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Does Primary Care Availability Mediate the Relationship Between Rurality and Lower Life Expectancy in the United States?

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Abstract

Introduction: Rural counties in the United States have lower life expectancy than their urban counterparts and comprise the majority of primary care provider (PCP) shortage areas. We evaluated whether PCP availability mediates the relationship between rurality and lower life expectancy. **Methods:** We performed a mediation analysis on a panel dataset which included county-level estimates (N = 3103) for the years 2010, 2015, and 2017, and on a subset containing only rural counties (N = 1973), with life expectancy as the outcome variable, urbanity as the independent variable, and PCP density as the mediating variable. County-level socio-demographic data were included as covariates. **Results and Conclusions:** PCP density mediated 10.1% of the relationship between urbanity and life expectancy in rural counties. Increasing PCP density in rural counties with PCP shortages to the threshold of being a non-shortage county (>1 physician/3500 population, as defined by the Health Resources and Services Administration) would be expected to increase mean life expectancy in the county by 26.1 days (95% confidence interval [CI]: 11.4, 49.3) and increasing it to the standards recommended by a Secretarial Negotiated Rulemaking Committee would be expected to increase mean life expectancy by 65.3 days (95% CI: 42.6, 87.5). PCP density is a meaningful mediator of the relationship between urbanity and life expectancy. The mediation effect observed was higher in rural counties compared to all counties. Understanding how PCP density may be increased in rural areas may be of benefit to rural life expectancy.

Keywords

access to care, community health, health outcomes, impact evaluation, primary care, prevention, underserved communities

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Introduction

Rural counties in the United States have a lower life expectancy and overall poorer health outcomes relative to urban counties, even after adjusting for other socio-demographic characteristics.[1-7] Increasing primary care provider (PCP) availability in deficient areas by employing relocation and retention incentives has been at the forefront of numerous government policy initiatives that aim to improve lower life expectancy in underserved areas and promote health equity between urban and rural areas.[8] PCP supply shortages make it incumbent on government policymakers to incentivize the distribution of PCPs to where they are likely to make the greatest impact in improving public health outcomes.[9]

PCP density (defined as the number of PCPs per unit of population) in rural areas continues to be lower than in urban areas (Figure 1).[10] Slightly more than two-thirds of the designated primary medical "health professional shortage areas" (areas with less than 1 primary care physician per 3500 population) across the US are classified as rural.[10] Improvements in primary care clinician density (defined as PCPs, nurse practitioners, and physician assistants per unit of population) in rural areas lag that of urban areas, and upcoming retirements of an aging rural physician workforce may exacerbate urban-rural health disparities by potentially adversely impacting already low rural life expectancy.[11,12] Prior analyses of county-level data suggest associations

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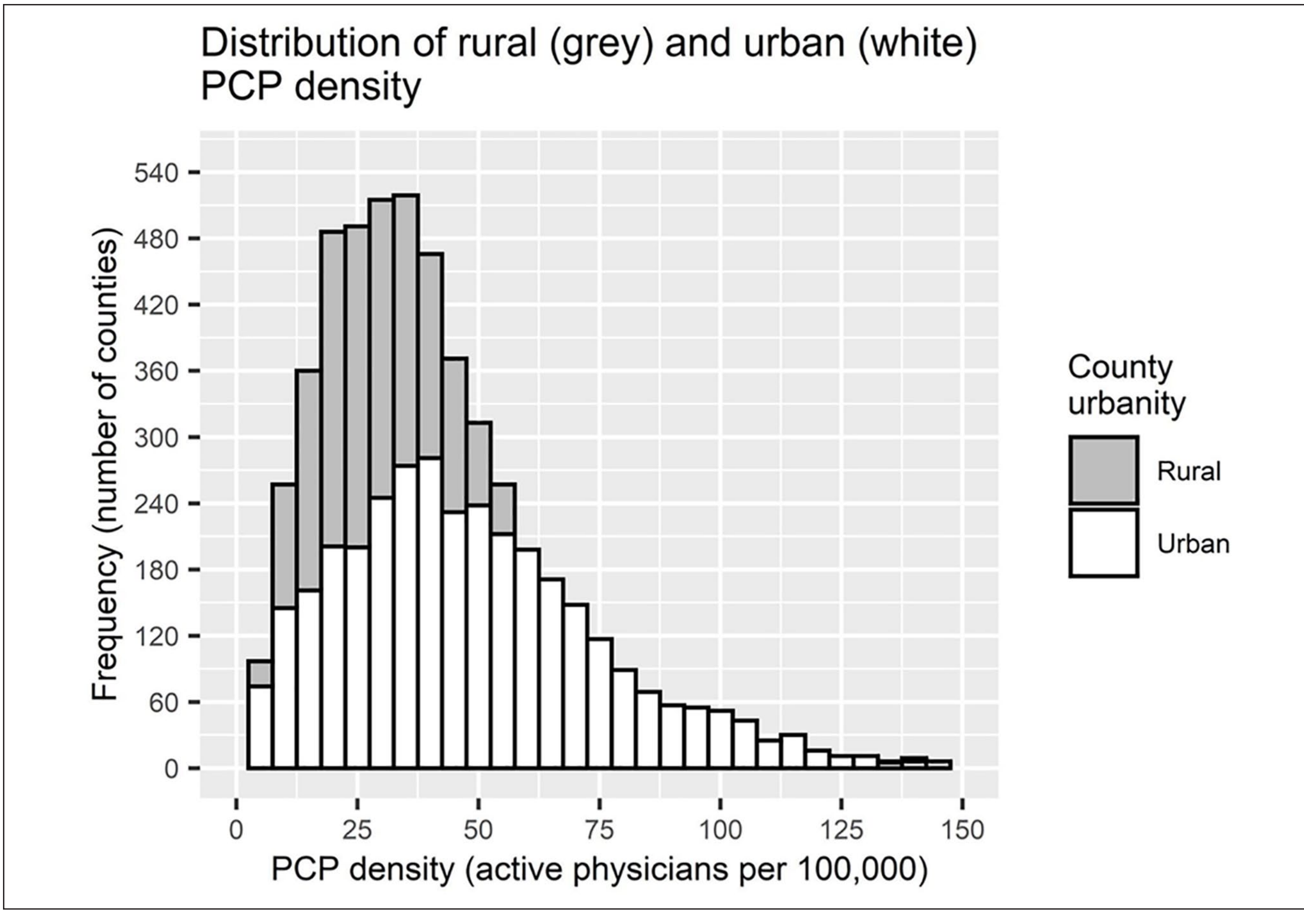

Figure 1. Distribution of PCP density among rural and urban US counties for the years 2010, 2015, and 2017.

between PCP density and improved health outcomes.[13,14] However, it remains unclear how much the low availability of PCPs in rural regions may help to explain poorer life expectancy in rural areas. In this study, we estimated whether and to what degree PCP density mediates the relationship between rurality and lower life expectancy.

Methods

We used publicly available data, primarily county-level statistics for the years 2010, 2015, and 2017, in our analysis. The primary outcome variable in this study, age-standardized life expectancy at birth, was obtained from the Institute for Health Metrics and Evaluation, which estimated age-adjusted life expectancy by county from raw mortality counts collected by the National Center for Health Statistics (NCHS).[15,16] We estimated the projected change in life expectancy when increasing PCP density in PCP shortage rural counties to the threshold of being a non-shortage county (>1 physician/3500 population) as defined by the Health Resources and Services Administration (HRSA), or alternatively to the higher threshold (>1 physician/1500 population) recommended by a Secretarial Negotiated Rulemaking Committee (SNRC).[17,18]

The independent variable, urbanity, was measured in accordance with the NCHS urban-rural continuum scheme, which categorizes counties on a scale of 1 (most metropolitan) to 6 (least metropolitan).[19] Counties were classified into these categories based on population size, population density, urban influence, and adjacency to metro areas.[19] Counties in categories 5 and 6 were classified as rural, while the others were classified as urban, consistent with both the NCHS designation of metropolitan for counties in categories 1 to 4 and nonmetropolitan for the others as well as prior research.[19-21] The mediating variable, PCP density, was sourced from the HRSA Area Health Resources File that utilizes data from the American Medical Association Physician Masterfile to define PCP density as the number of classified active non-federally employed physicians under 75 years old per 100,000 population in a county, including doctors of medicine or osteopathic medicine who were not hospital residents and whose major professional activity was office-based general family medicine, general practice, general internal medicine, or general pediatrics by self-report.[22,23]

We included covariates (Table 1) that may confound the relationship between the mediating variable (PCP density), the outcome variable (age-standardized life expectancy), and the independent variable (urbanity) in the analysis. The covariates were chosen based on the conceptualization of potential confounders that may both drive greater PCPs to live in an area and independently increase life-expectancy: demographics that increase property values due to discrimination or racism (e.g., lower minority populations) and that are associated with lower life-expectancy due to racism-mediated barriers to health and healthcare; health care insurance or infrastructure that increase PCP education or reimbursement rates and increases access to care; and socioeconomic or environmental characteristics that reflect greater educational opportunity or improved neighborhood quality of life that relates to improved social and environmental determinants of health. These covariates included percent female, percent Black, percent Hispanic, percent Native American, percent elderly, percent uninsured, percent insured by Medicare, medical care cost index (median Medicare expenditure per capita), unemployment rate, education rate, density of hospital beds per unit of population, number of days above the air quality standard per month, and median annual income in the county (refer to Table 1 for definitions and data sources).[24-29]

We used ordinary least squares regression for the mediation analysis, following an adapted version of the Baron and Kenny method.[30] First, we fitted a baseline model estimating the total effect of the independent variable, urbanity, on the dependent variable, life expectancy, while adjusting for covariates. This baseline model is based on the general formulation outlined in equation (1),

$$Y = \beta_0 + \beta_1 U + \sum_{i=2}^{15} \beta_i C_i + \varepsilon, \tag{1}$$

where Y denotes estimated life expectancy, β_0 denotes the y-intercept, β_1 denotes the coefficient associated with urbanity (U), β_i denotes the coefficient associated with each of the covariates (C_i), and ε denotes the random component of the relationship.

Second, we fitted a model estimating the effect of urbanity on the mediator, PCP density, while adjusting for covariates. This model is based on the general formulation outlined in equation (2),

$$M = \beta_0 + \beta_1 U + \sum_{i=2}^{15} \beta_i C_i + \varepsilon, \tag{2}$$

where M denotes estimated PCP density, β_0 denotes the y-intercept, β_1 denotes the coefficient associated with urbanity (U), β_i denotes the coefficient associated with each of the covariates (C_i), and ε denotes the random component of the relationship.

Third, we fitted a model estimating the effect of PCP density on life expectancy, while adjusting for urbanity and covariates. This model is based on the general formulation outlined in equation (3),

$$Y = \beta_0 + \beta_1 P + \beta_2 U + \sum_{i=3}^{15} \beta_i C_i + \varepsilon, \tag{3}$$

where Y denotes estimated life expectancy, β_0 denotes the y-intercept, β_1 denotes the coefficient associated with PCP density (P), β_2 denotes the coefficient associated with urbanity (U), β_i denotes the coefficient associated with each of the covariates (C_i), and ε denotes the random component of the relationship.

We estimated 95% confidence interval using nonparametric bootstrapping (100 samples) and performed a sensitivity analysis excluding all outliers beyond two standard deviations of the mean for PCP density and life expectancy to assess the robustness of our results. We repeated the process for the subset of rural counties. We used the results of the three models to derive the average causal mediation effects coefficient, the average direct effects coefficient, the total effect coefficient, and the proportion mediated coefficient.

We used the baseline model (equation (1)) to predict life expectancy using PCP density in rural counties that fall below the applicable standard, as defined in each case, to (i) the threshold of being a non-shortage area as defined by HRSA (>1 physician/3500 population) and (ii) to the higher threshold (>1 physician/1500 population) recommended by an SNRC.[17,18]

All statistical analyses were performed using R-4.1.1 (Vienna, R Foundation for Statistical Computing).[31] We transformed the data using R packages *dplyr* and *reshape2*, generated the plots and tables using *ggplot2*, *ggpubr*, and *tableone*, and created the mediation model using *mediation*.[31-37]

Results

Data were available for a total of 3103 US counties (Table 1), and a slight trend toward increasing rurality was observed, with the number of rural counties increasing from 1913 in 2010 to 1944 in 2017. Rural counties comprised 62.4% of all counties over the 3 observed time periods. Missing urbanity codes were imputed for 861 counties based on the output of a linear model trained on an NCHS dataset containing county urbanity codes for the years 1990, 2006, and 2013.

Median PCP density for rural counties increased from 31.0 PCPs per 100 000 in 2010 (mean 34.6; IQR: 17.0, 47.0), to 35.0 in 2015 (mean 38.3; IQR: 20.0, 52.0), before reverting to 31.0 in 2017 (mean 34.3; IQR: 16.0, 47.0). The number of rural PCP shortage counties based on the HRSA

Table 1. Descriptive Statistics, Stratified into an Overall Column for All Counties Across All Calendar Years Of Observation, Columns for Both Rural and Urban Counties for Each Year (2010, 2015, and 2017), All Health Resources and Services Administration (HRSA)-Defined Shortage Counties Across All Years, All Secretarial Negotiated Rulemaking Committee (SNRC)-Defined Shortage Counties Across All Years, and Data Source.

	Overall	2010: Rural	2015: Rural	2017: Rural	2010: Urban	2015: Urban	2017: Urban	All HRSA shortage counties (all years)	All SNRC shortage counties (all years)	Source
Number of counties	9309	1913	1948	1944	1190	1155	1159	3454	7851	Basu et al[13]
PCPs per 100,000 (median [IQR])	36.00 [21.00, 55.00]	31.00 [17.00, 47.00]	35.00 [20.00, 52.00]	31.00 [16.00, 47.00]	43.00 [27.00, 64.00]	46.00 [28.00, 64.00]	43.00 [27.00, 65.00]	16.00 [6.00, 22.00]	32.00 [18.00, 45.00]	Abrams et al[20], Murthy et al[21]
Life expectancy in years (median [IQR])	77.92 [76.11, 79.46]	77.65 [75.66, 79.28]	77.66 [75.77, 79.19]	77.65 [75.67, 79.36]	78.30 [76.74, 79.88]	78.16 [76.69, 79.66]	78.37 [76.78, 79.92]	77.37 [75.70, 78.97]	77.67 [75.90, 79.19]	Dwyer-Lindgren et al[15], CDC[16]
Urban-rural classification score (number of counties (%))										CDC[19]
1 [Metro, large central metro, MSA population 1 million or more]	269 (2.9)	*N/A*	*N/A*	*N/A*	108 (9.1)	92 (8.0)	69 (6.0)	31 (0.9)	115 (1.5)	
2 [Metro, large fringe metro, MSA population 1 million or more]	1090 (11.7)	*N/A*	*N/A*	*N/A*	383 (32.2)	366 (31.7)	341 (29.4)	289 (8.4)	832 (10.6)	
3 [Metro, medium metro, MSA population 250 000-999 999]	1046 (11.2)	*N/A*	*N/A*	*N/A*	369 (31.0)	364 (31.5)	313 (27.0)	257 (7.4)	730 (9.3)	
4 [Metro, small metro, MSA population less than 250,000]	1099 (11.8)	*N/A*	*N/A*	*N/A*	330 (27.7)	333 (28.8)	436 (37.6)	291 (8.4)	791 (10.1)	
5 [Non-metro, micropolitan, urban cluster population 10 000-49 999]	1859 (20.0)	600 (31.4)	636 (32.6)	623 (32.0)	*N/A*	*N/A*	*N/A*	481 (13.9)	1473 (18.8)	
6 [Non-metro, noncore]	3946 (42.4)	1313 (68.6)	1312 (67.4)	1321 (68.0)	*N/A*	*N/A*	*N/A*	1874 (54.3)	3234 (41.2)	
Pollution, days above air quality standard per month (median [IQR])	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	1.00 [0.00, 3.00]	0.00 [0.00, 1.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	American Hospital Association[26]
% Female (median [IQR])	50.32 [49.17, 51.21]	50.17 [49.16, 50.86]	49.29 [47.79, 50.71]	50.09 [49.06, 50.81]	50.64 [50.00, 51.31]	52.01 [50.08, 54.36]	50.64 [50.02, 51.30]	49.84 [48.45, 50.68]	50.20 [49.00, 51.05]	HRSA[22]
% Black (median [IQR])	2.50 [0.82, 10.96]	1.39 [0.63, 6.18]	1.42 [0.64, 6.02]	1.40 [0.65, 5.85]	5.85 [1.68, 15.38]	6.21 [1.78, 15.68]	6.25 [1.88, 16.00]	1.70 [0.65, 9.24]	2.42 [0.80, 9.95]	HRSA[22]
% Hispanic (median [IQR])	4.13 [2.20, 9.55]	3.32 [1.88, 8.06]	3.44 [1.94, 8.26]	3.54 [2.04, 8.47]	5.20 [2.76, 10.88]	5.35 [2.87, 11.06]	5.47 [2.90, 11.17]	3.42 [1.92, 7.55]	3.95 [2.13, 9.23]	HRSA[22]
% Native American (median [IQR])	0.60 [0.36, 1.26]	0.67 [0.35, 1.46]	0.69 [0.36, 1.50]	0.71 [0.38, 1.56]	0.52 [0.35, 0.96]	0.53 [0.35, 0.96]	0.53 [0.36, 0.94]	0.65 [0.36, 1.29]	0.61 [0.36, 1.27]	American Medical Association[23]
% Elderly (median [IQR])	17.29 [14.57, 20.20]	18.96 [16.59, 21.64]	16.87 [14.67, 19.58]	19.72 [17.38, 22.62]	15.86 [13.42, 18.15]	13.56 [11.47, 15.63]	16.54 [14.12, 18.81]	18.11 [15.59, 20.88]	17.42 [14.81, 20.23]	HRSA[22]
% Unemployment rate (median [IQR])	5.60 [4.20, 8.00]	5.40 [4.00, 6.80]	9.00 [6.57, 11.40]	4.40 [3.50, 5.60]	5.10 [4.30, 6.10]	9.00 [7.50, 10.60]	4.20 [3.60, 5.00]	5.70 [4.20, 7.90]	5.80 [4.30, 8.20]	Bureau of Labor Statistics Data[24]
Density of hospital beds per 100,000 (median [IQR])	198.45 [78.20, 375.30]	200.50 [74.93, 392.38]	224.47 [95.97, 426.71]	191.94 [71.09, 385.59]	184.19 [76.50, 332.51]	202.23 [86.90, 363.07]	180.33 [71.18, 329.14]	91.06 [0.00, 240.50]	175.89 [55.30, 332.60]	United States Census Bureau[25]
Medical care cost index, risk adjusted, per capita (median [IQR])	10 012.39 [9276.12, 10 815.44]	10 187.20 [9451.81, 11 066.63]	9536.08 [8779.43, 10 420.54]	10 474.19 [9778.33, 11 459.45]	10 054.54 [9495.27, 10 620.76]	9383.05 [8797.97, 9949.15]	10 341.60 [9732.92, 10 880.99]	10 204.38 [9425.35, 11 092.69]	10 060.15 [9327.26, 10 863.90]	CMS[27]
% Insured by Medicare (median [IQR])	20.09 [16.64, 23.33]	21.87 [18.90, 24.67]	19.66 [16.97, 22.42]	22.98 [20.28, 25.81]	18.13 [15.10, 20.95]	15.76 [13.04, 18.23]	19.30 [16.34, 21.86]	20.50 [17.26, 23.65]	20.25 [16.87, 23.36]	United States Census Bureau[25]
Annual income in USD (median [IQR])	45 392.00 [39 075.00, 53 035.00]	43 809.00 [38 198.00, 50 152.00]	38 539.00 [34 265.50, 43 584.75]	45 647.00 [40 054.75, 51 699.00]	52 128.50 [45 033.00, 60 831.50]	46 941.00 [41 076.50, 54 616.50]	55 717.00 [48 003.50, 65 505.50]	43 439.50 [37 208.50, 50 347.25]	44 574.00 [38 398.50, 51 823.50]	American Hospital Association[26]
% People 25+ years old without a high school diploma (median [IQR])	12.10 [8.50, 17.40]	12.90 [8.80, 18.30]	14.70 [10.45, 20.86]	12.00 [7.90, 17.40]	10.50 [7.80, 14.10]	12.25 [9.12, 16.67]	9.80 [7.10, 12.95]	14.20 [9.60, 19.70]	12.75 [8.90, 18.30]	American Medical Association[23], American Hospital Association[26]
% Uninsured (median [IQR])	17.70 [12.50, 23.40]	12.00 [8.60, 15.90]	18.90 [15.40, 22.80]	25.80 [20.70, 30.90]	10.50 [7.10, 13.60]	16.80 [13.00, 20.30]	22.60 [18.00, 27.60]	19.20 [13.80, 25.00]	18.10 [12.90, 23.80]	HRSA[22]

threshold (less than 1 PCP per 3500) was 867 in 2010 and decreased to 743 in 2015 before increasing to 898 in 2017. The median PCP density in the rural PCP shortage counties did not exhibit substantial variation and was 15.0 in 2010 (mean 13.6; IQR: 0.0, 23.0), 15.0 in 2015 (mean 13.5; IQR: 0.0, 22.0), before increasing slightly to 16.0 in 2017 (mean 13.4; IQR: 0.0, 22.0). By comparison, the median PCP density for the non-shortage rural counties was substantially higher at 45.0 in 2010, 47.0 in 2015, and 45.0 in 2017. Median PCP density for urban counties was substantially higher than for rural counties for each year and was 43.0 in 2010 (mean 48.0; IQR: 27.0, 64.0), 46.0 in 2015 (mean 49.4; IQR: 28.0, 64.0), and 43.0 in 2017 (mean 47.9; IQR: 27.0, 65.0). Raising the PCP density in those rural counties defined as shortage counties to the threshold of 1 PCP per 3500 population would require an additional 4255 PCPs nationwide.

Median life expectancy for rural counties was 77.7 years in 2010 (mean 77.5; IQR: 75.7, 79.3), 77.7 years in 2015 (mean 77.5; IQR: 75.8, 79.2), and 77.7 years in 2017 (mean 77.5; IQR: 75.7, 79.4). Median life expectancy in the primary care shortage rural counties was 77.4 years in 2010 (mean 77.3; IQR: 75.6, 79.0), 77.4 years in 2015 (mean 77.2; IQR: 75.7, 79.0), and 77.4 years in 2017 (mean 77.2; IQR: 75.5, 79.2). The primary care shortage rural counties had lower median life expectancy compared to the non-shortage rural counties for all years. Median life expectancy for the urban counties was 78.3 years in 2010 (mean 78.2; IQR: 76.7, 79.9), 78.2 years in 2015 (mean 78.1; IQR: 76.7, 79.7), and 78.4 years in 2017 (mean 78.3; IQR: 76.8, 79.9). Rural counties had a lower median life expectancy than urban counties for all years.

Results of the mediation analysis (Figures 2 and 3) indicate that PCP density mediated 4.7% of the relationship between urbanity and life expectancy, after adjusting for covariates. We performed a sensitivity analysis excluding outliers beyond 2 standard deviations of the mean for PCP density and life expectancy (Figure 2); the total number of counties decreased from 3103 to 3011, and the proportion mediated decreased slightly to 4.4%. Results of the mediation analysis run on the rural subset containing 1973 counties (Figure 2) indicate that PCP density mediated 10.1% of the relationship between urbanity and life expectancy, after adjusting for covariates. After outliers were excluded, the total number of counties decreased to 1928, and the proportion mediated decreased to 7.2%, though the confidence intervals widened to cross zero in the context of a smaller sample size. Regression coefficients and statistical significance of the 3 models comprising the mediation analysis for both the unaltered dataset and rural subset excluding outliers are presented in Figure 3.

Based on the total effect model used in the mediation analysis, increasing PCP density in rural counties with PCP shortages to the threshold of being a non-shortage county (>1 physician/3500 population, as defined by the Health Resources and Services Administration), would be expected to increase mean life expectancy in the county by 26.1 days (95% confidence interval [CI]: 11.4, 49.3). Increasing PCP density to the standards recommended by an SNRC (>1 physician/1500 population) would be expected to increase mean life expectancy by 65.3 days (95% CI: 42.6, 87.5).

Increasing the PCP density of a rural county from the 25th percentile (18 PCPs/100 000) to the rural median (32 PCPs/100 000) would be expected to increase mean life expectancy by 123.7 days. Increasing PCP density from the 25th percentile (18 PCPs/100 000) to the 75th percentile (49 PCPs/100 000) among rural counties would be expected to increase mean life expectancy by 274.8 days. Increasing the PCP density of a rural county from the 25th percentile (18 PCPs/100 000) to the urban median (44 PCPs/100 000) would be expected to increase mean life expectancy by 188.5 days.

Discussion

Rural areas have poorer health outcomes and lower life expectancy relative to urban areas.[1-7] Government initiatives have sought to increase PCP density in areas of shortage to improve health equity.[8] Rural areas comprise the majority of primary care shortage areas.[10] Here, we estimated the effect of increases in PCP density on life expectancy. Increasing PCP density in the PCP shortage rural counties to the threshold of being non-shortage county (1 PCP/3500 population) would be expected to increase mean life expectancy in that county by 26.1 days while increasing PCP density to the minimum standards recommended by an SNRC (1 PCP/1500 population) would be expected to increase mean life expectancy in the county by 65.3 days, adjusting for covariates. The results of the mediation analysis on the rural subset, assuming that the relationship between PCP density and life expectancy is causal, show that increases in PCP density would provide a greater benefit to rural counties, as PCP density mediates a notably greater proportion of the relationship in rural counties (10.1%) compared to in all counties (4.7%). The results of both mediation analyses indicate that there may be other potentially impactful mediators that remain unexplored.

Additionally, the results indicate that key covariates alter the effect of urbanity on life expectancy. When urbanity is the only variable taken into account, it appears that more urban environments have higher life expectancies; however, when all covariates are kept constant, it becomes apparent that rural populations have higher life expectancies than urban populations. Thus, while urbanity is correlated with life expectancy, the cause for higher life expectancies in urban areas may not be urbanity in and of itself, which appears to have a negative effect on life expectancies.

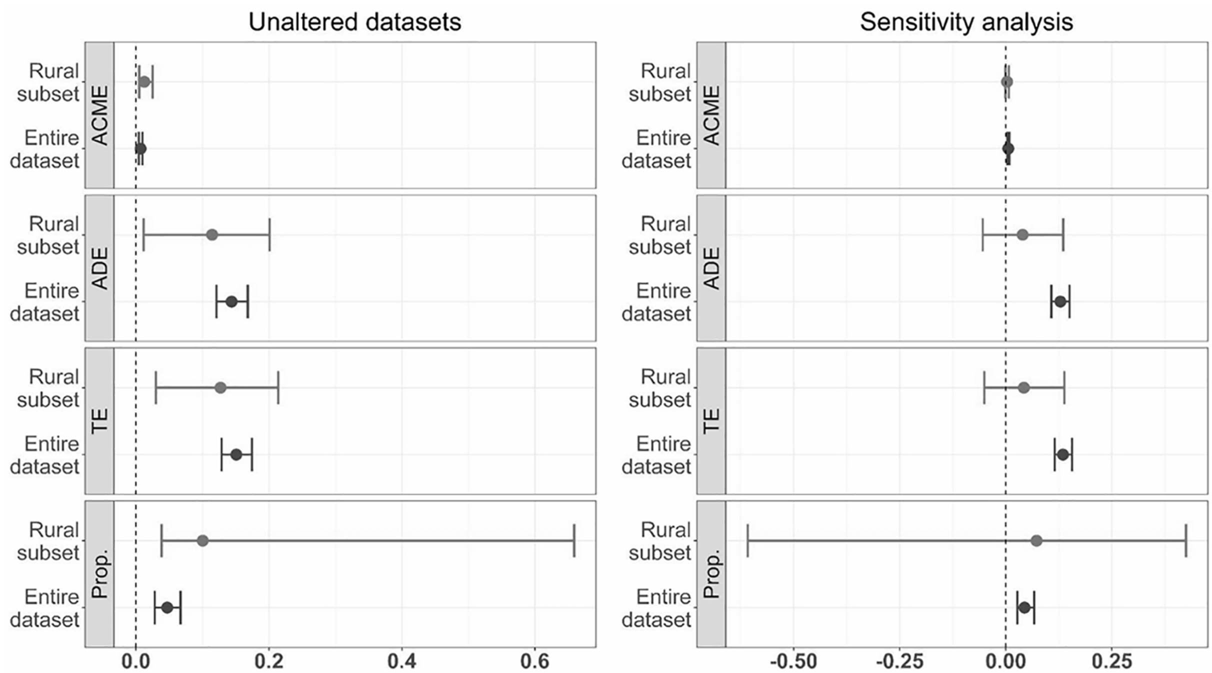

Figure 2. Estimated magnitude and direction of effects between county urbanity, county PCP density, and county life expectancy for the years 2010, 2015, and 2017. Covariates accounted for were percent female, percent Black, percent Hispanic, percent Native American, percent elderly, percent uninsured, percent insured by Medicare, medical care cost index, unemployment rate, education rate, density of hospital beds per unit of population, number of days above air quality standard per month, and median annual income. Effect estimates represented as circles, upper and lower bounds of 95% confidence interval represented as horizontal lines. Tighter spreads between estimates and confidence intervals indicate higher model precision and lower margin of error, larger spreads indicate lower model certainty and higher margin of error. Results of both the entire dataset (3103 counties) and rural subset (1973 counties) presented on the left. Results of both the entire dataset (3011 counties) and rural subset (1928 counties) after excluding outliers beyond 2 standard deviations of the mean for PCP density and life expectancy presented on the right. The average causal mediation effects (ACME) coefficient is an estimate of the proportion of the effect of urbanity on life expectancy that goes through PCP density, while adjusting for covariates. The average direct effects (ADE) coefficient is an estimate of the direct effect of urbanity on life expectancy, while adjusting for covariates. The total effect (TE) coefficient is the sum of the direct and indirect effect of urbanity on life expectancy, while adjusting for covariates. The proportion mediated (Prop.) coefficient is an estimate of the percentage of the relationship between urbanity and life expectancy mediated by PCP density. Positive coefficients indicate a positive correlation between the variables, while negative coefficients indicate an inverse correlation between the variables. For example, the average direct effects coefficient .2 indicates that as rurality increases, life expectancy increases when adjusting for covariates.

There are several limitations to the analysis. Conclusions are focused on the county level and cannot be applied to individuals (to avoid ecological fallacies). We used discrete divisions to demarcate the urban-rural continuum, which may not fully capture the subtle differences in urbanity among counties. We used a common physician-focused definition of a PCP and did not use alternative definitions, which may include nurse practitioners, who are not consistently counted in available data sources. We used linear models that may not fully capture nonlinear interactions between the variables.

Our results highlight the importance of primary care to rural health and the need for policymakers to consider a multi-pronged approach toward improving life expectancy in rural areas. Our results, when viewed in light of the realities of ongoing PCP shortages, suggest the need to evaluate alternative means of expanding primary care access, such as leveraging telehealth platforms and expanded teams to deliver the health benefits of primary care to underserved rural areas. Additional research should account for the increase in telemedicine utilization after the COVID-19 pandemic and the degree to which rural counties have increased access to PCPs not directly providing services in their physical geography but providing services virtually. Prior research suggests that minority-dominated rural counties are more likely to be health professional shortage areas and that minorities in rural areas face greater health risks and impaired access to preventive care; increasing primary care availability in rural areas may alleviate these disparities and align with policy goals of increasing health equity for minority populations.[38,39]

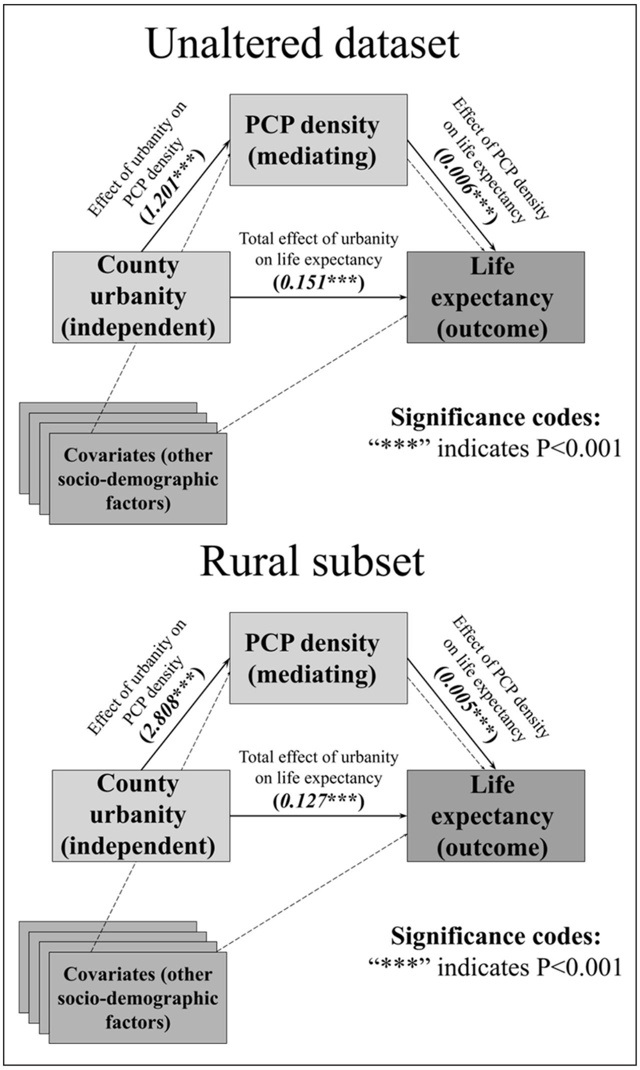

Figure 3. Mediation diagram (top) illustrating relationship between county urbanity, PCP density, and life expectancy after adjusting for covariates on the unmodified dataset. Mediation diagram (bottom) illustrating relationship between county urbanity, PCP density, and life expectancy after adjusting for covariates on the rural subset. Italicized numbers indicate regression coefficients associated with the predictor variable at the tail end of the arrow when predicting the indicated variable at the head of the arrow. Positive coefficients indicate a positive correlation between the variables, while negative coefficients indicate an inverse correlation between the variables. For example, the coefficient *0.151* indicates that the total (indirect + direct) effect of urbanity is that as rurality increases, life expectancy increases after adjusting for covariates.

Conclusion

PCP density was found to mediate a portion, but not a majority, of the relationship between urbanity and life expectancy. Research may be done to evaluate synergistic strategies to improve healthcare disparities, such as the implementation of preventative social interventions that target risk factors that negatively impact rural life expectancy directly. Future studies should evaluate the reasons behind the substantial difference in the mediating impact of PCP density between rural counties and all counties. This study nevertheless suggests that PCP availability mediates the relationship between rurality and low life expectancy. Hence, further work to understand how PCP density may be increased in rural zones may be of benefit to rural health and to the goal of mitigating urban-rural health disparities.

Declaration of Conflicting Interests

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