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The disparate impact of age-based COVID-19 vaccine prioritization by race/ethnicity in Denver, Colorado

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ABSTRACT

COVID-19 vaccines are an effective tool in preventing severe disease. Most states used an age-based prioritization for vaccine rollout. We examined the impact of a primarily age-based prioritization policy on reductions of severe disease in different racial and ethnic groups. We calculated age-specific rates of COVID-19 hospitalization and death by race/ethnicity in Denver, Colorado. To assess potentially averted hospitalizations and deaths by race/ethnicity, we then applied the first three phases of Colorado's primarily age-based vaccine rollout criteria to historical 2020 COVID-19 hospitalizations and deaths in Denver, Colorado. In the first 3 phases, 40% (1403/3473) of hospitalizations and 83% (503/604) of deaths occurred among those meeting age and long-term care facility criteria and could have been averted. Impacts varied by race/ethnicity with only 28% (440/1587) of hospitalizations and 74% (131/178) of deaths averted among Hispanic or Latino residents, compared to 57% (619/1094) of hospitalizations and 92% (252/274) of deaths among non-Hispanic White residents. We demonstrate using local data and policy that early age-based prioritization decisions disproportionately promoted reductions in severe disease among non-Hispanic White residents irrespective of COVID-19 risk in Denver, Colorado. These findings suggest that more equitable future vaccine prioritization policies, which lead with a goal of reducing health disparities through prioritizing susceptibility to adverse health outcomes rather than overall population-based cutoffs, are necessary. Our results have implications for future vaccination rollouts in limited vaccine resource conditions.

1. Introduction

Vaccines are one of the most effective tools in preventing severe coronavirus disease 2019 (COVID-19) and mitigating transmission [1]. Ensuring a high percentage of the population are vaccinated is critical to reducing the negative health and societal impacts of the pandemic, and carefully planned vaccination policies and strategies are essential to achieving this goal. The COVID-19 pandemic has highlighted the persistent role of structural racism in health disparities, with individuals who identify as Black, Hispanic or Latino, and Indigenous, and those living in areas of lower socioeconomic opportunity being over-represented among patients diagnosed, hospitalized and dying of COVID-19 [2–6]. Vaccine equity — defined as prioritizing vaccinations based on the best available evidence for reducing severe disease while treating all with equal dignity and value — is paramount to addressing new and existing health disparities [7,8]. This includes using data (qualitative, quantitative, and disaggregated to sub-population levels) to capture multiple intersections of risk, prioritization of those who have experienced the largest burden of disease, and working with those communities to tailor vaccination distribution with transparency and cultural humility. However, national guidance for the initial rollout, when vaccine availability was limited, utilized a largely age-based strategy [9]. Decisions on vaccine rollout were ultimately made at the local level and varied by state, [10] with most adopting some form of age prioritization: [10] few prioritized sub-populations based on local epidemiology [11]. While the risk for COVID-19 hospitalizations and deaths increases with age, exclusively age-based approaches ignore fundamental differences in comorbidities and life expectancy by race/ethnicity, geographic concentration of communicable disease, and barriers to healthcare [12].

As of April 2022, two-thirds of the eligible US population were fully vaccinated, a little less than half of whom have received a booster vaccine [13]. National and state data show that Black and Hispanic or Latino vaccination rates lagged behind those of the Asian and

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non-Hispanic White populations for the first several months of availability [14]. Initial rollout strategies for boosters based on time from completion of the initial vaccination and/or older age only repeats the original strategies, and although vaccination disparities have been closing over time, booster doses remain lower among Black and Hispanic or Latino people [14]. There is a need to re-examine strategies for vaccine rollout to achieve better protection in the future. The current analysis utilized local public health surveillance data on cases, hospitalizations, and deaths to estimate the impact of age-based vaccination strategies on preventing severe disease by race and ethnicity. Findings from our analysis provide data-driven information that can be used to inform policies and strategies to optimize vaccination coverage for additional COVID-19 boosters and future pandemics.

2. Materials and methods

We used a cross-sectional study design, including all adult (≥18 years) residents in Denver County with laboratory-confirmed COVID-19 reported to the state and local health department from March 1, 2020 through December 31, 2020. Data were accessed through the Colorado Electronic Disease Reporting System (CEDRS) and collected as part of the routine public health response, including case investigation interviews, laboratory-reported data, and medical record reviews. We categorized race/ethnicity into six groups: Black, non-Hispanic (Black); White, non-Hispanic (White); Asian/Pacific Islander, non-Hispanic (Asian/Pacific Islander); American Indian/Alaska Native, non-Hispanic (American Indian/Alaska Native); multiple race or other, non-Hispanic; and Hispanic or Latino. Age was defined as age at the date a case was reported to the state health department. Hospitalization and death status were obtained from local public health case report forms. Hospitalization due to COVID-19 was indicated in the case investigation interviews, through chart review, or determined through routine state linkage to hospital records. Deaths included all deaths among persons with COVID-19. Persons missing age were excluded; those missing race/ethnicity were included in overall Denver County estimates but excluded from race/ethnicity-specific estimates. Denver County population estimates were obtained from the Department of Local Affairs, 2019 Denver County population estimates by race, ethnicity, and age [15].

This study focused on hospitalizations and deaths averted in Denver County by the first 3 phases of Colorado's vaccine rollout: 1) Phase 1A: Highest-risk health care workers and individuals, including long-term care facility (LTCF) residents, 2) Phase 2B.1: Coloradans age 70 and over, moderate-risk health care workers and first responders, and 3) Phase 1B.2: Coloradans ages 65–69, pre-K-12 educators, child care workers in licensed child care programs, and those required for continuity of state government [16]. The percentage of hospitalizations and deaths averted for Denver overall and by race/ethnicity was calculated by phase, dividing persons with a COVID-19 hospitalization or death and meeting vaccine phase criteria by the overall number of persons experiencing a COVID-19 hospitalization or death. These phases spanned the first 3 months of vaccine distribution in Colorado (December 11, 2020-March 5, 2021). We limited our analyses to age and long-term care resident criteria because occupational criteria were a) not readily available for all in standard case report forms and b) primarily focused on prevention through methods other than personal risk of hospitalization and death (such as preserving capacity to care for patients, reducing transmission to high-risk populations, and enabling return to school).

2.1. Statistical analysis

We compiled descriptive statistics for COVID-19 cases, hospitalizations, and deaths in Denver County by age group, race/ethnicity, and long-term care facility resident status. We used a two proportion Z-test of equal proportions to evaluate significant differences in age and race/ethnicity proportions among cases, hospitalizations, and deaths to the proportional distribution of the Denver County adult population. Age-specific hospitalization and death rates were calculated for the following age groupings: 18–29, 30–39, 40–49, 50–59, 60–69, 70–79, and 80 + years using Department of Local Affairs 2019 Denver County population estimates. We calculated 95 % confidence intervals for age-specific rates using a Poisson distribution. All statistical analyses were performed using SAS Enterprise Guide version 7.11 (Statistical Analysis System, Cary, NC, USA). This study was reviewed by the Colorado Multiple Institutional Review Board and determined to be exempt.

Table 1
Summary of COVID-19 Outcomes for Denver County residents, aged 18 and over, March 1, 2020- December 31, 2020.

Characteristic	Denver Adult Population (N = 590056) No. (%)	Cases (N = 41625) No. (%)		Hospitalizations (N = 3473) No. (%)		Deaths (N = 604) No. (%)	
Age group (years)							
18–29	135,737 (23.0)	13,758 (33.1)	***	312 (9.0)	***	5 (0.8)	***
30–39	139,320 (23.6)	9896 (23.8)		381 (11.0)	***	8 (1.3)	***
40–49	106,813 (18.1)	6818 (16.4)	***	445 (12.8)	***	18 (3.0)	***
50–59	82,412 (14.0)	5176 (12.4)	***	633 (18.2)	***	53 (8.8)	***
60–69	69,071 (11.7)	3211 (7.7)	***	667 (19.2)	***	80 (13.2)	
70–79	36,545 (6.2)	1627 (3.9)	***	519 (14.9)	***	161 (26.7)	***
80 +	20,158 (3.4)	1139 (2.7)	***	516 (14.9)	***	279 (46.2)	***
Race and ethnicity							
American Indian/Native Alaskan	4003 (0.7)	325 (1.0)	***	33 (1.0)	*	10 (1.7)	**
Asian/Pacific Islander	25,664 (4.3)	1004 (3.0)	***	122 (3.6)		22 (3.8)	
Black	54,791 (9.3)	2406 (7.1)	***	410 (12.0)	***	68 (11.7)	*
Hispanic or Latino	152,176 (25.8)	16,365 (48.3)	***	1587 (46.4)	***	178 (30.6)	***
White	353,422 (59.9)	12,683 (37.4)	***	1094 (32.0)	***	274 (47.2)	***
Multiple or other	—	1088 (3.2)		173 (5.1)		29 (5.0)	
Unknown	—	7754		54		23	
Long–Term Care Facility Residents	—	1263		348		254	

Significant p-value for two proportion Z-test for equality of proportions compared to Denver adult population at * $p<0.05$ ** $p<0.01$ *** $p<0.001$. Data source (s): Colorado Electronic Disease Reporting System; Colorado State Demography Office, Department of Local Affairs (DOLA), 2019. County-level population denominators for long-term care residents were unavailable.

3. Results

Between March 1, 2020-December 31, 2020, there were 46,782 laboratory-confirmed cases of COVID-19 reported among residents of Denver County, Colorado. Of those, 18/46,782 (0.04 %) were excluded due to missing age, and 41,625 were ≥ 18 years and therefore, included in the study. Approximately half of all COVID-19 cases (48.3 %) and hospitalizations (46.4 %) in Denver County were among Hispanic or Latino residents, roughly double their representation in the Denver population (25.8 %; Table 1). Black residents had a slightly lower percentage of cases (7.1 %) but higher percentage of hospitalization and death (12.0 % and 11.7 %) compared to their representation in the Denver population (9.3 %). American Indian/Alaska Native residents had a higher percentage of cases, hospitalization, and death (1.0 %, 1.0 %, 1.7 %) compared to their representation in the Denver population (0.7 %) and White residents had substantially lower case, hospitalization, and death rates (37.4 %, 32.0 %, 47.2 %) compared to their representation in the Denver population (59.9 %). The Asian/Pacific Islander population had a lower percentage of cases and similar percentage of hospitalizations and deaths as their representation in the Denver population. The majority of deaths occurred among those in the older age groups, ranging from 0.8 % of total deaths occurring in the 18–29 age group to 46.2 % of all deaths occurring in persons aged 80 years and older.

Age-specific rates of hospitalization were higher with each successive age group from 229.9/100,000 persons in the 18–29 year age group to 2559.8/100,000 persons among those 80 + years (Fig. 1; Supplemental Table 1). Similar to hospitalizations, higher mortality rates were observed within the oldest age groups ranging from 3.7/100,000 persons among those 18–29 to 1384.1 /100,000 persons among those 80 years and older (Fig. 2; Supplemental Table 1). A higher proportion of Black and Hispanic or Latino residents experienced severe illness or death at younger ages than White residents. Data on other racial groups are not reported here due to small sample size.

Overall, during phase 1A of the vaccine rollout, 10 % (348/3473) of hospitalizations and 42 % (251/604) of deaths could have been prevented if all long-term care facility residents were vaccinated and immune (Fig. 3a). Thirty-two percent (1125/3473) of hospitalizations and 78 % (472/604) of deaths could have been averted if all long-term

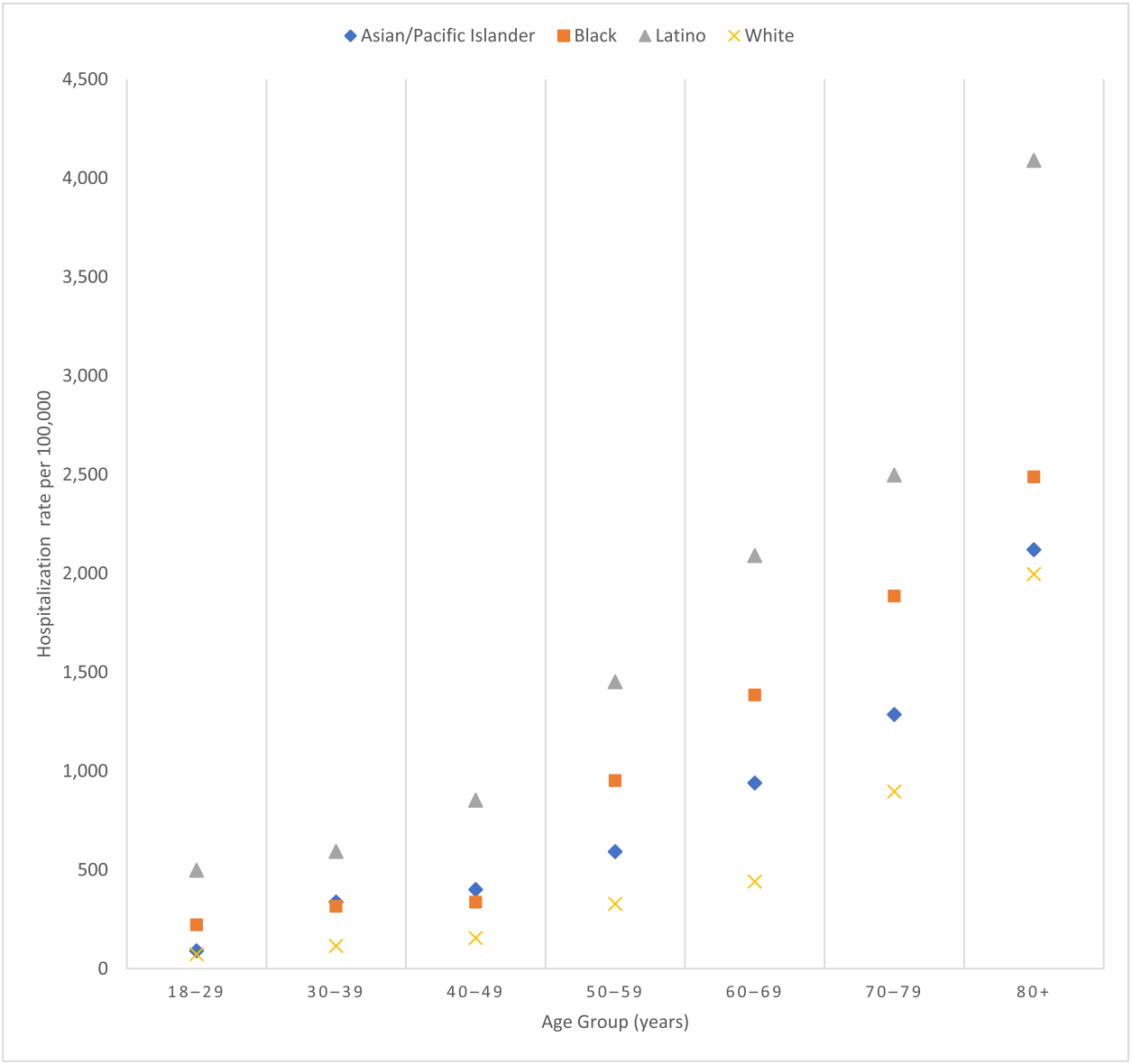

Fig. 1. COVID-19 age-specific hospitalization rates by race/ethnicity, Denver County residents, aged 18 and over, March 1, 2020- December 31, 2020. Data source (s): Colorado Electronic Disease Reporting System; Colorado State Demography Office, Department of Local Affairs (DOLA), 2019.

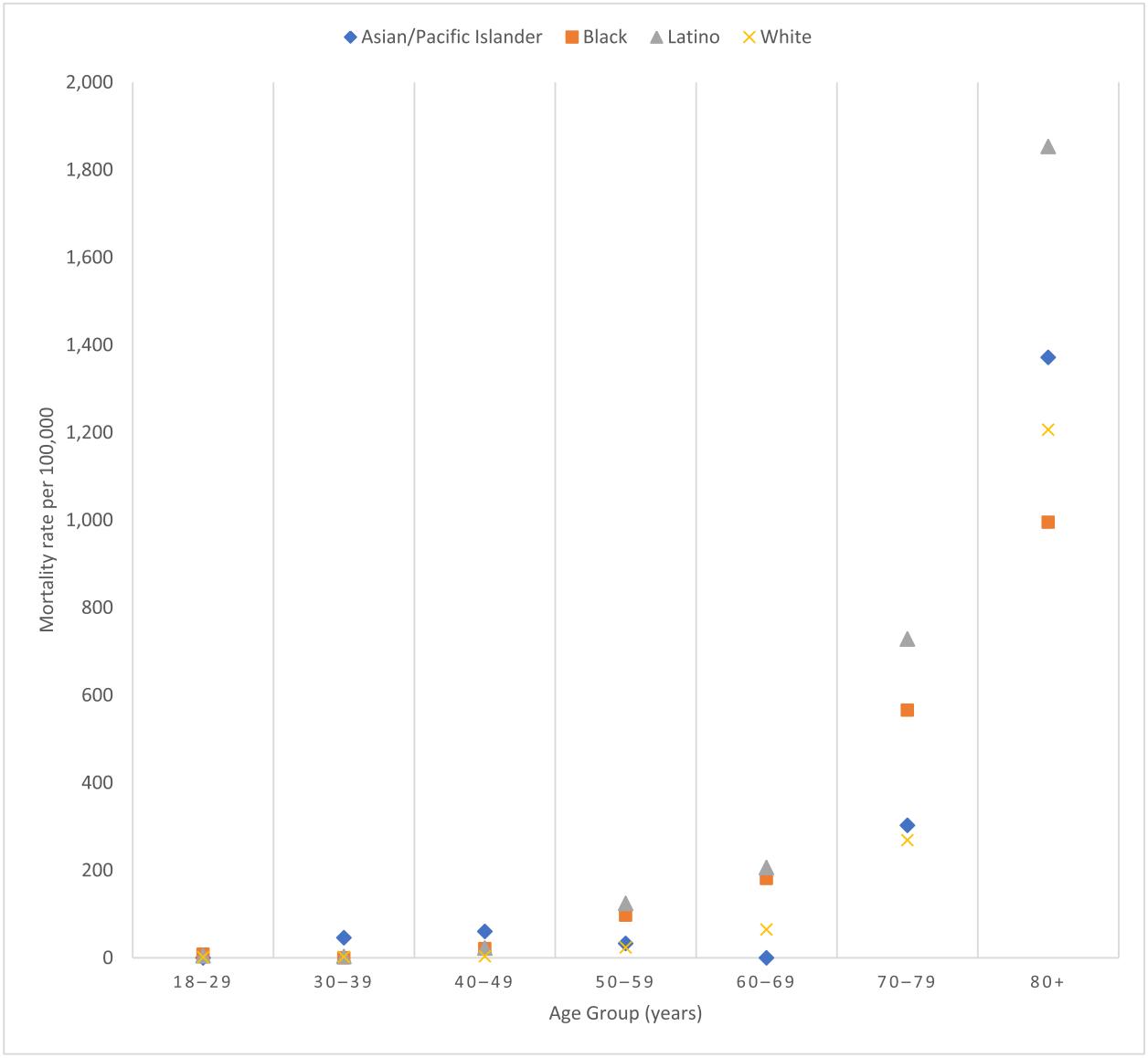

Fig. 2. COVID-19 age-specific mortality rates by race/ethnicity, Denver County residents, aged 18 and over, March 1, 2020- December 31, 2020. Data source (s): Colorado Electronic Disease Reporting System; Colorado State Demography Office, Department of Local Affairs (DOLA), 2019.

care facility residents or persons aged 70 and older were vaccinated and immune (phase 1B.1). Forty percent (1402/3473) of hospitalizations and 83 % (503/604) of all deaths could have been averted when expanding to long-term care facility residents and persons aged 65 and older (Phase 1B.2). Due to the age-based prioritization of vaccine rollout, early phases had the biggest potential reduction in hospitalizations and deaths for racial/ethnic groups whose hospitalizations and deaths were more concentrated at older ages (Fig. 3b, Fig. 3c). The highest potential hospitalization reductions were for White residents compared to all other racial/ethnic groups. Racial/ethnic differences in averted hospitalizations were the largest by the 3rd phase of vaccine rollout (Phase 1B.2). By then, an estimated 57 % of hospitalizations would have been averted for White residents, 45 % of hospitalizations would have been averted for Black residents, 38 % of hospitalizations would have been averted for Asian/Pacific Islander residents, and only 28 % of hospitalizations would have been averted for Hispanic or Latino residents.

In contrast to hospitalizations, the biggest difference by race/ethnicity in averted deaths would have happened during the first phase (Phase 1A) of vaccine rollout (Fig. 3c). Vaccinating long-term care residents alone could have averted 58 % of deaths among White residents, 43 % of deaths among Black residents, 32 % of deaths among Asian/Pacific Islander residents, and 19 % of deaths among Hispanic or Latino residents. By the end of the first three phases, at best nearly all deaths (92 %) would have been averted for White residents, while only 68 % and 74 % of deaths would have been averted forAsian/Pacific Islander and Hispanic or Latino residents, respectively.

4. Discussion

We applied the earliest COVID-19 vaccine phase criteria in Colorado to historical COVID-19 hospitalizations and deaths and found primarily age-based vaccine policy fell short of mitigating health inequities. Compared to those identifying as non-Hispanic White, we found higher rates of hospitalization and death at all ages among Black and Hispanic or Latino residents and larger relative differences by race/ethnicity at younger age groups, which is consistent with other

Fig. 3. Percentage of potential hospitalizations and deaths averted by vaccine phase: Applying age and long-term care facility vaccine phase criteria to Denver 2020 COVID-19 hospitalizations and deaths. A. Percentage of hospitalizations and deaths averted by vaccine phase B. Percentage of hospitalizations averted by vaccine phase, by race/ethnicity C. Percentage of deaths averted by vaccine phase, by race/ethnicity. Source/Notes: Colorado Electronic Disease Reporting System. Occupational vaccine phase qualification criteria (teachers, healthcare worker, etc.) not included.

studies [3,5,17]. By pairing these age-specific rates with the Colorado vaccine rollout, we demonstrated that the greatest reductions in severe outcomes with a primarily age-based vaccine rollout would be expected among the White population. Pre- pandemic racial and ethnic differences in life expectancy due to social factors including access to healthcare, prevalence of comorbidities, income, and neighborhood

residence [18,19] contribute to these findings of more concentrated deaths among persons identifying as White in older age groups.[20] Although concerns have been previously raised regarding the equity of exclusively age-based policies [12], our study provides local, data-driven evidence of the systematic bias of vaccine age prioritization by race/ethnicity. Our findings suggest that age-based vaccine prioritization strategies fail to incorporate risk factors for severe disease, fall short of meeting national goals for vaccine equity and optimal universal protection, and may further widen racial/ethnic disparities. Similar time-since-last-dose criteria for prioritization of boosters will only repeat the prior protocols.

Although we do not evaluate alternative vaccine prioritization approaches within the scope of this study, several alternatives have been proposed. Comparisons of age-based versus "hot-spot" or place-based rollouts have shown that prioritization by geographic areas with highest COVID-19 burden would not only provide a more equitable approach but will significantly reduce hospitalizations overall [21,22]. Other more equitable strategies include using geographic deprivation indices or social networks to prioritize vaccinating residents who have been structurally and historically disadvantaged [21,23]. Evidence also suggests that vaccine prioritization based directly on race/ethnicity may be more equitable; [23] however, such a strategy would likely face legal and political barriers. Last, a National precedent is needed to ensure equitable access to vaccines and boosters. Currently, local-level conversations and grass-roots actions have helped to make vaccines more accessible to some communities at highest risk, but they have had to work within state-defined vaccine phases and have not been bolstered by national guidance [21].

This study has several limitations. First, we were unable to explore impacts of occupation-related vaccine phase criteria within the scope of this analysis. We expect prioritization of these individuals to contribute to reductions in hospitalizations and deaths both directly (outcomes among individual workers) as well as indirectly through maintaining a functioning healthcare workforce and positive benefits to society such as keeping schools open. We focus on the first 3 phases of vaccine rollout in Colorado, which were limited to healthcare workers, first responders, and educators; these occupations have higher representation among White residents [24–26] and are unlikely to reduce our overall observed differences by race/ethnicity. Second, because of small sample sizes and limited detail in data collection, we were unable to conduct analyses for some racial/ethnic groups and aggregated populations with potentially heterogenous risk (e.g., prior studies have shown differences in severe COVID-19 outcomes between Pacific Islander and Asian populations) [2]. Third, social activity and levels of county "openness" varied during the study timeframe which may result in different patterns of infection between groups and don't account for changes to social patterns post-vaccination. All of these may bias the impact of varying strategies when solely applying historical death and hospitalization data to later policies. Last, our analyses assumed 100 % vaccine coverage and efficacy and did not consider well documented barriers [27–29] to vaccination among Black and Hispanic or Latino residents, which we would expect to widen observed disparities within vaccine phases.

5. Conclusions

Ultimately, COVID-19 vaccination is a critical strategy in reducing the negative health and societal impacts of the pandemic. The benefits of ethical and equitable vaccine prioritization span beyond individuals, positively impacting entire communities and regions, irrespective of race/ethnicity. We demonstrate using local data and policy that early age-based prioritization decisions systematically disadvantaged communities of color regardless of COVID-19 risk. As we consider future limited resource emergency responses and booster rollouts for our communities in the US, it will be critical to re-evaluate, rather than repeat past prioritization decisions. Our study provides one such method of critically evaluating policies through disaggregation by race/ethnicity.

CRediT authorship contribution statement

Kaylynn Aiona: Conceptualization, Methodology, Formal analysis, Visualization, Writing – original draft. **Emily Bacon:** Conceptualization, Methodology, Writing – review & editing. **Laura J. Podewils:** Conceptualization, Methodology, Writing – review & editing. **Michelle K. Haas:** Conceptualization, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.hpopen.2022.100074.

References

[1] Gupta S, Cantor J, Simon KI, Bento AI, Wing C, Whaley CM. Vaccinations Against COVID-19 May Have Averted Up To 140,000 Deaths In The United States. Health Aff (Millwood) 2021;40(9):1465–72.
[2] Mackey K, Ayers CK, Kondo KK, et al. Racial and Ethnic Disparities in COVID-19-Related Infections, Hospitalizations, and Deaths : A Systematic Review. Ann Intern Med 2021;174(3):362–73.
[3] Wortham JM, Lee JT, Althomsons S, et al. Characteristics of Persons Who Died with COVID-19 - United States, February 12-May 18, 2020. MMWR Morb Mortal Wkly Rep 2020;69(28):923–9.
[4] Acosta AM, Garg S, Pham H, et al. Racial and Ethnic Disparities in Rates of COVID-19-Associated Hospitalization, Intensive Care Unit Admission, and In-Hospital Death in the United States From March 2020 to February 2021. JAMA Netw Open 2021;4(10):e2130479.
[5] Arrazola J, Masiello MM, Joshi S, et al. COVID-19 Mortality Among American Indian and Alaska Native Persons - 14 States, January-June 2020. MMWR Morb Mortal Wkly Rep 2020;69(49):1853–6.
[6] Magesh S, John D, Li WT, et al. Disparities in COVID-19 Outcomes by Race, Ethnicity, and Socioeconomic Status: A Systematic Review and Meta-analysis. JAMA Network Open 2021;4(11):e2134147.
[7] McClung N, Chamberland M, Kinlaw K, et al. The Advisory Committee on Immunization Practices' Ethical Principles for Allocating Initial Supplies of COVID-19 Vaccine - United States, 2020. MMWR Morb Mortal Wkly Rep 2020;69(47):1782–6.
[8] National Academies of Sciences Engineering and Medicine, Health and Medicine Division, Board on Population Health and Public Health Policy, Board on Health Sciences Policy, Committee on Equitable Allocation of Vaccine for the Novel Coronavirus. The National Academies Collection: Reports funded by National Institutes of Health. In: Kahn B, Brown L, Foege W, Gayle H, editors. Framework for Equitable Allocation of COVID-19 Vaccine. Washington (DC): National Academies Press (US)2020.
[9] Dooling K, Marin M, Wallace M, et al. The Advisory Committee on Immunization Practices' Updated Interim Recommendation for Allocation of COVID-19 Vaccine - United States, December 2020. MMWR Morb Mortal Wkly Rep 2021;69(5152):1657–60.
[10] State COVID-19 Vaccine Priority Populations: KFF 2022. Accessed from: https://www.kff.org/other/state-indicator/state-covid-19-vaccine-priority-populations/.
[11] COVID-19 Vaccine Response Team KM, Blair Hanewall. COVID-19 Vaccine Prioritization Guidance and Allocation Framework. Washington State Department of Health 2021.
[12] Martin EG, Birkhead GS, Holtgrave DR. Maintaining a Focus on Health Equity During the COVID-19 Vaccine Rollout. J Public Health Manag Pract 2021;27(3):226–8.
[13] Centers for Disease Control and Prevention. COVID-19 Vaccinations in the United States. https://covid.cdc.gov/covid-data-tracker/#vaccinations_vacc-total-admin-rate-total. Published 2022. Accessed April 11, 2022.
[14] KFF. Latest Data on COVID-19 Vaccinations by Race/Ethnicity. 2022. Available from: https://www.kff.org/coronavirus-covid-19/issue-brief/latest-data-on-covid-19-vaccinations-race-ethnicity/.
[15] 2019-Based Population Estimates. Colorado Demography Office Colorado Department of Local Affairs. 2021. Accessed from: https://demography.dola.colorado.gov/2019.
[16] Find Out When You're Eligible for the Vaccine. Colorado Department of Public Health and Environment. https://covid19.colorado.gov/for-coloradans/vaccine/

find-out-when-youre-eligible-for-a-covid-19-vaccine#vax%20phase. Accessed 9/1/2021, 2021.
[17] Bassett MT, Chen JT, Krieger N. Variation in racial/ethnic disparities in COVID-19 mortality by age in the United States: A cross-sectional study. PLoS Med 2020;17(10):e1003402.
[18] Chetty R, Stepner M, Abraham S, et al. The Association Between Income and Life Expectancy in the United States, 2001–2014. JAMA, J Am Med Assoc 2016;315(16):1750–66.
[19] Sommers BD, Baicker K, Epstein AM. Mortality and access to care among adults after state Medicaid expansions. The New England journal of medicine 2012;367(11):1025–34.
[20] Kochanek KD, Xu J, Arias E. Mortality in the United States, 2019. NCHS Data Brief 2020;395:1–8.
[21] Schmidt H, Weintraub R, Williams MA, et al. Equitable allocation of COVID-19 vaccines in the United States. Nat Med 2021;27(7):1298–307.
[22] Mishra SSN, Ma H, et al. A vaccination strategy for Ontario COVID-19 hotspots and essential workers. Science Briefs of the Ontario COVID-19 Science Advisory Table 2021;2(26).
[23] Wrigley-Field E, Kiang MV, Riley AR, et al. Geographically targeted COVID-19 vaccination is more equitable and averts more deaths than age-based thresholds alone. Sci Adv 2021;7(40):eabj2099..
[24] Salsberg E, Richwine C, Westergaard S, et al. Estimation and Comparison of Current and Future Racial/Ethnic Representation in the US Health Care Workforce. JAMA Netw Open 2021;4(3):e213789.
[25] The National Center for Education Statistics at IES. Data Point: Race and Ethnicity of Public School Teachers and Their Students. 2020 September 2020. Accessed from: https://nces.ed.gov/pubs2020/2020103.pdf.
[26] Colorado Department of Education. Count of Teachers by District, Ethnicity and Gender. Accessed from: School/District Staff Statistics | CDE (state.co.us). 2022.
[27] Fletcher FE, Maybank, A. . Opinion: 5 ways to make the vaccine rollout more equitable March 25th, 2021, 2021.
[28] Khubchandani J, Macias Y. COVID-19 vaccination hesitancy in Hispanics and African-Americans: A review and recommendations for practice. Brain, Behavior, & Immunity - Health 2021;15:100277.
[29] Kricorian K, Turner K. COVID-19 Vaccine Acceptance and Beliefs among Black and Hispanic Americans. PLoS ONE 2021;16(8):e0256122.