Title: The Effect of Physician Supply on Prevalence of Dementia in Rural and Urban Areas

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Abstract:

We explored rural and urban disparities in Alzheimer's disease and related dementia (ADRD) diagnosis. Using a 20-percent random sample of Medicare beneficiaries older than 65 merged with Area Health Resource File, we used county fixed-effect two-stage linear regression model to estimate the effect of physician supply on ADRD prevalence, using Chinese Import

Competition as an instrument variable, controlling for county-level socioeconomic characteristics. Findings reveal higher ADRD prevalence in urban areas, despite a greater per-capita physician supply growth in urban regions compared to rural ones. For every 1% increase in per-capita physicians above the mean, ADRD prevalence decreases by 0.56% in urban areas ($P<0.01$). In contrast, in rural-adjacent areas, it increases by 0.77% ($P<0.05$), and in rural nonadjacent areas, by 0.99% ($P<0.05$). These results highlight the nuanced impact of physician availability on ADRD prevalence, emphasizing the need for targeted healthcare strategies in rural communities to address this growing public health concern.

Introduction

Rising life expectancy has led to an increasing prevalence of age-related diseases, such as Alzheimer's disease and related dementia (ADRD). The more rapid increase in the US rural older population may lead to higher rates of dementia in these communities. However, growing evidence suggests that rural residents face disparities in the availability, accessibility, and affordability of healthcare services compared to their urban counterparts, making diagnosis more challenging, leading to an underestimation of ADRD prevalence in these communities.

Rural areas in the United States have a higher proportion of the population aged 65 years and older compared to their urban counterparts.[1] Additionally, rural residents are poorer and less educated compared to their urban counterparts.[2] Rural residents face significant disparities in disease, morbidity, potentially preventable deaths, longevity, life expectancy, and mortality compared to their urban counterparts. However, the prevalence and incidence of dementia are lower in rural communities compared to their urban counterparts.[3,4]

Rural residents experience greater risk factors for developing ADRD, including chronic health conditions and lifestyle factors such as hypertension, diabetes, obesity, hyperlipidemia, head trauma, depression, alcoholism, tobacco use, and lower educational attainment.[5-7] Rural residents with dementia have higher mortality rates, lower visits to any physicians, more hospitalizations but shorter stays, higher antipsychotic medications, lower use of home care services, and higher use of nursing homes compared to urban residents.[3,7] Older adults in rural communities may be underdiagnosed with ADRD and/or diagnosed at later stages of dementia.

There has been a longstanding disparity in the supply of physicians in rural and urban communities and a persistent shortage of physicians in rural communities. Physicians aggregate in urban areas, creating a worldwide shortage of rural physicians: Only 9% of physicians serve the 20% of the population that reside in rural areas.[8,9] Thus, despite their poorer health status, rural residents are getting less professional medical attention than their urban counterparts. Rural residents have lower access to health information from sources including primary care providers and specialist doctors.

The objective of this study is to investigate the impact of physician availability on ADRD prevalence, with a specific focus on rural and urban communities. To establish a causal relationship between physician supply and ADRD prevalence, we utilize Chinese Import Competition (CIC) as an instrumental variable. This approach helps us discern the causal effect of physician supply on ADRD prevalence in both rural and urban areas.

Methods

Conceptual Framework

Our goal was to determine how the supply of physicians can affect ADRD rates and to address why this relationship is different in rural and urban communities. As illustrated in Figure 1, the supply of physicians can affect prevalence of ADRD in two different ways. Firstly, the "quality effect" posits that in areas with a greater physician supply, increased competition among healthcare professionals or lower physician workloads may enhance the overall quality of care, consequently reducing the prevalence of ADRD. This quality effect is expected to be consistent across both urban and rural regions. Secondly, the "availability effect" suggests that in areas with

more physicians, individuals have increased opportunities to access healthcare services, leading to higher chances of ADRD diagnosis. Together, these two effects offer a comprehensive understanding of the intricate relationship between healthcare professional availability and ADRD healthcare utilization, shedding light on potential disparities and opportunities for improvement in rural settings.

Data Sources and Study Cohort

We used a 20-percent random sample of Medicare beneficiaries older than 65 (2002-2014) to create a dataset that contains ADRD prevalence in a given county year. We merged this data with Area Health Resource File (AHRF) which contains county-level data on the availability of healthcare services and demographics. We then merged the data with Chinese Import Competition (CIC), calculated CIC based on the Census Integrated Public Use Micro Samples and World Trade Organization (WTO) data.

Prevalence of ADRD

We identified beneficiaries with ADRD by utilizing the CCW flag for ADRD or Senile Dementia. The study's eligible beneficiaries were aged 65 or older, qualifying for Medicare enrollment based on their age. We excluded beneficiaries who did not enroll in both Medicare Parts A and B for at least one month each year after reaching the age of 65. The outcome variable, the prevalence of ADRD, was defined as the ratio of Medicare beneficiaries with ADRD to the total beneficiary population in a given county-year.

Physicians Supply

Our main explanatory variable was per-capita physician supply, defined as the number of active non-federal physicians per 1000 population in a given county-year.

Rural and Urban Categorization

We used the 2013 Rural-Urban Continuum Codes from the US Department of Agriculture Economic Research Service[10] to categorize counties by level of urbanization into: urban counties, rural counties adjacent to an urban county (rural-adjacent counties), and rural counties not adjacent to an urban county (rural-nonadjacent counties).

Instrumental variable

We employed the CIC measure as our instrumental variable, which assesses the extent to which the value of net imports from China substitutes for regional production relative to observed regional production values. Essentially, a higher CIC signifies that regional production is more replaceable by Chinese imports.

Covariates

We controlled for the county-level per capita income, unemployment rate, and ratios of the beneficiaries who are female, black, or Hispanic.

Statistical Analysis

We first used county-fixed effects linear regression model to examine the association between supply of physicians and ADRD prevalence. The county-fixed effect in the panel data models controlled for the unobserved, secular county-specific factors that might affect the outcome. The year fixed effect addressed any implicit trends in the availability of physicians and the outcome.

Estimation of the fixed-effect panel linear regression model entailed an endogeneity bias problem because physicians might expect higher profits in an area where more ADRD patients resided (simultaneity). To address this problem, we used two staged linear regression model using CIC as an instrumental variable. We used the interaction between CIC and the level of rurality to compare the effect in each rural and urban setting. This approach allowed us to disentangle the causal relationship between physician supply and ADRD prevalence.

Furthermore, to validate our findings, we repeated our analysis using the total number of active non-federal physicians as the outcome variable. To control for size effects, we applied natural logarithms to the explanatory variable.

Results

Our sample included 10,590,016 individuals in 3,041 counties (57.08% females, 8.18% Black, and 1.86% Hispanic adults 65 years and older): 1,127 urban counties, 1,000 rural-adjacent, and 914 rural-nonadjacent counties (Supplement Table 1). ADRD prevalence was higher in urban counties during all study years followed by rural adjacent counties. ADRD prevalence rates peaked in 2008 and declined steadily in all counties. There were fewer per-capita physicians in rural areas with a sharp growth in urban areas (from 2.78 in 2002 to 3.03 physicians per 1,000 population in 2014) whereas a persistent decline in rural areas following a peak in 2003 (from 1.07 and 1.32 in 2002 to 0.99 and 1.33 in rural-adjacent and nonadjacent in 2014).

Our results indicate that a 1% increase (above the mean) in per-capita physicians decreases ADRD prevalence by 0.0055%p ($P<0.01$) in urban, increases by 0.0010%p ($P=0.26$) in rural-adjacent, and decreases by 0.0003%p ($P=0.749$) in rural nonadjacent (Table 1). Our 2SLS results indicate that a 1% increase in per-capita physicians decreases ADRD prevalence by 0.56%p ($P=0.037$) in urban, whereas increases by 0.77%p ($P=0.019$) and 0.99%p ($P=0.045$) in rural-adjacent and rural-nonadjacent.

Tables

Table 1. The effect of supply of physicians on ADRD prevalence in rural and urban areas and elasticity of ADRD prevalence with respect to per capita supply of physicians

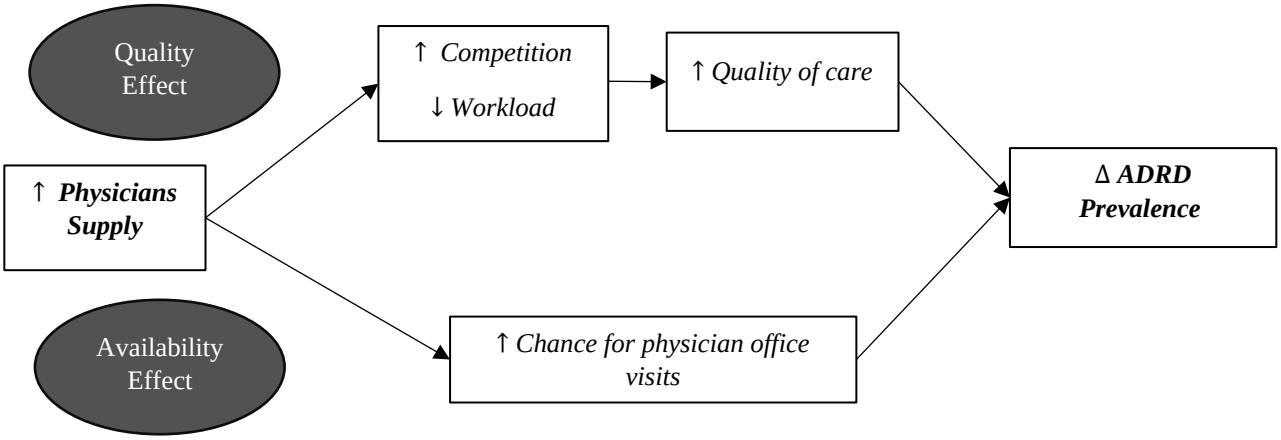
Supply of physicians	**MDs, Per 1,000 population**		**MDs, Total**	
Model	**Panel FE**	**Panel FE IV**	**Panel FE**	**Panel FE IV**
Number of counties	3,064	3,064	2,991	2,991
Urban areas	-0.0024***	-0.0675***		
	(0.0000)	(0.0235)		
Rural-adjacent areas	0.0043***	0.220**		
	(0.0011)	(0.0870)		
Rural nonadjacent areas	0.0023**	0.198**		
	(0.0010)	(0.0868)		
Urban areas			-0.0036***	-0.0663***
			(0.0009)	(0.0161)
Rural-adjacent areas			0.0047***	0.171***
			(0.0011)	(0.0486)
Rural nonadjacent areas			0.0037***	0.126***
			(0.0012)	(0.0379)
Per-capita income	-0.0002***	0.0000	-0.0002***	-0.0002***
	(0.0000)	(0.0001)	(0.0000)	(0.0001)
Unemployment rate	-0.0123	-0.0550**	-0.0104	-0.0227**
	(0.00892)	(0.0226)	(0.00900)	(0.0116)
% Female	0.195***	0.0929**	0.205***	0.202***
	(0.00844)	(0.0395)	(0.00905)	(0.0111)
% Black	0.0384***	0.119***	0.0332***	0.0189
	(0.00981)	(0.0400)	(0.00997)	(0.0139)
% Hispanic	-0.0915***	-0.0631*	-0.0949***	-0.0693**
	(0.0271)	(0.0338)	(0.0286)	(0.0332)
Constant	-0.0057		0.0028	
	(0.0055)		(0.0075)	
Elasticity of ADRD prevalence with respect to per capita supply of physicians.*				
Urban areas	-0.06	-1.70	-0.03	-0.58
	[-0.08 – -0.04]	[-2.86 – -0.54]	[-0.05 – -0.02]	[-0.86 – -0.31]
Rural-adjacent areas	0.02	1.52	0.01	1.00
	[-2.15× 10^{-4} – 0.04]	[0.26 – 2.77]	[2.27 × 10^{-3} – 0.02]	[0.23 – 1.63]
Rural nonadjacent areas	-1.65×10^{-2}	1.70	1.32×10^{-3}	0.58
	[-0.02 – 0.02]	[0.04 – 3.36]	[-0.01 – 0.02]	[0.14 – 1.01]

Note. All models are adjusted for per capita income, unemployment rate, gender, race/ethnicity.
The null hypothesis of the weak instrument was rejected by Anderson-Rubin Wald test (P<0.01) and Stock-Wright LM test (P<0.01).

* We transformed the estimates to elasticity of ADRD prevalence rate with respect to per capita supply of physicians at the average ADRD prevalence rate (urban: 11.35%, rural-adjacent: 16.32%, rural nonadjacent: 17.10%) and the average number of non-federal physicians per 1,000 total population (urban: 2.86, rural-adjacent: 1.05, rural nonadjacent: 1.34).

Figures

Figure 1. Access to Care and Prevalence of ADRD



Implications for Policy and Practice

The study reveals a clear disparity in physician supply between rural and urban areas: Rural areas had significantly fewer per-capita physicians compared to urban areas, while urban areas experienced a steady increase in physician supply over the study period. This discrepancy in physician availability likely contributes to the difficulties faced by rural residents in accessing appropriate healthcare services for dementia diagnosis and management.

- Due to the shortage of physicians in rural communities, older adults with ADRD are under diagnosed in these communities.
- Increasing the supply of physicians in rural areas may lead to a higher number of individuals diagnosed with ADRD in these communities and potentially a diagnosis at an earlier stage which can help in the management of the disease.

Discussion and Conclusion

Our study confirms the physician's availability effect; since the response of ADRD prevalence was higher in rural-adjacent and rural-nonadjacent counties compared to urban counties, the hypothesis that the available effect was stronger in rural areas compared to urban is confirmed. Also, since ADRD prevalence increased by an additional per-capita physician supply in rural-adjacent and rural-nonadjacent counties, more physicians in rural areas may lead to a higher number of elderlies diagnosed with ADRD.

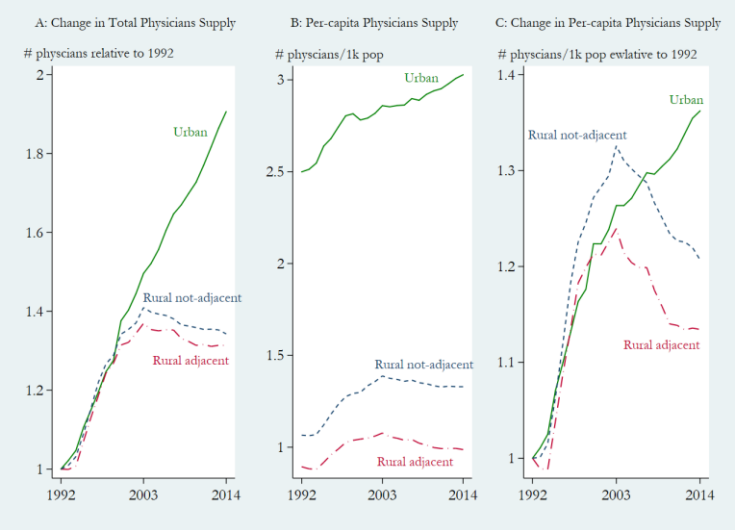
Supplemental Content (if > 1 tables or figures)

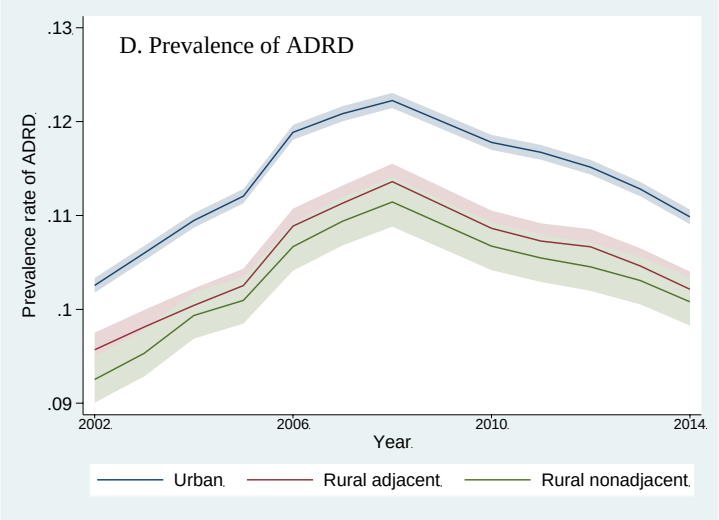
Supplement Table 1. Summary Statistics

	2002			2014		
	Urban	**Rural adjacent**	**Rural nonadj.**	**Urban**	**Rural adjacent**	**Rural nonadj.**
Number of counties	1,144	1,005	909	1,122	999	909
% Over 65	12.86	15.34	16.32	14.86	18.44	18.74
ADRD prevalence rate	10.26	09.57	9.25	10.98	10.21	10.08
Per-capita MDs (per 1000 pop)	2.7830	1.0819	1.3250	2.9392	1.0059	1.3410
Total MDs	2,972	57	53	3,494	56	62
Chinese import competition	3.33	4.12	5.68	5.39	0.1323	0.1477
% Female	0.5985	0.5940	0.5921	0.5712	0.5640	0.5634
% Black	0.0805	0.0542	0.0358	0.0834	0.0467	0.0314
% Hispanic	0.0143	0.0034	0.0050	0.0188	0.0028	0.0039
Per capita income	$41,779	$30,722	$30,777	$47,284	$36,483	$39,081
Unemployment rate	0.0567	0.0653	0.0608	0.0619	0.0670	0.0640

Note. The final sample included 10,534,436 Medicare beneficiaries in 3,066 counties and 36,525 county-years.

Supplement Figure 1. Supply of Physicians and Prevalence of ADRD in urban, rural-adjacent and rural nonadjacent counties in the US.





Note. The data for ADRD prevalence rates were obtained 20-percent random sample of Medicare beneficiaries older than 65 (2002-2014). The data for county-level per capita income and unemployment rates were obtained from the Area Health Resources Files. Plots were weighted by county population. Shaded areas represent 95% CIs.

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