.
6. Stevens DL, Bryant AE. Endemic, epidemic and pandemic infections: the roles of natural and acquired herd immunity. Current Opinion in Infectious Diseases. 2023; 36: 171-176.
7. Morris GL 3rd. Neighborhood Condition Prevalence Rates Correlate With COVID-19 Mortality in Milwaukee County, Wisconsin. J Patient Cent Res Rev. 2023; 10: 38-44.
8. Bonham-Werling J, DeLonay AJ, Stephenson K, Hendricks KA, Bednarz L, et al. Using statewide electronic health record and influenza vaccination data to plan and prioritize COVID-19 vaccine outreach and communications in Wisconsin communities. American Journal of Public Health. 2021; 111: 2111-2114.
9. Centers for Disease Control and Prevention. Frequently asked questions about COVID-19 vaccination. 2021.
10. Persad G, Peek ME, Emanuel EJ. Fairly prioritizing groups for access to COVID-19 vaccines. Jama. 2020; 324: 1601-1602.
11. Tatar M, Shoorekchali JM, Faraji MR, Wilson FA. International COVID-19 vaccine inequality amid the pandemic: Perpetuating a global crisis?. Journal of global health. 2021; 11.
12. Callaghan T, Moghtaderi A, Lueck JA, Hotez P, Strych U, et al. Correlates and disparities of intention to vaccinate against COVID-19. Social science & medicine (1982). 2021; 272: 113638.
13. Press VG, Huisingh-Scheetz M, Arora VM. March. Inequities in technology contribute to disparities in COVID-19 vaccine distribution. In JAMA Health Forum. American Medical Association. 2021; 2: e210264-e210264.
14. Caspi G, Dayan A, Eshal Y, Liverant-Taub S, Twig G, et al. Socioeconomic disparities and COVID-19 vaccination acceptance: A nationwide ecologic study. Clinical Microbiology and Infection. 2021; 27: 1502-1506.
15. Bignucolo A, Scarabel L, Mezzalira S, Polesel J, Cecchin E. Sex disparities in efficacy in COVID-19 vaccines: a systematic review and meta-analysis. Vaccines. 2021; 9: 825.
16. Siegel M, Critchfield-Jain I, Boykin M, Owens A, Muratore R, et al. Racial/ethnic disparities in state-level COVID-19 vaccination rates and their association with structural racism. Journal of racial and ethnic health disparities. 2021; 1-14.
17. Aw J, Seng JJB, Seah SSY, Low LL. COVID-19 vaccine hesitancy-A scoping review of literature in high-income countries. Vaccines. 2021; 9: 900.
18. Strully KW, Harrison TM, Pardo TA, Carleo-Evangelist J. Strategies to address COVID-19 vaccine hesitancy and mitigate health disparities in minority populations. Frontiers in Public Health. 2021; 9: 645268.
19. Morris GL 3rd. Neighborhood Condition Prevalence Rates Correlate With COVID-19 Mortality in Milwaukee County, Wisconsin. J Patient Cent Res Rev. 2023; 10: 38-44.
20. CDC 500 Cities Project. https: //www.cdc.gov/500cities/index.htm Last Accessed 8/20/2022
21. US Census https://data.census.gov/profile/Milwaukee_city,_Milwaukee_County,_Wisconsin?g=060XX00US5507953000

22. CDC https: //www.atsdr.cdc.gov/placeandhealth/svi/interactive_map.html

23. Wisconsin Department of Health https: //www.dhs.wisconsin.gov/covid-19/vaccine-data.htm

24. Hardeman A, Wong T, Denson JL, Postelnicu R, Rojas JC. Evaluation of health equity in COVID-19 vaccine distribution plans in the United States. JAMA Network Open. 2021; 4: e2115653-e2115653.

25. Brakefield WS, Olusanya OA, White B, Shaban-Nejad A. Social determinants and indicators of COVID-19 among marginalized communities: a scientific review and call to action for pandemic response and recovery. Disaster Medicine and Public Health Preparedness. 2023; 17: e193.

26. Cuadros DF, Gutierrez JD, Moreno CM, Escobar S, Miller FD, et al. Impact of healthcare capacity disparities on the COVID-19 vaccination coverage in the United States: a cross-sectional study. The Lancet Regional Health-Americas. 2023; 18.

27. Peña JM, Schwartz MR, Hernandez-Vallant A, Sanchez GR. Social and structural determinants of COVID-19 vaccine uptake among racial and ethnic groups. Journal of Behavioral Medicine. 2023; 46: 129-139.

28. Cuadros DF, Gutierrez JD, Moreno CM, Escobar S, Miller FD, et al. Impact of healthcare capacity disparities on the COVID-19 vaccination coverage in the United States: a cross-sectional study. The Lancet Regional Health-Americas. 2023.

29. Levy BL, Vachuska K, Subramanian SV, Sampson RJ. Neighborhood socioeconomic inequality based on everyday mobility predicts COVID-19 infection in San Francisco, Seattle, and Wisconsin. Science advances. 2022; 8: eabl3825.

30. Barry V, Dasgupta S, Weller DL, Kriss JL, Cadwell BL, et al. Patterns in COVID-19 vaccination coverage, by social vulnerability and urbanicity-United States, December 14, 2020-May 1, 2021. Morbidity and Mortality Weekly Report. 2021; 70: 818.

31. Wrigley-Field E, Kiang MV, Riley AR, Barbieri M, Chen YH, et al. Geographically targeted COVID-19 vaccination is more equitable and averts more deaths than age-based thresholds alone. Science advances. 2021; 7: eabj2099.

32. https: //city.milwaukee.gov/CovidVax Last Accessed 8/12/2023

33. https://www.jsonline.com/story/news/local/milwaukee/2021/04/22/wisconsin-center-covid-19-vaccination-site-end-may-28/7333423002/

34. Goldstein JR, Cassidy T, Wachter KW. Vaccinating the oldest against COVID-19 saves both the most lives and most years of life. Proceedings of the National Academy of Sciences. 2021; 118: e2026322118.

35. Zhao S, Hu S, Zhou X, Song S, Wang Q, et al. The prevalence, features, influencing factors, and solutions for COVID-19 vaccine misinformation: systematic review. JMIR Public Health and Surveillance. 2023; 9: e40201.

36. Zimmerman T, Shiroma K, Fleischmann KR, Xie B, Jia C, et al. Misinformation and COVID-19 vaccine hesitancy. Vaccine. 2023; 41: 136-144.

37. George MF, Rosenberg BD, Dale SN, Kirkland LH, Culross PL, et al. "They'll take a gun to me before I get that shot": Rationalization, emotions, and misinformation in COVID-19 vaccine hesitancy. Social and Personality Psychology Compass. 2023; e12815.