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Internet access and cardiovascular death in the United States

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Abstract

As high-speed internet becomes increasingly important as a resource for cardiovascular disease (CVD) prevention and management services, gaps in digital infrastructure may have detrimental impact on health outcomes. Using national census and CDC data from 2018 we evaluated state-level rates of household internet access and age-adjusted cardiac mortality. After adjusting for state level demographic variables, and rates of education, income, and health insurance, internet access rates were inversely associated with age adjusted CVD mortality, showing that the potential for internet access to affect CVD management deserves further study.

Keywords

Internet; Telemedicine; Cardiac mortality; Social determinants of health

1. Introduction

Internet use has proven health benefits including the exchange of health-related infromation [1]. Telemedicine visits have accelerated in recent years [2,3] and depend on reliable internet access for timely care delivery [4]. The management of both acute and chronic cardiac conditions can likely benefit from internet-based support, as identified in a prospective

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trial to reduce heart failure hospitalizations and all-cause mortality beyond usual care [5]. At the individual patient level, high-speed (broadband) internet access is related to sociodemographic factors such as income, level of education, and racial/ethnic minoritized status [6]. At the population health level, a recent study found that counties with large Black and Indigenous American populations have disproportionately decreased access to broadband internet compared with others in the US [7].

Cardiovascular disease (CVD) remains the leading cause of death in the US and across much of the world [8] with, CVD mortality having a large public health burden resulting in substantial health policy implications. Population-level access to healthcare is essential to our nation's public health and the association of access to reliable, highspeed internet with health outcomes deserves further study. Using publicly available data, we tested the hypothesis that high-speed internet (broadband) access is inversely related to age-adjusted CVD mortality at the state level.

2. Methods

We used the most recent publicly available date to evaluate national rates of household internet access and age-adjusted cardiac mortality at the state-level. The primary exposure was broadband internet access, which was estimated at the state level using 5-year American Community Survey (ACS) Estimates Data Profiles of US internet subscription rates (percentage of subscriptions per households per state) in 2018 (accessed at www.data.census.gov). The primary outcome was age-adjusted CVD mortality (ICD-10 codes: I00-I99), ascertained by state using 2018 CDC WONDER vital statistics (accessed at www.wonder.cdc.gov). Confounding variables at the state-level were collected from 2018 ACS 5-year Estimates Data Profiles and included sex, race, educational attainment, household income, and health insurance. To account for variation in public health infrastructure, we collected each state's allocation of CDC public health funding per capita in 2018 (CDC data available from TFAH.org). All datasets used for this publication are open-access.

First, the distribution of age-adjusted CVD mortality was assessed and determined to be non-normal by a Kolmogorov-Smirnov goodness-of-fit test ($p = 0.02$). The variance of age-adjusted CVD mortality was much larger than the mean, indicating overdispersion and the need to model with a negative binomial distribution. We used a multivariable negative binomial regression model to assess the relation between rates of state-level internet access and age-adjusted CVD mortality. Incidence rate ratios per 5 percentage point increase in internet use were calculated using $\exp^{(beta*5)}$, where beta represents the model coefficient for internet use. We adjusted for state-level variables including sex, race, educational attainment, household income, health insurance and public health funding per capita. Variables were assessed for multicollinearity.

3. Results

In 2018, the national average percentage of households with at least one internet subscription was 79.8 % (SD = 4.2, range 68 % [Alabama] to 86.5 % [Washington]).

There were 866,981 CVD deaths in 2018. Table I summarizes characteristics by quartiles of internet access rates.

Internet access rates were associated with education, income, and health insurance. As broadband subscription rates increased, CVD mortality rates decreased in most states (Fig. 1).

In multivariable analysis, the state-level rate of internet access was inversely associated with the CVD mortality rate (p-value = 0.001) (Fig. 2).

For each 5-point increase in the proportion of households with internet access per state, we observed a 12 % lower CVD mortality rate (adjusted rate ratio = 0.88, 95 % CI, 0.83–0.94).

4. Discussion

In this brief report, we show the linear association between broadband internet access and cardiovascular mortality in the US in 2018. As hypothesized, we found a strong inverse relationship between rates of high-speed internet access and death from CVD at the state level. Results of our analysis demonstrate that states experiencing low rates of broadband internet access also have lower aggregate levels of education, household incomes, and health insurance coverage, yet the strength of state-level internet rates as a predictor of CVD mortality persists despite multivariable adjustment.

The structural and social determinants of health form a well-documented relationship with cardiovascular outcomes. Likewise, the access to and use of health information has been shown to differ by sociodemigraphic status [9]. Notably, groups with limited technological resources are likely similar to the otherwise medically underserved communities who often face disparities in clinical outcomes [10]. The multivariable-adjusted analysis adds to the existing literature that internet access can serve as an independant structural contributor to cardiovascular health in the US [11].

4.1. Limitations

Our cross-sectional analysis has several notable limitations, primarily, the inability to establish a direction of causality between broadband access and CVD mortality. Due to the highly aggregated nature of the data, we cannot adjust for patient-level clinical information. Further, the data may be subject to inaccurate reporting of broadband internet access. However, any overreporting would likely bias our findings towards the null. We define internet access as broadband household subscription, which does not reflect other sources of access (e.g., mobile devices, libraries, workplaces). It is important to consider other means of internet connection as research has shown that Americans with lower incomes more often rely on smartphones rather than broadband for internet access [12]. Lastly, given the effect of COVID-19 on increasing internet use and CVD mortality, results from 2018 may lack generalizability to current conditions. However, continual increases in telemedicine use make the focus of this work a critical area for future research.

5. Conclusions and future directions

If equitably expanded, tele- and mobile health services could augment receipt of appropriate cardiac care [2]. Policies like the Emergency Broadband Benefit (EBB) Program, designed to help families and households struggling to afford internet service during the COVID-19 pandemic, could serve as an example for strategies to promote internet access. EBB implementation should be studied for the effects of improved internet access on state-wide rates of CVD. These findings are foundational to future work assessing the impact of internet-based technologies on health outcomes. More research is needed to determine if disparities in internet access could further marginalize individuals facing adversity.

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.

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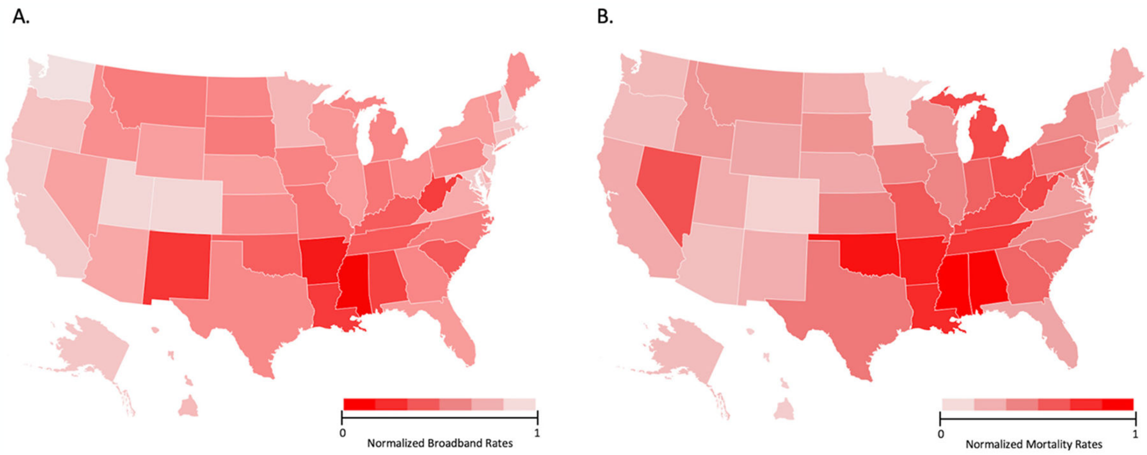

Fig. 1.
US maps compare rates of age-adjusted CVD mortality by state per 100,000 people in the year 2018. A: Normalized Broadband Subscription Rates per State; B: Normalized, Age-adjusted CVD Mortality Rates per State.

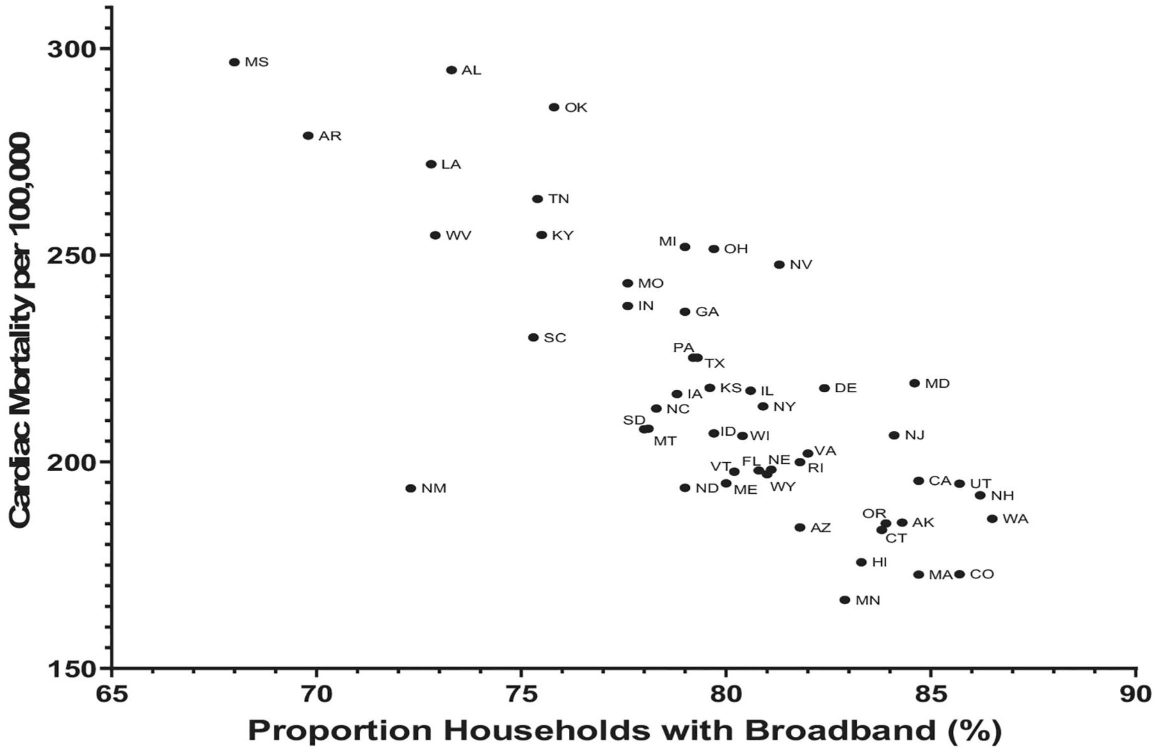

Fig. 2.

The linear relationship between internet access and predicted age-adjusted CVD mortality per 100,000 people in the year 2018. There is a significant inverse relationship between internet access rates and CVD mortality rates that persists after adjusting for covariates (p-value = 0.001).

Table I

State-level demographic data for the US in 2018 by quartile of internet access.

Internet access rates (range)	**Quartile 1 n = 13 (68–78)**	**Quartile 2 n = 12 (78.1–80)**	**Quartile 3 n = 13 (80.2–83.3)**	**Quartile 4 n = 12 (83.8–86.5)**	**p- value**
Male, % (median, IQR)	49.1 (0.6)	49.4 (1.0)	49.3 (0.9)	49.7 (1.5)	0.11
White, % (median, IQR)	77.0 (15.4)	83.1 (13.2)	77.2 (16.6)	76.2 (21.9)	0.28
HS Graduate or Higher, % (mean, SD)	86.9 (2.11)	90.0 (2.87)	89.6 (2.47)	90.5 (2.61)	0.002
Median household income, $ (median, IQR)	54,434 (7508)	60,117 (6060)	65,012 (7783)	75,622 (9076)	<0.001
No Health Insurance, % (median, IQR)	11.4 (2.4)	10.2 (5.7)	8.1 (6.1)	7.9 (2.2)	0.009
Public Health Funding per capita, $ (median, IQR)	24.64 (5.31)	23.7 (9.79)	22.3 (14.81)	22.5 (7.17)	0.54
Cardiovascular Disease Mortality per 100,000 population, (median, IQR)	254.9 (41.2)	217.2 (23.3)	199.9 (15.8)	185.8 (15.5)	<0.001

IQR = interquartile range.

Quartile 1 = AL, AR, IN, KY, LA, MO, MS, NM, OK, SC, SD, TN, WV; Quartile 2 = GA, IA, ID, KS, ME, MI, MT, NC, ND, OH, PA, TX; Quartile 3 = AZ, DE, FL, IL, MN, NE, NV, NY, RI, VA, VT, WI, WY; Quartile 4 = AK, CA, CO, CT, HI, MA, MD, NH, NJ, OR, UT, WA.