

Title: Why COVID-19 may be disproportionately killing African Americans: Black overrepresentation among COVID-19 mortality increases with lower irradiance, where ethnicity is more predictive of COVID-19 infection and mortality than median income

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Abstract: COVID-19 is killing African Americans at a rate 7% to 193% higher than the general population. Understanding why, as well as the reasons behind the wide variation, is paramount to saving lives. Here, we test two potential explanations for this effect. On the one hand, African Americans might be dying more because they have a lower average income (‘the Socioeconomic Hypothesis’). On the other hand, they might be dying more because they have less vitamin D because their skin is more resistant to UV radiation, as we previously showed that COVID-19 infections and deaths decrease with higher irradiance, which is known to cause vitamin D production (‘the Vitamin D Hypothesis’). The two hypotheses are not mutually exclusive. We show that the overrepresentation of African Americans among COVID-19 deaths shows a significant negative correlation with mean solar irradiance, with a 20% decrease in Global Horizontal Irradiance leading to a 76% increase in the overrepresentation of African Americans amongst COVID-19 deaths. We then show that in Michigan, one of the US states with the lowest irradiance in early April, the % of each county’s population that is black, more than its median income, median age or % of the population above 65 years old, predicts COVID-19 infections and mortality rates. These results suggest a susceptibility linked to low irradiance may play a large role in African American vulnerability to COVID-19, and that black populations in (darker) locations with lower irradiance may benefit from sunlight exposure and/or vitamin D intake during the COVID-19 pandemic, a hypothesis which should be tested immediately with a controlled study.

One Sentence Summary: African American overrepresentation among COVID-19 deaths increases with lower irradiance, where race is more predictive of COVID-19 infection and mortality than median income

Main Text:

The world is enveloped in a COVID-19 pandemic. It is urgent to find potential ways to curb the growth of infections and deaths. Understanding the risk factors that contribute to infections and deaths can help in the search for cure and/or prevention.

Not everybody is at equal risk of COVID-19. African Americans are being infected and killed by COVID-19 at higher rates than the general population. Counties that are majority-black have three times the rate of infections and almost six times the rate of deaths as counties where white

residents are in the majority¹. The reasons remain unknown, as do ways to reduce or reverse this trend.

We previously showed that the number of COVID-19 cases and deaths grow more rapidly in locations with lower irradiance and following lower irradiance days, and posited vitamin D deficiency could perhaps underlie it². Vitamin D can reduce risk of infections. Evidence supporting the role of vitamin D in reducing risk of COVID-19 includes that the outbreak occurred in winter, a time when 25-hydroxyvitamin D (25(OH)D) concentrations are lowest; that the growth of cases in the Southern Hemisphere near the end of summer has been lower than that in the Northern Hemisphere; that vitamin D deficiency has been found to contribute to acute respiratory distress syndrome; and that case-fatality rates increase with age and with chronic disease comorbidity, both of which are associated with lower 25(OH)D concentration³⁴: age decreases the capacity of human skin to product vitamin D³⁵.

One way to test this hypothesis is to look at whether groups at higher risk of vitamin D deficiency are affected by COVID-19 at higher rates than the general population. The prevalence of vitamin D deficiency is more common in people with darker skin who have a natural barrier to the already lower UV irradiation penetrating the skin⁶⁷. People with dark skin need five times as much exposure to sunlight in order to obtain desirable amounts of vitamin D⁸. As predicted by our hypothesis that vitamin D deficiency is a risk factor for COVID-19, as of April 3rd, 2020, African Americans made up almost half of Milwaukee County's 945 cases and 81% of its 27 deaths in a county whose population is only 26% black. Milwaukee is one of the few places in the United States that is tracking the racial breakdown of people who have been infected by the novel coronavirus. In Michigan, where the state's population is 14% black, African Americans made up 35% of cases and 40% of deaths as of Friday morning. Detroit, where a majority of residents are black, has emerged⁹ as a hot spot with a high death toll. A disproportionate number of African Americans in Illinois and North Carolina were infected: 14.6% of Illinois residents are black¹⁰, yet they make up 29.4% of COVID-19 diagnoses and 41.2% of COVID-19 deaths¹¹. In North Carolina, African Americans make up 22% of the population, but 37% of confirmed cases and 20% of deaths¹².

African Americans have lower income than other ethnic groups in the US¹³. It has recently been demonstrated that low income areas in New York have seen the greatest increases in COVID-19 cases¹⁴. It has been hypothesized that this effect can be explained by differences in socioeconomic status across races¹⁵, since lower income people have been slower to adopt social distancing, and more often have jobs that don't allow them to do that^{16,17}.

To test these potentially competing hypotheses to explain the prevalence of COVID-19 in the African American population, we correlated the extent of overrepresentation of black people among COVID-19 deaths across multiple U.S. cities and states that provided a racial breakdown of the victims, including Chicago, Milwaukee county, Michigan, North Carolina, Washington DC, Louisiana, Florida and Connecticut, with solar irradiance data¹⁸. We found that at lower irradiances, such as those in Detroit, the % of blacks among COVID-19 deaths were 193% higher than the % of blacks in the general population. In contrast, at higher irradiances, such as those in Florida, the % of blacks among COVID-19 deaths was only 7% higher than the % of blacks in the general population. This association (Fig. 1) had a Pearson coefficient of correlation of -0.76 ($p < 0.05$).

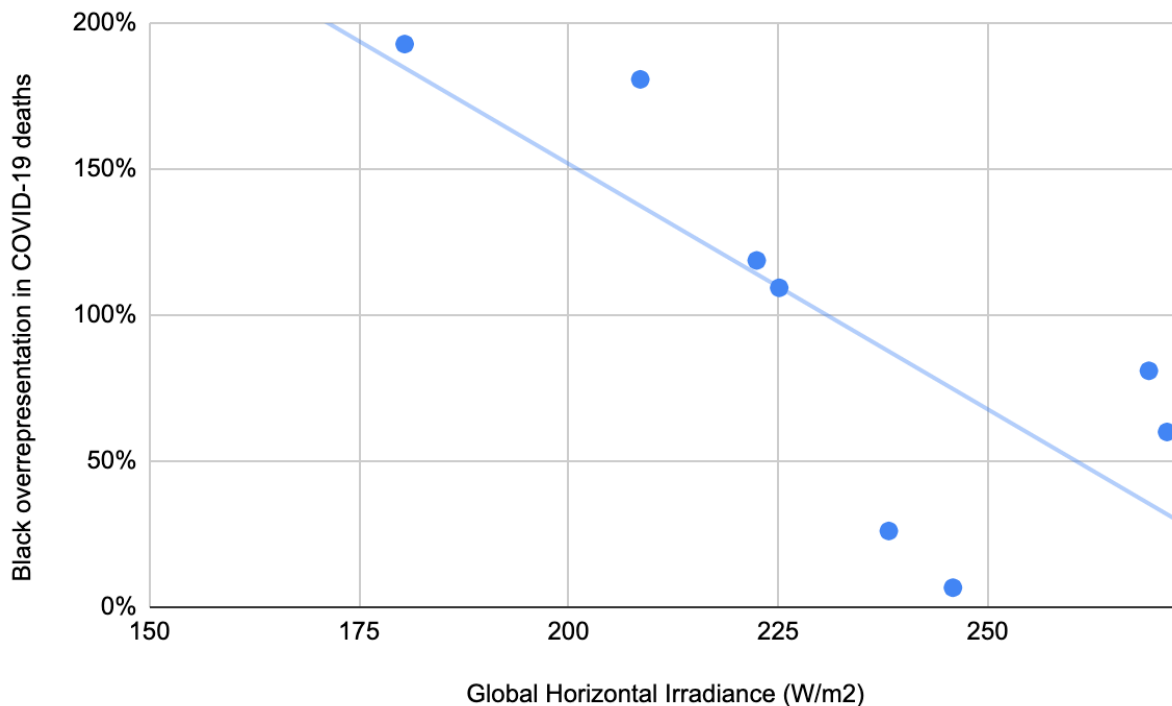


Figure 1. The lower the irradiance, the higher African Americans are overrepresented among COVID-19 deaths (Pearson's correlation coefficient = -0.76 , $p < 0.05$). Overrepresentation was defined as % of black among COVID-19 deaths divided by % of blacks in the corresponding general population for that county or state minus 1. GHI was obtained using the latest available Solcast data (April 6th to April 8th).

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We then took the state with the highest overrepresentation of African Americans among COVID-19 deaths, and carried out a county by county analysis of COVID-19 infection numbers and death rates¹⁹ as a function of each county's median income, % of the population that is African American, median age, % of the population over 65 and average number of people per household, to assay which of these demographic indicators best predicted COVID-19 incidence and mortality. The percentage of each county's inhabitants showed statistically significant correlations both with COVID-19 incidence and mortality among each county's general population (Fig. 2). None of the other demographic indicators analyzed showed a statistically significant correlation or one that was comparable to the fraction of African Americans in each county (Table 1).

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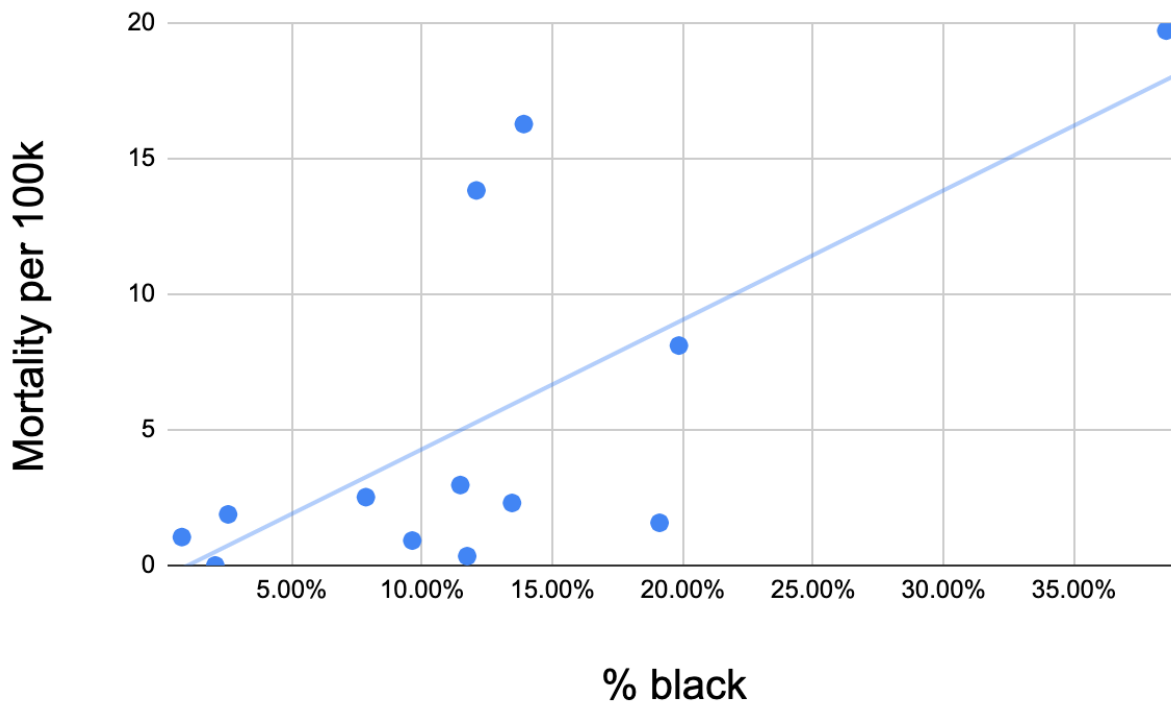


Figure 2. Mortality in the MI general population increases with the % of the population that is black. Pearson's correlation coefficient = 0.70, $p < 0.01$. The number of cases per 100,000 inhabitants also correlated positively with the % of the county's population that is black ($R = 0.61$, $p < 0.05$).

| | R incidence | R case mortality |
|---------------------|-------------|------------------|
| Median income | 0.21 | -0.25 |
| % black | 0.57 | 0.35 |
| People/housing unit | -0.19 | -0.18 |
| Median age | 0.13 | 0.04 |
| % over 65 | -0.23 | -0.28 |

5 Table 1. Pearson's coefficient of correlation between COVID-19 incidence and COVID-19 case mortality in 13 Michigan counties for different demographic indicators. The % of the population that is black showed the only statistically significant correlation ($p < 0.05$).

10 Vitamin D reduces the risk of about 17 types of cancer, bacterial infections for diseases such as dental caries, periodontitis, septicemia, and tuberculosis, viral infections such as respiratory infections and Epstein–Barr virus, autoimmune diseases such as asthma and multiple sclerosis, cardiovascular diseases such as coronary heart disease, diabetes, and stroke, and dementia. Several studies have also reported longer life expectancy with higher vitamin D supplement or serum 25-hydroxyvitamin D levels²⁰. Sensible sun exposure (usually 5-10 min of exposure of the arms and legs or the hands, arms, and face, 2 or 3 times per week) and increased dietary and supplemental vitamin D intakes are reasonable approaches to guarantee vitamin D sufficiency²¹.

15 Serum levels of calcifediol, the prehormone produced in the liver by hydroxylation of vitamin D₃, saturate within five months of whole-body UV exposure for ten minutes three times a week⁴.

We hypothesize that dark-skinned people living in regions with high irradiance suffer from vitamin D insufficiency less frequently, reducing their overrepresentation in COVID-19 cases and deaths, whilst their vitamin D levels in low irradiance regions are more frequently insufficient relative to those of other races to successfully fend off COVID-19.

5 If vitamin D makes people more resistant to COVID-19, the right policy might be one that supplements vitamin D deficiencies with oral supplements or exposure to sunlight or artificial UV-B, particularly in at-risk populations such as African Americans living in low irradiance locations. Oral vitamin D supplements, when they didn't lead to gastrointestinal intolerance (9% of cases in one study, 0 in the other), normalized vitamin D deficiency in all remaining
10 subjects^{22,23}. It wouldn't be the only health benefit known to come from spending time outdoors: there are reports that open-air sunlight treatment of the 1918 Spanish Flu pandemic reduced fatality of hospital cases from 40% to 13%²⁴. In contrast, the low relative humidities produced by indoor heating and cold temperatures are known to favor influenza virus spread²⁵.

15 We recommend a controlled study be undertaken comparing vitamin D levels in COVID-19 victims versus a healthy control population, as well as a study to test whether vitamin D intake and/or a daily minimum dose of sunlight prove to have protective effects against COVID-19.

References and Notes:

- 20 1. R. Theabault et al., <https://www.washingtonpost.com/nation/2020/04/07/coronavirus-is-inflicting-killing-black-americans-an-alarmingly-high-rate-post-analysis-shows/?arc404=true> (2020).
2. A. Bäcker. Follow the Sun: Slower COVID-19 case and death count growth at higher irradiance and temperature. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3567587 (2020).
- 25 3. W.B. Grant, et al. Evidence that Vitamin D Supplementation Could Reduce Risk of Influenza and COVID-19 Infections and Deaths. *Nutrients* **12**, 988 (2020).
4. M. Wacker & M. F. Holick. Sunlight and Vitamin D, *Dermato-Endocrinology*, **5**:1, 51-108 (2013).
5. J. MacLaughlin and M. F. Holick, *J. Clin. Invest.* **76**, 1536–1538 (1985).
- 30 6. S. S. Harris, *J. Nutr.* **136**, 1126–1129 (2006).
7. A. Correia et al. Ethnic aspects of vitamin D deficiency. *Arq Bras Endocrinol Metabol.* **58**: 540–544 (2014).
8. Webb, A.R. and O. Engelsen. Calculated Ultraviolet Exposure Levels for a Healthy Vitamin D Status. *Photochemistry and Photobiology.* **82**(6), 1697-1703 (2006).
- 35 9. K. Shamus et al. <https://www.freep.com/story/news/health/2020/04/03/coronavirus-covid-19-cases-wayne-county-detroit-michigan/5116620002/> (2020)
10. U.S. Census Bureau, Population Estimates Program (PEP), <https://www.indexmundi.com/facts/united-states/quick-facts/illinois/black-population-percentage#map> (2020).
- 40 11. Illinois Department of Public Health, <http://www.dph.illinois.gov/covid19/covid19-statistics> (2020).
12. North Carolina Department of Health and Human Services <https://www.ncdhhs.gov/covid-19-case-count-nc#by-race/ethnicity> (2020).

13. R. Akee et al. Race Matters: Income Shares, Income Inequality, and Income Mobility for All U.S. Races. *Demography* **56**, 999–1021. <https://doi.org/10.1007/s13524-019-00773-7> (2019).
14. L. Buchanan et al. <https://www.nytimes.com/interactive/2020/04/01/nyregion/nyc-coronavirus-cases-map.html> (2020).
- 5 15. Meagan Flynn <https://www.washingtonpost.com/nation/2020/04/07/chicago-racial-disparity-coronavirus/> (2020)
16. J. Valentino-DeVries et al. <https://www.nytimes.com/interactive/2020/04/03/us/coronavirus-stay-home-rich-poor.html> (2020)
- 10 17. E. Gould, H. Shierholz. Not everybody can work from home. Black and Hispanic workers are much less likely to be able to telework. <https://www.epi.org/blog/black-and-hispanic-workers-are-much-less-likely-to-be-able-to-work-from-home/> (2020)
18. Solcast, Solar irradiance data API, <https://solcast.com/> (2020).
19. FOX2, <https://www.fox2detroit.com/news/track-michigan-coronavirus-cases-by-county-with-this-interactive-map-2020>
- 15 20. W.B. Grant. The Health Benefits of Solar Irradiance and Vitamin D and the Consequences of Their Deprivation. Springer Science+Business Media, LLC (2010).
21. M. F. Holick. Sunlight and vitamin D for bone health and prevention of autoimmune diseases, cancers, and cardiovascular disease. *Am J Clin Nutr.* **80**(6 Suppl): 1678S–1688S (2004).
- 20 22. T. Golombick T, T. Diamond. The effect of a combined oral calcium and vitamin D supplement for treating mild to moderate vitamin D deficiency in postmenopausal women. *Clin Interv Aging.* **3**(1):183–186. doi:10.2147/cia.s2458 (2008).
23. M. Bellows et al. "Vitamin D Deficiency in TAMU Female Basketball Players and Supplement Effectiveness," *International Journal of Exercise Science: Conference Proceedings: 2* : Iss. 5 , Article 19 (2013).
- 25 24. R.A. Hobday, J.W. Cason. The open-air treatment of pandemic influenza. *Am J Public Health* **99** (Suppl 2):S236–S242 (2009).
25. A.C. Lowen et al., Influenza virus transmission is dependent on relative humidity and temperature. *PLOS Pathogens* **3**: e151 (2007).
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