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Mapping One Million COVID-19 Deaths and Unhealthy Lifestyle Behaviors in the United States: Recognizing the Syndemic Pattern and Taking Action

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ABSTRACT

Tragically, the United States (US) surpassed one million documented deaths due to the coronavirus disease 2019 (COVID-19) pandemic. A convincing association between unhealthy lifestyle behaviors and poorer outcomes associated with COVID-19 infection has already been demonstrated and communicated by the Centers for Disease Control and Prevention in public health messaging. The US is experiencing not a pandemic, but a syndemic, specifically an unhealthy lifestyle behaviors—chronic diseases—COVID-19 syndemic. This syndemic has almost certainly significantly contributed to the more than one million deaths the United States has experienced during the pandemic. Decades of a high prevalence of unhealthy lifestyle behaviors laid the foundation for our current unfortunate situation by increasing vulnerability to a novel virus, especially among subgroups who have been historically marginalized. As such, a major pathway to defeating this syndemic is through the promotion of healthy living behaviors for all. Now is the time for action appropriate to meet the demands of a syndemic and a new path forward to a healthier and more equitable future.

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Tragically, the United States surpassed one million documented deaths due to the coronavirus disease 2019 (COVID-19) pandemic. [Figure 1](#) from the Centers for Disease Control and Prevention (CDC) illustrates the state-by-state death rate per 100,000 individuals.¹ Clearly, the COVID-19 mortality rates across the states differed substantially, with the Southeast region bearing a heavier burden from this pandemic. The United States and many other parts of the world have begun to emerge from the COVID-19 health crisis, although challenges remain with variants

of the virus and controlling outbreaks. At this time, it is important not only to look ahead but also to reflect on challenges faced and patterns that have emerged during the pandemic. Perhaps, as we reflect on the now more than one million lives lost in the United States and apparent differences in mortality rates across states, lessons can be learned from comparing similar mapping patterns for other major health issues we face.

A convincing association between unhealthy lifestyle behaviors and poorer outcomes associated with COVID-19 infection (eg, hospitalization and mortality risk) has already been demonstrated and communicated by the CDC in public health messaging.²⁻⁷ These behaviors and conditions included physical activity, obesity, diabetes, and smoking. Sallis et al⁸ reported that individuals infected with COVID-19 were at significantly higher risk for hospitalization if they reported a sedentary lifestyle prior to diagnosis.⁸ Cunningham⁹ assessed the relationship between physical activity and both COVID-19 cases and deaths across US counties, demonstrating that low physical activity levels were associated with higher death rates (ie, those with COVID-19 cases had a higher mortality rate if physical activity levels were low). In fact, based on the study by Sallis et al⁸ and 24 others, the CDC recently recognized physical inactivity as a conclusive risk factor for severe COVID-19.¹⁰ It appears that the COVID-19 and physical inactivity pandemics have collided and synergistically contributed to particularly poor outcomes.¹¹ These observations are consistent with previous research demonstrating a similar trend between higher physical activity levels and lower severity of infection during the 2009 H1N1 influenza epidemic; physical activity clearly improves immune function and is therefore a vital medicine to combat viral infections.¹² A clear link between obesity, heavily related to lifestyle behaviors (ie, physical inactivity, increased sedentariness, and poor diet) and poor COVID-19 outcomes has also been demonstrated.^{13,14} The CDC provides US maps related to the prevalence of physical inactivity, smoking, and obesity, which are illustrated in Figures 2-4, respectively.¹⁵⁻¹⁷ Althoff et al¹⁸ assessed food environment and diet trends in the United States, providing several nationwide maps illustrated in Figure 5. Moreover, sleep-related hypoxia has been associated with a worsening of COVID-19-related outcomes,¹⁹ and the CDC has previously reported the prevalence of low sleep durations (ie, ≤ 6 hours in a 24-hour period) to be of epidemic proportions.²⁰ Additionally, stresses related to living with the pandemic has led to sleep dysfunction; changes in sleep-wake cycle disrupted sleep and decreased sleep quality.²¹ Long-term effects of sleep

on COVID-19 outcomes and the pandemic-related impact on population sleep patterns still need to be assessed longitudinally. Figure 6 provides the CDC map related to the prevalence of short sleep duration.²²

Collectively, a clear pattern emerges among the maps illustrated in Figures 1-6. Specifically, COVID-19 mortality rates are generally highest in the Southeast region, where unhealthy lifestyle behaviors (ie, physical inactivity, poor nutrition, smoking, low sleep quality) and excess body mass likewise have the highest prevalence.

A similar example, using US maps to illustrate the link between poor outcomes and unhealthy lifestyle behaviors, is possible when comparing COVID-19 mortality rates with maps for chronic disease mortality rates. As a leading chronic disease example, illustrated in Figure 7,²³ cardiovascular disease death rates are again highest in the Southeast region. The link between unhealthy lifestyle behaviors and an increased risk of prematurely being diagnosed with one or more chronic diseases has been known for decades and is beyond dispute.²³ Furthermore, evidence has emerged during the COVID-19 pandemic convincingly indicating a significantly higher risk for hospitalization and mortality in individuals diagnosed with one or more chronic condition when infected with COVID-19.^{24,25} These lines of evidence combine to support a conclusion that the United States is experiencing not a pandemic, but a syndemic, defined as “two or more health conditions or diseases that negatively interact with and affect the outcomes of one another,”²⁶ specifically, an unhealthy lifestyle behaviors—chronic diseases—COVID-19 syndemic. This syndemic^{27,28} has almost certainly significantly contributed to the more than one million deaths the United States has experienced during the pandemic.

Given that the threshold for a syndemic is 2 highly prevalent health conditions or diseases, we will remain in an unhealthy lifestyle—chronic disease syndemic for the foreseeable future. If something drastic does not change, we will remain poorly prepared for the next viral pandemic and suffer similar, if not worse, outcomes than those experienced during the COVID-19 pandemic. Researchers are already acknowledging that future pandemic preparedness must focus on addressing the chronic disease and unhealthy lifestyle crises.²⁹ Unfortunately, early evidence indicates the COVID-19 pandemic has resulted in a further deterioration of healthy living behaviors around the world (ie, further declines in physical activity and poorer nutritional habits), which now seems to be resulting in an acceleration in weight gain trends on a population level.^{6,30} If this observation signals the new *unhealthy lifestyle baseline*, chronic

CLINICAL SIGNIFICANCE

- The United States surpassed one million documented deaths due to the coronavirus disease 2019 (COVID-19) pandemic.
- A convincing association between unhealthy lifestyle behaviors and poorer outcomes associated with COVID-19 infection has been demonstrated and communicated by the Centers for Disease Control and Prevention in public health messaging.
- Clinicians play a central role in this pathway by embracing and commonly practicing healthy living medicine.

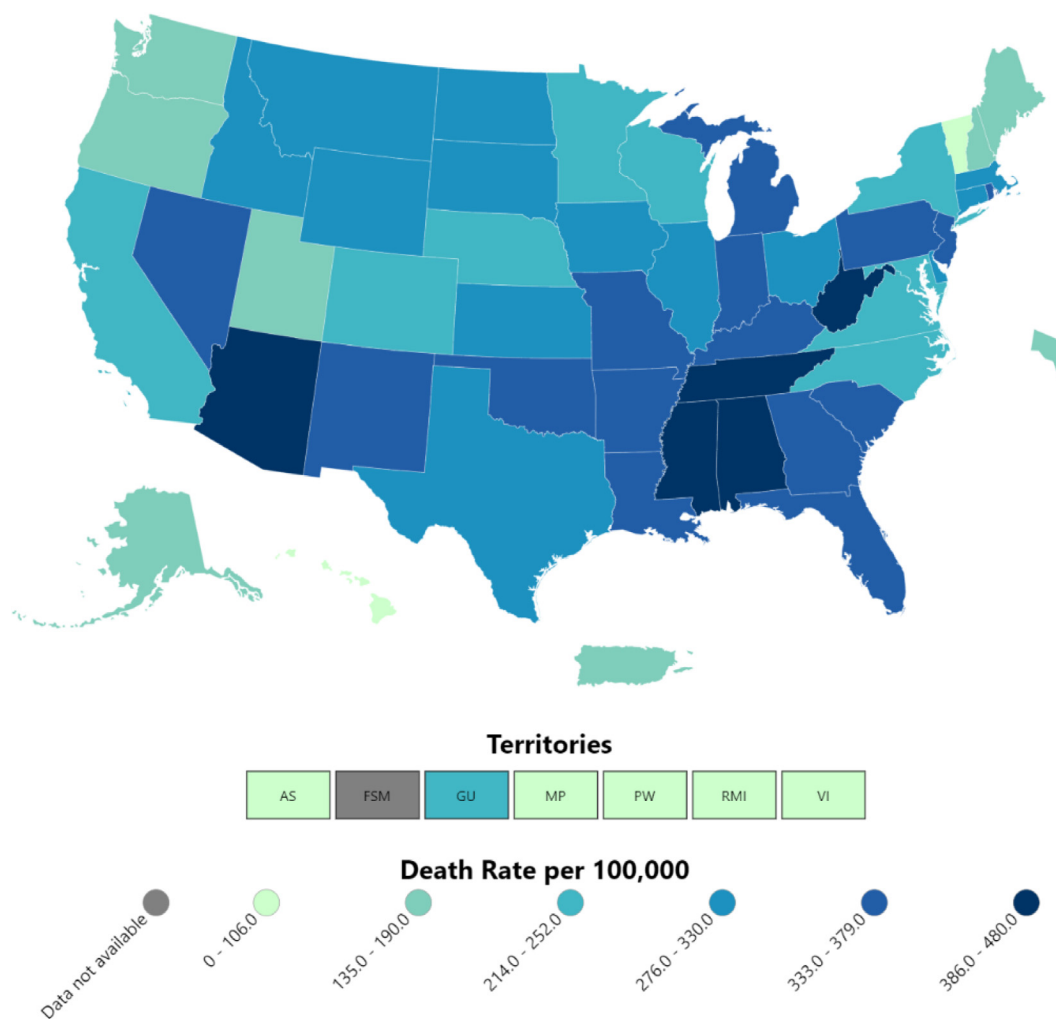


Figure 1 COVID-19 death rate in the United States reported to the CDC, by state/territory (deaths per 100,000). Source:¹ Centers for Disease Control and Prevention (CDC): https://covid.cdc.gov/covid-data-tracker/#cases_deathsper100k. AS = American Samoa; FSM = Federated States of Micronesia; GU = Guam; MP = Northern Mariana Islands; PW = Palau; RMI = Republic of Marshall Islands; VI = Virgin Islands.

disease incidence and prevalence will increase further in the coming decades, with catastrophic consequences.

How did we get to this point? It can be convincingly argued that the deleterious health outcomes we are currently experiencing have been decades in the making, and the ever-increasing prevalence of unhealthy living phenotypes creates widespread vulnerabilities across the population for both chronic and infectious diseases. This is not to say that a universal adoption of healthy living behaviors would eliminate all chronic disease and poor outcomes with viral pandemics. Certainly, contributory factors to an unfavorable health trajectory (eg, cardiovascular disease, cancer, hospitalization/death due to a viral infection) are multifactorial. However, the link between healthy living behaviors and a significantly higher likelihood for a favorable health trajectory across the lifespan is undeniable.³¹

Imagine a world where physical activity, good nutrition, not using tobacco products, sleep hygiene, and a healthy

body weight were normative across the population. Chronic disease incidence and prevalence would have been far lower in the United States leading up to the COVID-19 pandemic. For example, population-level adoption of a more physically active lifestyle, increasing moderate-vigorous intensity physical activity by 10 minutes per day, was recently projected to prevent 111,174 deaths per year in the United States.³² In a European study including more than 116,000 subjects, Nyberg et al³³ found that men and women with an ideal lifestyle score—based on smoking status, body weight, physical activity, and alcohol consumption—lived approximately 9 years longer without a chronic disease diagnosis, compared with those with the poorest lifestyle score. Although broad, population-level adoption of healthy living behaviors would not have prevented the current viral pandemic, far fewer than one million COVID-19-related deaths in the United States would likely have occurred. We are unaware of any current analysis that has

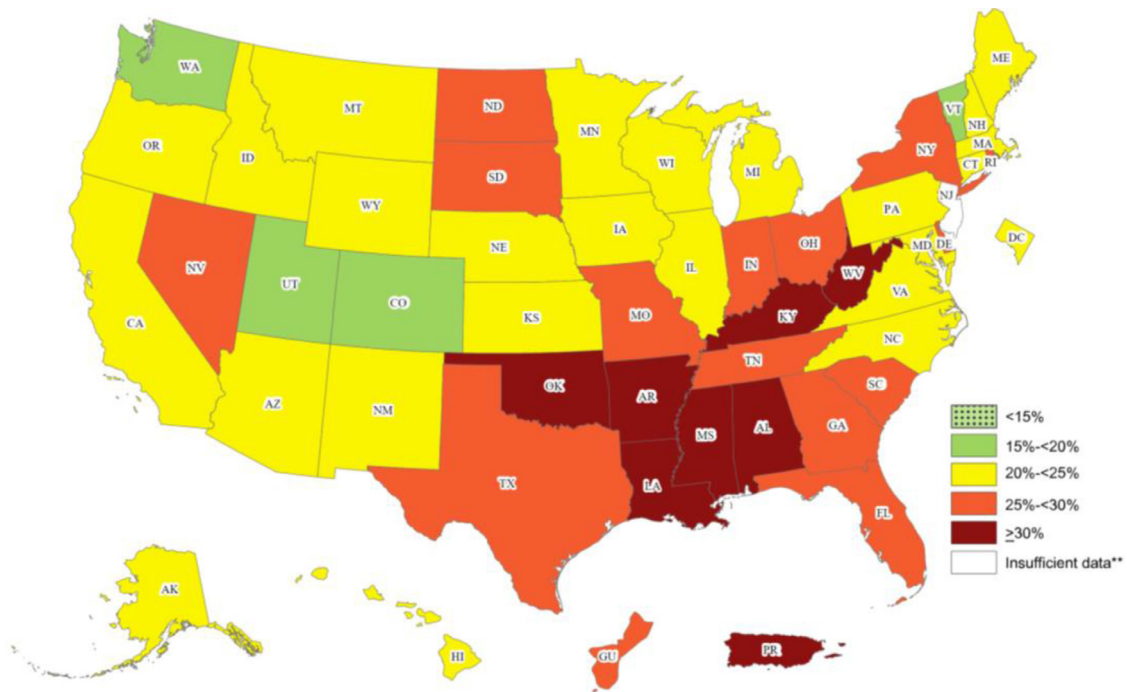


Figure 2 Prevalence of self-reported physical inactivity among US adults, Behavior Risk Factor Surveillance System, 2017-2020. Source:¹⁵ Centers for Disease Control and Prevention (CDC): <https://www.cdc.gov/physicalactivity/data/inactivity-prevalence-maps/index.html#overall>.

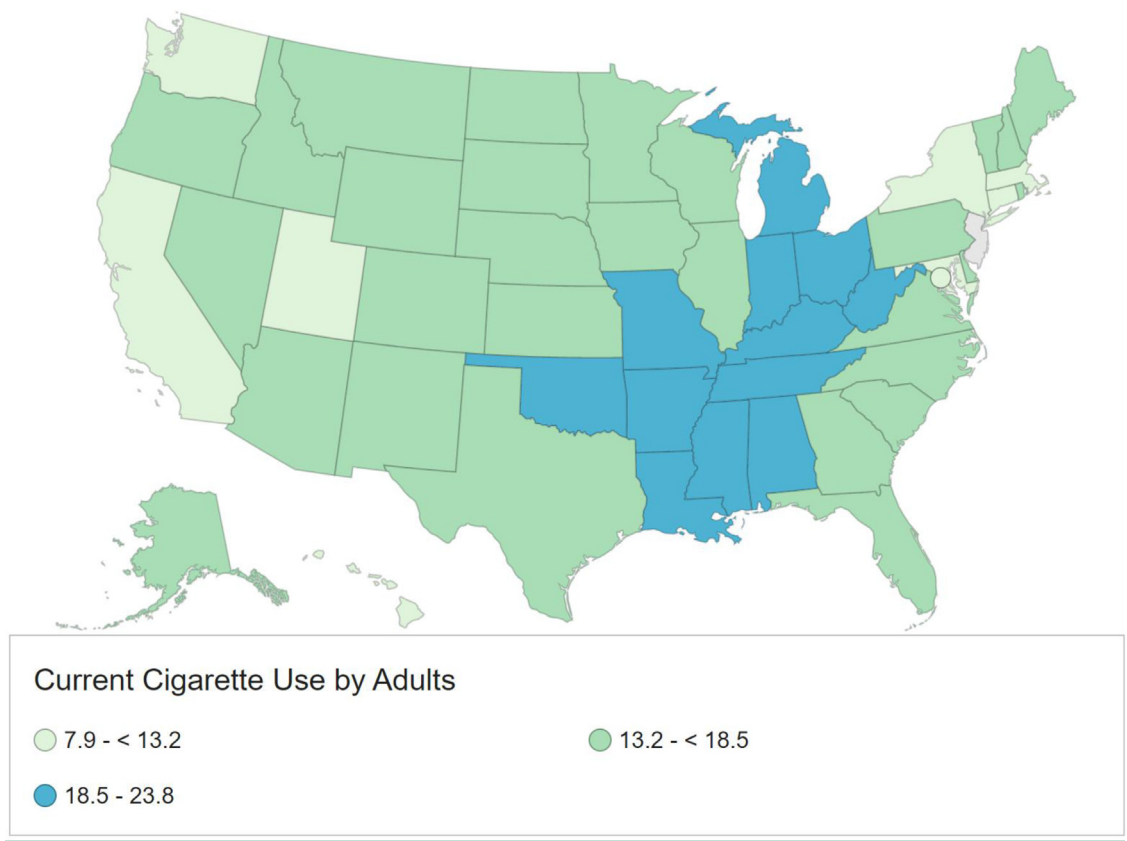


Figure 3 Current cigarette use among adults, Behavior Risk Factor Surveillance System, 2019. Source:¹⁷ Centers for Disease Control and Prevention (CDC): <https://www.cdc.gov/statesystem/cigaretteuseadult.html>.

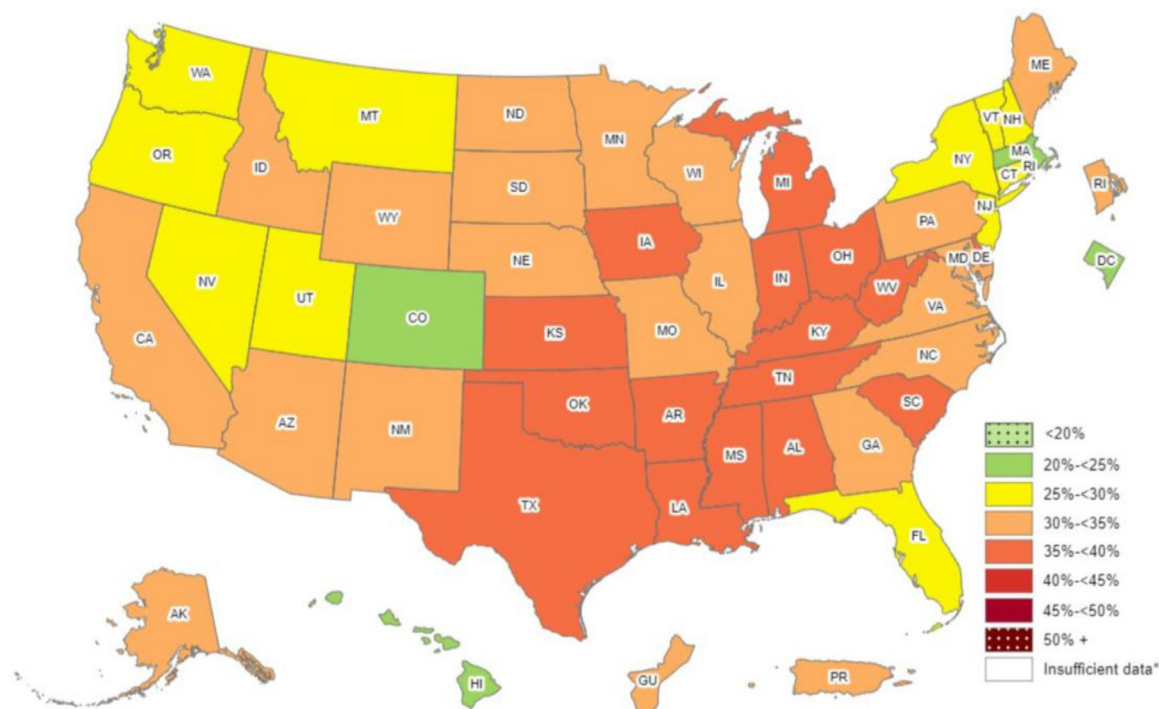


Figure 4 Prevalence of self-reported obesity among US adults, Behavior Risk Factor Surveillance System, 2020. Source:¹⁶ Centers for Disease Control and Prevention (CDC): <https://www.cdc.gov/obesity/data/prevalence-maps.html#overall>.

estimated the number of COVID-19 deaths that would have been prevented with increased adoption of a healthy lifestyle. We are confident that, when such analyses are performed, the number of deaths that could have been prevented will be shown to be substantial. There is evidence emerging during the COVID-19 pandemic which indicates that healthy living behaviors may have altered the projected impact of the COVID-19 pandemic in certain parts of the world. For example, hospitalization and mortality rates due to COVID-19 are far lower in Sub-Saharan Africa than projected during the initial phases of this global health crisis. One postulated reason for these better-than-expected outcomes is the higher prevalence of a physically active lifestyle in this part of the world.³⁴ Additional research is required in this area.

The message provided in this commentary is not new, but it is nonetheless extremely important and worthy of repeating in the context of the COVID-19 crisis until the reality of the current syndemic is understood and stimulates meaningful change in public health actions. The similarities among the US maps of COVID-19, chronic diseases, and healthy lifestyle behaviors illustrated herein provide yet more supporting evidence justifying a call to action. An appropriate response to the syndemic requires systematic and coordinated policy, systems, and educational and programmatic actions that promote and support the adoption of healthy living behaviors on a population level.

A first step in this call to action is to examine and understand the complex relationships among the adoption of

lifestyle behaviors, both healthy and unhealthy, and key health outcomes, such as chronic diseases and the viral pandemics. Recently, Pronk and Faghy³⁵ proposed a causal systems mapping approach to promote healthy living behaviors for pandemic preparedness. The authors recognize that “promoting healthy living factors remains challenged by a lack of scalability and sustainability due, in part, to a mismatch between intervention focus on individual behavior change as opposed to recognizing complex and multifactorial causes that prevent people from living healthy lifestyles and maintaining them long term (such as political will, economic benefits, and urban planning).”³⁵ The authors further propose that a causal systems map approach would aid key stakeholders across multiple sectors and enhance preparedness for future pandemics on a population level. A similar causal systems map approach would be beneficial in exploring the complex relationship between lifestyle behaviors and chronic diseases. Causal systems mapping could be used to better understand the complex relationships among COVID-19, chronic disease, and unhealthy lifestyle behaviors. Understanding these complex relationships will increase the likelihood of implementing effective healthy living messaging and programming across multiple sectors (eg, community, education, health care). Ma and Sallis²⁹ also rightly recognize that the COVID-19 response and preparedness must account for the chronic disease health crisis we have been living with well before the current viral pandemic. As mentioned previously, COVID-19, chronic disease, and unhealthy lifestyle

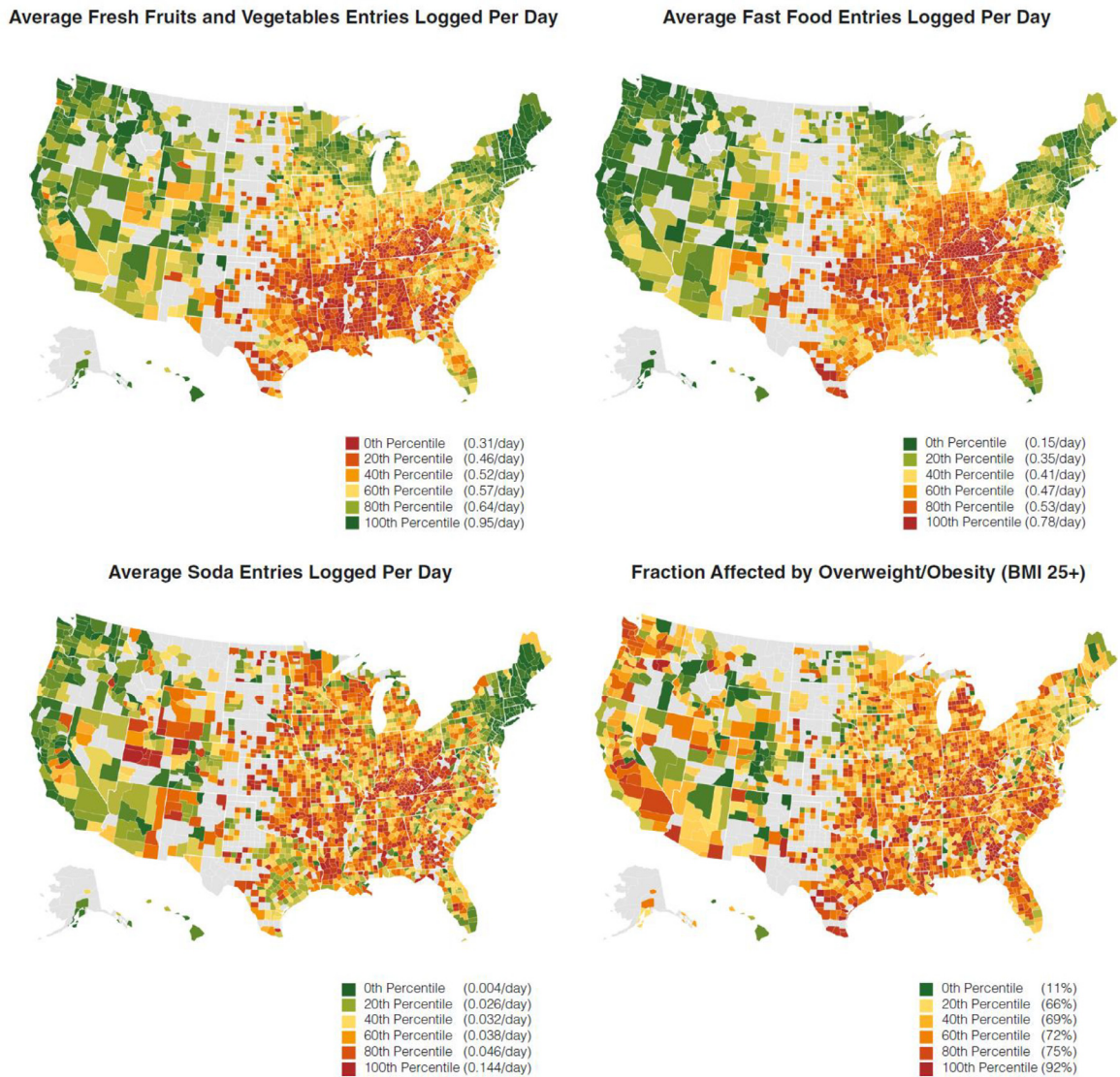


Figure 5 Dietary habits and body mass index status across the United States. Source:¹⁸ Althoff T, Nilforoshan H, Hua J Leskovec J. Large-scale diet tracking data reveal disparate associations between food environment and diet. *Nat Commun.* 2022;13(1):267.

behaviors have become a new syndemic that must be addressed comprehensively if we hope to improve outcomes in the remainder of the COVID-19 crisis and be better prepared for future syndemics.

There is a critical race and social justice component to the present syndemic such that individuals in underserved communities are being disproportionately impacted by poor COVID-19 outcomes, chronic disease incidence and prevalence, and unhealthy living behaviors.^{26,36} In fact, the health inequities associated with the COVID-19–chronic disease–unhealthy lifestyle triad are an integral part of this syndemic that must be simultaneously addressed in the renewed spirit of race and social justice.³⁶ Meaningfully moving toward an increased adoption of healthy living behaviors on a population level, for all individuals regardless of race, sex, or social strata, is central to addressing the present

syndemic, which can be argued to be one of the biggest health crises of our generation.

In conclusion, surpassing one million deaths related to COVID-19 was a tragic milestone for the United States. Visualization of the US COVID-19 mortality map, in comparison with US maps of several lifestyle behaviors, obesity, and chronic disease, show a clear pattern that convincingly demonstrates the syndemic we currently face. Decades of a high prevalence of unhealthy lifestyle behaviors laid the foundation for our current unfortunate situation by increasing vulnerability to a novel virus, especially among subgroups who have been historically marginalized. Other authors have referred to the COVID-19 pandemic as a “a wake-up call for lifestyle-related preventable conditions,”³⁷ and we could not agree more. As such, a major pathway to defeating this syndemic is through the promotion of healthy living behaviors for all. Now is the time for

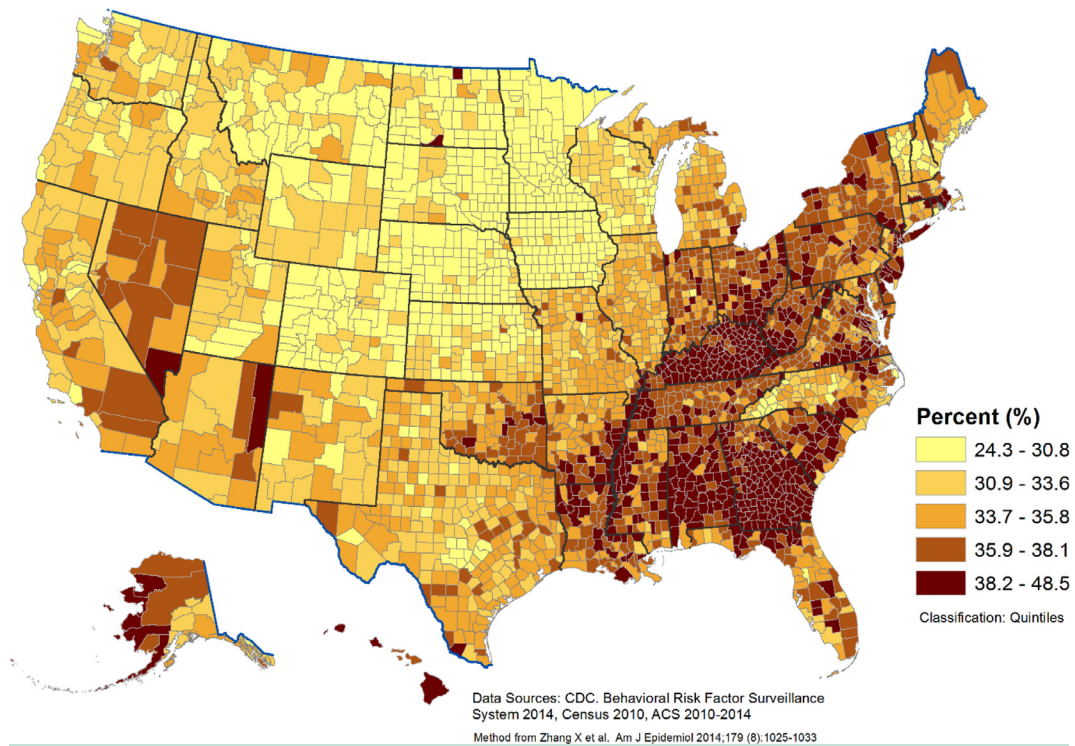


Figure 6 Prevalence of short sleep duration (<7 hours) for adults aged ≥18 years, by county, United States, 2014. Source:²² Centers for Disease Control and Prevention (CDC): https://www.cdc.gov/sleep/data_statistics.html.

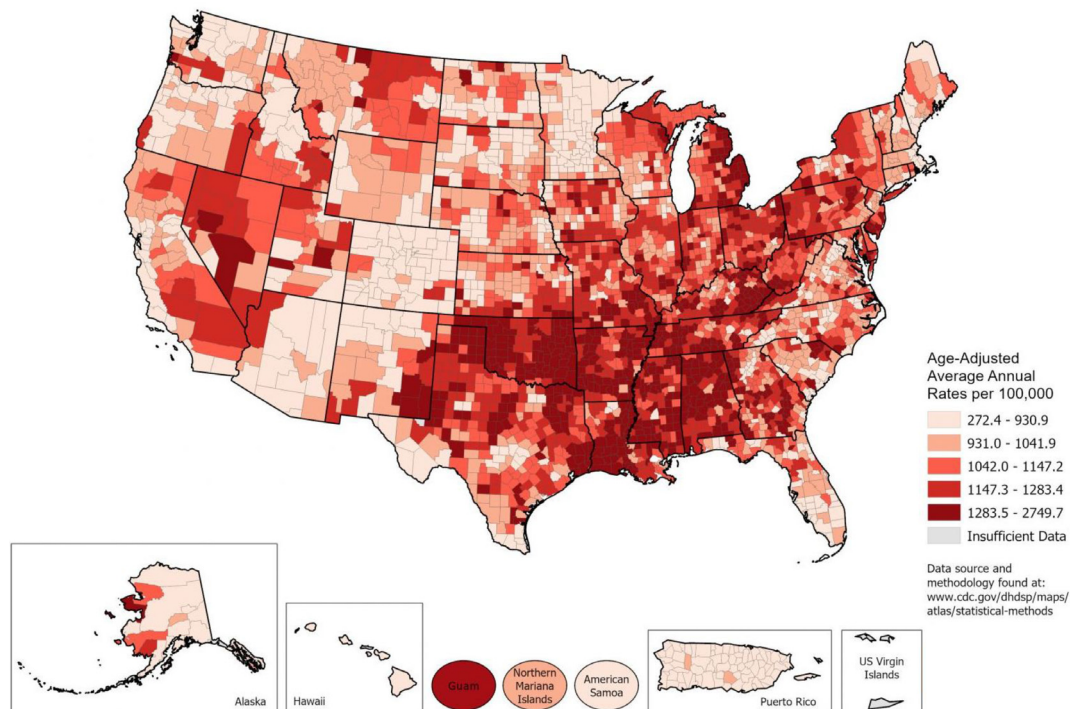


Figure 7 Heart disease death rates, 2017-2019 adults, ages 65+ years, by county. Source:²³ Centers for Disease Control and Prevention (CDC): https://www.cdc.gov/dhdsdp/maps/national_maps/hd65_all.htm; CDC Disclaimer: Use of CDC material, including any links to the materials on the CDC, Agency for Toxic Substances and Disease Registry (ATSDR) or Department of Health and Human Services (HHS) websites, does not imply endorsement by CDC, ATSDR, HHS or the United States Government. CDC material is otherwise available on the agency website for no charge.

action appropriate to meet the demands of a syndemic and a new path forward to a healthier and more equitable future.

References

- Centers for Disease Control and Prevention (CDC). COVID data tracker. Available at: https://covid.cdc.gov/covid-data-tracker/#cases_deathsper100k. Accessed May 24, 2022.
- Tavakol Z, Ghannadi S, Tabesh MR, et al. Relationship between physical activity, healthy lifestyle and COVID-19 disease severity; a cross-sectional study:[online ahead of print] *Z Gesundh Wiss* 2021 Feb 4:1–9.
- Merino J, Joshi AD, Nguyen LH, et al. Diet quality and risk and severity of COVID-19: a prospective cohort study. *Gut* 2021;70(11):2096–104.
- Hamer M, Kivimäki M, Gale CR, Batty GD. Lifestyle risk factors, inflammatory mechanisms, and COVID-19 hospitalization: a community-based cohort study of 387,109 adults in UK. *Brain Behav Immun* 2020;87:184–7.
- Hamer M, Kivimäki M, Gale CR, Batty GD. Lifestyle risk factors for cardiovascular disease in relation to COVID-19 hospitalization: a community-based cohort study of 387,109 adults in UK:[Preprint] *medRxiv* 2020 May 13 [2020.05.09.20096438].
- Hall G, Laddu DR, Phillips SA, Lavie CJ, Arena R. A tale of two pandemics: how will COVID-19 and global trends in physical inactivity and sedentary behavior affect one another? *Prog Cardiovasc Dis* 2021;64:108–10.
- Baker J, Krishnan N, Abroms LC, Berg CJ. The impact of tobacco use on COVID-19 outcomes: a systematic review. *J Smok Cessat* 2022;2022:5474397.
- Sallis R, Young DR, Tartof SY, et al. Physical inactivity is associated with a higher risk for severe COVID-19 outcomes: a study in 48 440 adult patients. *Br J Sports Med* 2021;55(19):1099–105.
- Cunningham GB. Physical activity and its relationship with COVID-19 cases and deaths: Analysis of U.S. counties. *J Sport Health Sci* 2021;10(5):570–6.
- Centers for Disease Control and Prevention (CDC). Brief summary of findings on the association between physical inactivity and severe COVID-19 outcomes. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/downloads/clinical-care/E-Physical-Inactivity-Review.pdf>. Accessed: March 31, 2022.
- Ramirez Varela A, Sallis R, Rowlands AV, Sallis JF. Physical inactivity and COVID-19: when pandemics collide. *J Phys Act Health* 2021;18(10):1159–60.
- Laddu DR, Lavie CJ, Phillips SA, Arena R. Physical activity for immunity protection: inoculating populations with healthy living medicine in preparation for the next pandemic. *Prog Cardiovasc Dis* 2021;64:102–4.
- Cedano J, Fabian Corona E, Gonzalez-Lara M, et al. Characteristics and outcomes of patients with COVID-19 in an intensive care unit of a community hospital; retrospective cohort study. *J Community Hosp Intern Med Perspect* 2021;11(1):27–32.
- Lavie CJ, Sanchis-Gomar F, Henry BM, Lippi G. COVID-19 and obesity: links and risks. *Expert Rev Endocrinol Metab* 2020;15(4):215–6.
- Centers for Disease Control and Prevention (CDC). Physical activity. Available at: <https://www.cdc.gov/physicalactivity/data/inactivity-prevalence-maps/index.html#overall>. Accessed May 24, 2022.
- Centers for Disease Control and Prevention (CDC). Overweight and obesity. Available at: <https://www.cdc.gov/obesity/data/prevalence-maps.html#overall>. Accessed: May 24, 2022.
- Centers for Disease Control and Prevention (CDC). State Tobacco Activities Tracking and Evaluation (STATE) system. Available at: <https://www.cdc.gov/statesystem/cigaretteuseadult.html>. Accessed May 24, 2022.
- Althoff T, Nilforoshan H, Hua J, Leskovec J. Large-scale diet tracking data reveal disparate associations between food environment and diet. *Nat Commun* 2022;13(1):267.
- Pena Orbea C, Wang L, Shah V, et al. Association of sleep-related hypoxia with risk of COVID-19 hospitalizations and mortality in a large integrated health system. *JAMA Netw Open* 2021;4(11):e2134241.
- Watson NF, Badr MS, Belenky G, et al. Joint consensus statement of the American Academy of Sleep Medicine and Sleep Research Society on the recommended amount of sleep for a healthy adult: methodology and discussion. *J Clin Sleep Med* 2015;11(8):931–52.
- Bhat S, Chokroverty S. Sleep disorders and COVID-19. *Sleep Med* 2022;91:253–61.
- Centers for Disease Control and Prevention (CDC). Sleep and sleep disorders. Available at: https://www.cdc.gov/sleep/data_statistics.html. Accessed: May 24, 2022.
- Centers for Disease Control and Prevention (CDC). Division for heart disease and stroke prevention. Available at: https://www.cdc.gov/dhdsp/maps/national_maps/hd65_all.htm. Accessed May 24, 2022.
- Chishinga N, Smith S, Gandhi NR, et al. Characteristics and risk factors for mortality by coronavirus disease 2019 pandemic waves in Fulton County, Georgia: a cohort study March 2020–February 2021. *Open Forum Infect Dis* 2022;9(4):ofac101.
- Ejaz H, Alsrhani A, Zafar A, et al. COVID-19 and comorbidities: deleterious impact on infected patients. *J Infect Public Health* 2020;13(12):1833–9.
- Arena R, Laddu D, Severin R, Hall G, Bond S. Healthy Living and Social Justice: ADDRESSING THE CURRENT SYNDEMIC IN UNDERSERVED COMMUNITIES. *J Cardiopulm Rehabil Prev* 2021;41(3):E5–6.
- Hart L, Horton R. Syndemics: committing to a healthier future. *Lancet* 2017;389(10072):888–9.
- Singer M, Clair S. Syndemics and public health: reconceptualizing disease in bio-social context. *Med Anthropol Q* 2003;17(4):423–41.
- Ma J, Sallis JF. A national strategy for COVID response and pandemic preparedness must address noncommunicable chronic diseases:[online ahead of print] *J Gen Intern Med* 2022 May 9:1–2.
- Arena R, Hall G, Laddu DR, Phillips SA, Lavie CJ. A tale of two pandemics revisited: physical inactivity, sedentary behavior and poor COVID-19 outcomes reside in the same Syndemic City. *Prog Cardiovasc Dis* 2022;71:69–71.
- Behrens G, Fischer B, Kohler S, Park Y, Hollenbeck AR, Leitzmann MF. Healthy lifestyle behaviors and decreased risk of mortality in a large prospective study of U.S. women and men. *Eur J Epidemiol* 2013;28(5):361–732.
- Saint-Maurice PF, Graubard BI, Troiano RP, et al. Estimated number of deaths prevented through increased physical activity among US adults. *JAMA Intern Med* 2022;182(3):349–52.
- Nyberg ST, Singh-Manoux A, Pentti J, et al. Association of healthy lifestyle with years lived without major chronic diseases. *JAMA Intern Med* 2020;180(2):760–8.
- Wachira LJ, Arena R, Sallis JF, et al. Why are COVID-19 effects less severe in Sub-Saharan Africa? Moving more and sitting less may be a primary reason. *Prog Cardiovasc Dis* 2022;71:103–5.
- Pronk NP, Faghy MA. Causal systems mapping to promote healthy living for pandemic preparedness: a call to action for global public health. *Int J Behav Nutr Phys Act* 2022;19(1):13.
- Hall G, Arena R, Severin R. Social justice as it relates to healthy living behaviors and medicine: the current state of inequity and the path forward:[online ahead of print] *Prog Cardiovasc Dis* 2022;71:1–3.
- Lim MA, Smith L. COVID-19 pandemic: a wake-up call for lifestyle-related preventable conditions in older adults. *Aging Clin Exp Res* 2021;33(8):2367–8.