Original Research

Primary Care Physician Supply and Population Health Outcomes in Florida, 2010-2019

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Abstract

Background
Primary care physicians play vital roles in the prevention and management of chronic disease. With increasing rates of chronic disease and a national primary care physician shortage, the role that primary care physician supply has on health outcomes in Florida is not well understood. The objective of this study was to investigate the relationship between primary care physician supply (PCPS) and population health outcomes of obesity, life expectancy, coronary artery disease hospitalization, and death rate as reported by county in the state of Florida for the years 2010, 2013, 2016, and 2019.

Methods
This was a retrospective, cross-sectional study. Secondary data was used from the Florida Department of Health. Numerous population health and social determinants of health variables related to PCPS in the literature were selected for analysis. Correlation and linear regression analyses were conducted using STATA14.

Results
The association between PCPS and obesity was the strongest association in this analysis and was significant for each year with an average of 9.25 primary care physicians per 100 000 people needed to decrease the obesity rate by 1%. PCPS was positively correlated with life expectancy for years 2013, 2016, and 2019 and negatively correlated with the death rate in 2010 and 2019. In the multiple regression, PCPS was negatively associated with areas having a high rate of uninsured persons, unemployment, decreased education, and age over 65.

Conclusion
Increased supply of primary care physicians in Florida is significantly associated with decreased rates of obesity and death and increased life expectancy. Our results also indicate that areas with higher levels of social vulnerability also have inequitable distributions of PCPS. Therefore, PCPS should be increased, particularly in areas with the highest need, as primary care physicians in the state of Florida play an important role in improving the overall health of the populations they serve.

Keywords
primary health care; access to primary care; primary care physicians; population health; population health management; Florida; obesity; hospitalizations; life expectancy

Introduction
In May 2021, the National Academies of Sciences, Engineering, and Medicine (NASEM) published a Consensus Study Report calling for a restructuring of the United States (US) healthcare system around a high-quality, accessible primary care network.[1] It asserted that primary care is uniquely situated in the healthcare system as the only component where an increase in supply is associated with improved population health outcomes.[1] Primary care physicians, including general internists, family medicine, and pediatric physicians, accomplish this largely through their role in providing preventative

health services and disease management for patients. For many in the US, primary care physicians are the first line of defense against the adverse effects of both acute and chronic disease, preventing costly and risky hospitalizations through patient education, health screenings, and management of underlying conditions.[2]

Chronic disease is estimated to be responsible for 7 out of 10 deaths in the US and at least 75% of all healthcare spending.[3] Chronic conditions such as obesity and coronary artery disease have been increasing in the general population while a national shortage of primary care physicians has been worsening, resulting in more people year-over-year being unable to access primary care for management of their chronic conditions.[4-6] Examining the relationship between primary care physician supply (PCPS) and population health, a national survey found that between 2005 and 2015, the mean PCPS decreased from 46.6 per 100 000 people to 41.4 per 100 000 people.[6] It also found a 0.9-1.4% decrease in population mortality rates and an average of 51 days increased life expectancy with the addition of 10 primary care physicians per 100 000 people. A 2005 study found a 7-13.4% decreased risk of hospitalizations with the addition of 40 primary care physicians per 100 000 people.[7] While these studies provide important insights on a national level, the impact that PCPS has on a state-specific level remains poorly understood for many areas of the country, including the state of Florida.

As of 2020, Florida is estimated to have a population of 21.5 million people with projections to grow to over 25.7 million by 2030.[8] The state has some unique demographics relative to the rest of the US with its large elderly population, a large proportion of minority communities, and pockets of socioeconomic disparity.[8] Due to these characteristics, national trends may not necessarily follow the same pattern within the state. For example, in 2015 almost 65% of Florida's total population had at least 1 diagnosed chronic disease,[9] a prevalence 33% higher than the national average.[3] Therefore, the aim of this study is to examine the associations between PCPS in Florida and population health factors such as obesity, hospitalizations due to coronary artery disease, life expectancy, and death rate between the years 2010-2019.

Methods

All data were obtained from publicly available statistics on the Florida Department of Health (FDOH) website. As per Florida statute, primary care physicians were defined as licensed physicians who report their specialty to FDOH as family medicine, internal medicine, or pediatrics. The count of each physician type per 100 000 persons was reported by county in Florida and then added together to give PCPS for each county. There is not specificity from the FDOH data to know if the physicians were outpatient or inpatient based. Obesity rate was measured as the percentage of all adults who are obese. Hospitalizations due to coronary artery disease (CAD) were measured per 100 000 persons. Life expectancy was measured by the FDOH and reported an average number of years a person is expected to live from birth. The death rate was measured as all-cause deaths per 100 000 persons.[9]

These outcomes were selected based on their representations of the various stages of prevention. With obesity being a major risk factor for the leading causes of death in Florida, it was selected as a marker of primary prevention effectiveness.[10] As increased CAD hospitalizations have been found to be driven in part by a lack of patient education about and management of risk factors such as obesity, smoking, hypertension, or hyperlipidemia, CAD hospitalizations were selected as a marker of secondary prevention.[11] Life expectancy and death rate were selected as overall indicators of all levels of prevention, including tertiary prevention, as they represent opposite ends of the terminal outcomes of disease progression.[12-14]

In considering other variables that might affect the outcomes, a literature review was conducted to determine what social determinants of health (SDoH) are strongly associated with PCPS and could, therefore, serve as potential confounding variables in our analysis. The list of these compiled variables was taken from several studies,[6,7,15] and based on the SDoH variables available.[9] The following were included in the analysis: percentage of individuals below the poverty level, percentage of families

Table 1. Primary Care Physician Supply Correlation Coefficients for Each Outcome Variable and Year

Outcome	2010	2013	2016	2019
Obesity	-0.6375*	-0.6337*	-0.6757*	-0.6110*
CAD hospitalization rate	-0.2355	-0.3303	-0.3340	-0.3183
Life expectancy	0.3774	0.4865*	0.4199*	0.4451*
Death rate	-0.4276*	-0.3979	-0.4112	-0.4154*

*$P < .05$

below poverty level, educational attainment (individuals 25 or older with a high school diploma), race/ethnicity of being White, number of hospital beds per 100 000 population, percentage of unemployment, percentage over age 65, percentage of adults without health insurance, and percentage of adults who are current smokers. Because the variables of obesity and smoking were only available for the years 2010, 2013, 2016, and 2019, those were the years examined for this report. This study was approved as exempt by the University of Central Florida Internal Review Board.

Statistical analyses include the correlation between PCPS and each health outcome. The hypothesis is that PCPS will be directly correlated with life expectancy and inversely with obesity, hospitalizations for CAD, and death rate. The number of physicians needed to modify the health outcome was determined using the slope of each correlation line. Multiple regression was performed with the health outcomes of interest and SDoH variables to determine the relationship with PCPS while controlling for the other variables for each of the years. Prior to running each regression, the variable inflation factor (VIF) was calculated for each variable to determine the extent of collinearity. All VIF values greater than 10 were assessed for exclusion from the regression. All analyses were conducted using STATA14.[16]

Results

There was variability in correlation coefficients for the comparisons of PCPS and each health outcome (**Table 1**). There was a moderate inverse correlation between PCPS and obesity for each year, with all being statistically significant (2019 = -0.6375, 2013 = -0.6337, 2016 = -0.6757 and 2019 = -0.6110). The correlations for CAD hospitalization rate and PCPS were negative, but none were statistically significant in any of the years. The correlation of PCPS and death rate was inversely related with mild correlation coefficients, but only 2 were statistically significant (2010 = -.04276 and 2019 = -0.4154). The correlations for PCPS and life expectancy were also moderate and in the positive direction with 3 of the 4 years being statistically significant (2013 = 0.4865, 2016 = 0.4199, and 2019 = 0.4451).

The graphical representations of the comparison of PCPS and health outcomes in each Florida county for each year are shown in **Figure 1A-D**. The slopes for the outcome in each figure were compared to see if there were differences between the years. The comparisons for CAD hospitalizations, life expectancy, and death rate had no statistical differences between the years. For obesity (**Figure 1A**), which visually appears to have dissimilarities, there was only one statistically significant difference in the slopes of 2019 and 2010 ($t = 2.67$, $P < 0.001$). The other obesity slope comparisons (2019 and 2016, 2019 and 2013, 2016 and 2010, 2010 and 2013) were not significant. Using the slope of the line, we then calculated the number of primary care physicians per 100 000 people needed to modify the outcome for each year (**Table 2**). The least number of physicians needed to

Table 2. Additional Primary Care Physicians Needed per 100 000 Population to Impact Outcomes

Outcome	2010	2013	2016	2019
Decrease obesity by 1%	6	10	10	11
Decrease CAD hospitalization by 100	82	86	114	148
Increase life expectancy by 1 year	28	35	36	36
Decrease death rate by 100	44	71	64	74

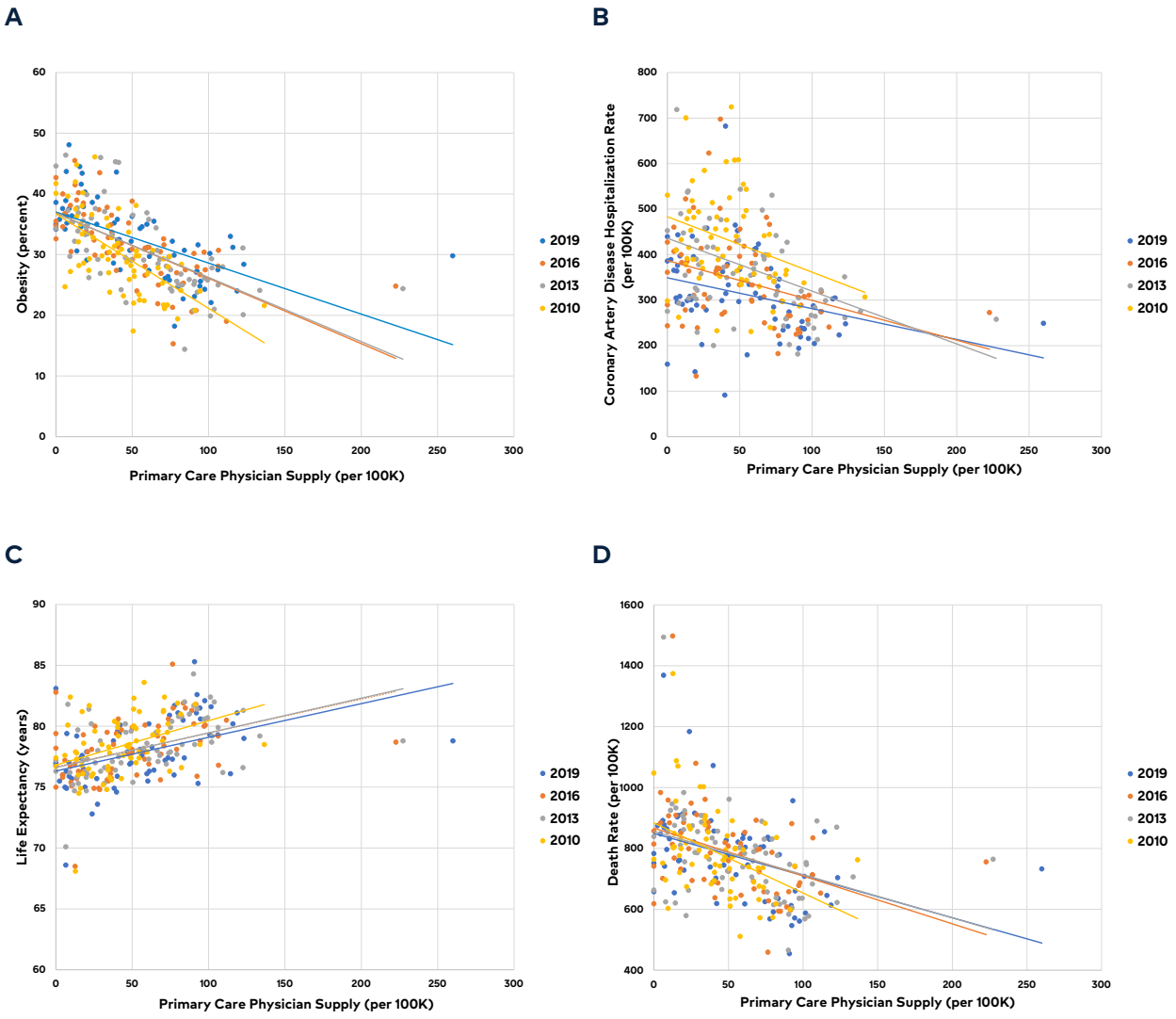

Figure 1. Scatterplots with correlation lines for each year show **A.** obesity and PCPS, **B.** coronary artery disease hospitalization and PCPS, **C.** life expectancy and PCPS, and **D.** death rate and PCPS.

modify an outcome was 6 to decrease obesity by 1%, while the most physicians needed was 148 to decrease CAD hospitalizations by 100 per 100 000 population.

For the regression models to statistically predict PCPS, multiple variables were found to have multicollinearity. They would not be independent predictors, so they were excluded from the analysis. Of the independent variables, hospital beds, age over 65, and no insurance status were significant variables associated with PCPS in 3 of the 4 models. The number of hospital beds was the only variable in more than 1 model with a positive correlation coefficient, with White race being weakly positively associated with PCPS in 2010 but weakly negatively associated in 2016. Notably, most years did not find any of the population health outcomes of interest independently associated with PCPS when controlled against the other SDoH. The most robust regression model for PCPS was for the year 2019, with an adjusted R^2 of 0.8563, demonstrating over 85% of the variability for PCPS was explained by the variables used (education, hospital beds, age over 65, and no insurance). That same year also had 2 of the strongest negative correlation coefficients in the regression for PCPS, education and no insurance at -2.951 and -2.323,

respectively. All the regression analyses were statistically significant (**Table 3**).

Discussion

Primary care physicians in Florida play a critical role in supporting the health of the populations they serve by providing services that support the prevention of adverse health consequences, leading to increased life expectancy and decreased death rate. We find that Florida follows national trends of increased life expectancy and decreased death rate with increasing PCPS. In fact, our findings that 33.75 primary care physicians per 100 000 population are needed to increase life expectancy by 1 year (365 days) are more than 2 times the effect found in a 2019 national study, where 10 primary care physicians per 100 000 were found to increase life expectancy by 51.5 days.[6]

The literature suggests that PCPS is correlated with decreased preventable hospitalizations, including those due to CAD,[6,17] but there was a lack of statistical significance in our study for these variables. Possible explanations for the findings could be due to the nature of the data used. This analysis focused on hospitalization rate due to CAD for all ages in Florida, not specifically preventable CAD hospitalizations. As Florida has a higher proportion of the elderly demographic at highest risk for CAD hospitalizations, there is likely potential for a confounding variable. From the regression analysis, PCPS was related to a small decrease in CAD in 2013. As the analysis included age over 65 as a control when examining the relationship between PCPS and CAD, this explanation could be a contributory factor to why the correlation analysis did not find statistical significance. Although 3 out of 4 regression models did not find statistically significant associations between PCPS and CAD, there still appear to be additional factors at play in Florida. Other studies have found that disparities in primary care physician access potentially contribute to disproportionately increased preventable hospitalizations among minority communities,[7,18] so a more targeted analysis focusing on minority populations may be helpful in targeting resources. Overall, further investigation is needed to determine the relationship between PCPS and hospitalizations in Florida.

The inverse relationship between PCPS and the obesity rate in Florida represents the strongest association in our analysis. Obesity and related chronic diseases have continued to increase in the general population and have caused sig-

Table 3. Adjusted R^2 and the Statistically Significant Variables From the PCPS Regression Analysis After Eliminating Collinearity*

Year	Adjusted R^2	Statistically significant variables	Coefficient	95% confidence interval	*P* value
2010	0.4721	Obesity	-0.4844051	-0.8009213 to -0.167889	0.003
		White race	-0.2624244	-0.4484292 to -0.0764197	0.007
		Hospital beds	0.0170147	0.0020383 to 0.031991	0.027
		Unemployment	-1.103365	-1.927836 to -0.2788946	<0.001
2013	0.7161	CAD	-.0157069	-0.0278201 to -0.0035936	0.012
		Education	-0.7504501	-1.2767 to -0.2242005	0.006
		Hospital beds	0.025422	0.0116932 to 0.0391509	<0.001
		Over 65	-0.331778	-0.6546978 to -0.0088583	0.044
		No insurance	-0.8047833	-1.221142 to -0.3884243	<0.001
2016	0.5986	Education	-0.7148124	-1.213372 to -0.2162528	0.006
		White race	0.2817341	0.0622953 to 0.5011728	0.013
		Over 65	-0.310246	-0.5658411 to -0.0546508	0.018
		No insurance	-1.053132	-1.535461 to -0.570804	<0.001
2019	0.8563	Education	-2.950745	-4.875371 to -1.026118	0.003
		Hospital beds	0.1431820	0.0865847 to 0.1997793	<0.001
		Over 65	-1.245893	-2.21876 to -0.2730255	0.013
		No insurance	-2.322633	-4.349105 to -0.2961619	0.025

*Each of these regression models was statistically significant with $P < 0.001$.

nificant strain on the healthcare system.[3,19] The downstream impacts of reducing the obesity rate could reduce health spending and death, as an estimated 75% of all health spending and 70% of all deaths in the US result from chronic diseases for which obesity is a major risk factor.[3,19,20] Primary care physicians serve an important role in facilitating weight loss among obese patients.[21,22] In fact, nationally counties with greater than 81 primary care physicians per 100 000 individuals were found to have a 20% lower obesity rate relative to counties with less than 47 primary care physicians per 100 000.[23] Obesity is a leading independent risk factor for development of and death from cardiovascular mortality, with over two-thirds of all deaths among obese individuals resulting from cardiovascular disease.[24] Nationally, an addition of 10 primary care physicians per 100 000 individuals was associated with a 0.9% reduction in cardiovascular mortality.[6] With much of this cardiovascular mortality owing to obesity as a leading cause,[24] and with a reduction in obesity leading to improved cardiovascular outcomes,[25] our findings that on average 9.25 primary care physicians per 100 000 were associated with a 1% reduction in obesity can be seen to be part of an expected impact of primary care physicians on population health outcomes. These findings underscore the value primary care physicians could provide to overall health in the state. Determining the extent to which a causal relationship exists could help inform policy changes to address both population health and healthcare spending concerns in Florida.

While national studies support the association between PCPS and improved population health outcomes, some do not account for socioeconomic factors or how those factors varied over time.[6,7,18] Our analysis found that across most models, markers of social vulnerability such as no insurance, unemployment, and low educational attainment were negatively associated with PCPS. This supports the findings of many studies that PCPS is disproportionately higher in areas with higher socioeconomic status,[26-28] supporting inequitable distribution of healthcare resources previously identified in Florida.[29] Additionally, the weak positive association between PCPS and hospital beds logically supports those areas that have hospitals in Florida, which are disproportionately urban,[30] and also have a higher number of primary care physicians due to their large employment of physicians. Age over 65 was also found in our models to be negatively correlated with PCPS, indicating that areas that have higher rates of elderly patients, and, therefore, higher rates of chronic disease burden, also have less access to primary care physicians. Between negative associations with unemployment, no insurance, education, and age over 65, our study suggests that the areas in Florida that have a lower socioeconomic status and higher average age, likely representing the highest need for regular primary care, also have the greatest PCPS deficit. Surprisingly, while not a primary population health outcome of interest, smoking was not independently associated with PCPS despite well-established evidence that primary care physicians are critical to the facilitation of smoking cessation.[31] Furthermore, the lack of association between many of the population health outcomes of interest over most years despite their positive association in the correlation analysis requires further investigation into the nature of the relationship between SDoH, PCPS, and population health outcomes in Florida.

As our study demonstrates, Florida is susceptible to the beneficial impacts of primary care physicians, and, as a result, increasing PCPS would be an effective population health strategy to confront the rising rates of chronic disease in the state. A major concern regarding PCPS is a shortage of 21 978 primary care physicians is projected for Florida by 2030,[5] yet current medical school graduates are less likely to choose primary care.[32] Increasing the number of primary care residencies would be the most effective way to address the shortage of primary care physicians in the least amount of time according to the National Institute for Healthcare Reform.[33] Numerous studies have investigated the time-to-effect of increased access to primary care physicians, with findings supporting that population-based improvements in obesity, mortality rate, and self-reported quality of life could be realized within 12 months of increasing supply.[34-36] While these studies were not conducted in Florida specifically, the results suggest that significant improvements in population health outcomes could be expected within 1 year of increasing PCPS. Other measures of prevention, such as

time-to-effect of statin medications or smoking cessation for prevention of mortality from CAD often take up to a decade to become evident in a large population.[37,38] Therefore, the potential population health impacts from variations in PCPS in the later years of this analysis may become more evident in the mid-to-late half of this decade.

Limitations

There were some important limitations to the study. Complete data sets were only available for years 2010, 2013, 2016, and 2019 preventing analysis of most years between 2010-2019. As only data from Florida counties were analyzed, these findings cannot generalize to the entire US. Among the population health outcomes of interest, the all-cause death rate used in our analysis included every ICD-10 code and, therefore, did not have accidental deaths separated out. This may serve to confound the strength of this outcome as a measure of prevention owing to the limited ability of physicians to prevent accidental deaths. Additionally, the PCPS reported in this study may not reflect the true PCPS, as medical specialty reporting is neither required nor verified in Florida. Medical subspecialties such as cardiology, pulmonology, nephrology, etc may report as internal medicine. The data available also did not differentiate between physicians who practice in an outpatient setting from those who practice in an inpatient setting as hospitalists. Thus, it is not known how many specialist or hospitalist physicians reported as primary care, leading to inaccurate calculations of PCPS. Non-physician clinicians such as nurse practitioners and physician assistants who may play roles as primary care providers were also not included as data were not available. Other providers such as these may be providing care that was measured in our study outcomes.

While this study considered several SDoH, notable exceptions not incorporated into this study are language acuity, access to transportation, and food security, which might influence health outcomes. Additionally, as county-level data was used, intracounty health disparities could be lost within county-level averages. This could lead to certain high-need populations within specific counties being overlooked, and as such an analysis that included zip codes as opposed to counties would have provided a more precise assessment of the association between PCPS and health outcomes in Florida.

Conclusion

PCPS is lower in areas with increased health maintenance needs, and, thus, increasing PCPS is an integral part of improving population health in Florida's communities. An increase in PCPS in the state was associated with decreased obesity, increased life expectancy, and decreased death rate in the general population. The effect that PCPS has on population health is more than twice as strong as the national average, underscoring the especially critical role primary care physicians play in Florida. As PCPS changes in Florida, the impacts these changes have on population health in the state should be continuously reassessed at least every 10 years.

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Conflicts of Interest

The authors declare they have no conflicts of interest.

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