

Are Older Populations at a Disadvantage?

County-Level Analysis of Confirmed COVID-19 Cases in Urban and Rural America

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Author contributions

Seung-won Emily Choi conceptualized the study, carried out the data analysis, and wrote the paper.

Tse-Chuan Yang provided critical feedback on statistical analyses and wrote the paper.

Declarations of interest

None.

ABSTRACT

Objectives: This study examines how areas with older populations are affected by COVID-19 and whether urban and rural counties face different challenges.

Methods: Applying negative binomial regression to a dataset of U.S. counties ($N = 3,042$), we estimated the relationship between older population ratios and the number of confirmed COVID-19 cases, and how this relationship changes over time in urban and rural counties, respectively.

Results: Although low-ratio counties show the highest number of confirmed cases of COVID-19 at the beginning of the pandemic, confirmed cases in high-ratio counties (more than 25% of the total population is 65 and older) increase exponentially with time in urban areas. High-ratio rural counties hit their peak later and recover more slowly compared to low- and medium-ratio rural counties.

Discussion: Both urban and rural counties with larger older populations are more vulnerable and their disadvantages in COVID-19 infections are more rapidly exacerbated over time in urban areas. This underscores the importance of early action in those counties for effective intervention and prevention.

Keywords: Coronavirus; urban-rural variations; pandemic; aging

Current data on Coronavirus Disease 2019 (COVID-19) suggest that the disease disproportionately affects older adults in the U.S. both mentally and physically. Recent studies have shown that the COVID-19 pandemic affects older adults in varied ways, such as growing health and financial concerns, anxiety, loneliness, and social exclusion (Barber & Kim, 2020; Kivi, Hansson, & Bjälkebring, 2020; Losada-Baltar et al., 2020; Seifert, Cotten, & Xie, 2020). Little research, however, has directly examined the patterns of COVID-19 incidence per se in older populations, though a sizable number of COVID-19 confirmed cases are identified among older adults, and the likelihood of fatality increases with age (Stokes et al., 2020).

Moreover, many previous studies have focused on regions or individuals, rather than nationally representative units like counties. Although some county-level studies have considered the proportion of older residents when investigating geographical disparities in COVID-19 (Peters, 2020; Yang, Choi, & Sun, 2020; Zhang & Schwartz, 2020), population aging as a primary domain has received little attention. In light of prior findings, it is possible that counties with larger concentrations of older adults may have worse COVID-19 outcomes, such as more confirmed cases, than those having smaller concentrations.

Another feature of the COVID-19 pandemic is the uneven distribution of confirmed cases across space. Although the outbreak has hit urban areas harder than rural areas, there is a growing concern about the spread of COVID-19 in rural counties (Ameh, Njoku, Inungu, & Younis, 2020). Place of residence has important health implications for older populations based on rural-urban health disparities. The proportion of older populations is higher in rural regions than in urban regions (Smith & Trevelyn, 2019), and rural dwelling is linked to older adults' overall health disadvantages (e.g., lower life expectancy, higher morbidity, riskier health behaviors, lower insurance coverage rates, limited access to medical services, etc.) relative to

urban-dwelling older adults (Cohen, Cook, Sando, & Sabik, 2018; Vierboom & Preston, 2020; Yen, Michael, & Perdue, 2009). Nevertheless, the urban-rural differences specifically associated with COVID-19 remain underexplored. This study, to our knowledge, is among the first to assess geographical differentials in the spread of COVID-19, with an emphasis on older populations.

Guided by the empirical background above, this study examines how older population ratios of U.S. counties are associated with COVID-19 and the change in disease prevalence over time. We further investigate geographical patterns of these associations in urban and rural counties.

Methods

We constructed a county-level dataset including the contiguous U.S. counties ($N = 3,042$) based on four data sources: Coronavirus Live Map, County Health Ranking and Roadmaps, and the Area Health Resources Files.¹

Measures²

The dependent variable is the number of confirmed COVID-19 cases in a county as of June 28th, 2020. The total population was included in the negative binomial analysis as the exposure variable.

Our key independent variable, older population ratio (i.e., the percentage of adults aged 65 and over), was categorized into “low” (reference; < 15%), “medium” (15-25%), and “high” (> 25%). We defined rural/urban status with the percentage of rural population in a county: counties where more than 50 percent of population live in areas with less than 2,500 people were defined

¹ Detailed information on data sources is in Part A of the online supplement.

² See Part B of the online supplement for detailed operationalization of variables.

as “rural;” otherwise they were “urban” (Ratcliffe, Burd, Holder, & Fields, 2016). Time was measured by the number of days from the first confirmed case in a county until June 28th, 2020 (range: 0-159) and was centered. To capture the potential non-linear relationship between time and COVID-19 infections, a square term of time was considered.

For covariates, we created three variables to assess racial/ethnic composition: the percentages of non-Hispanic blacks, non-Hispanic Asians, and Hispanics. Furthermore, we calculated the socioeconomic status (SES) score, where higher scores indicate better SES. The percentage of adults (18-64) without health insurance, life expectancy at birth, and the Health Professional Shortage Area (HPSA) code were used, since the vulnerable populations and health infrastructure of counties affect population health. Finally, we considered non-white/white residential segregation and population density for their contribution to the transmission of infectious diseases.

Analytic approach

Beyond a descriptive analysis by urban/rural status, we implemented several negative binomial regression models (with a logit link function) to account for the potential bias caused by over-dispersion. We standardized all continuous variables in the analysis to facilitate comparisons. The last model included an interaction term between older population ratio and time in order to test a time effect on COVID-19 by aging in urban and rural counties, respectively.

Results

Table 1 presents the descriptive statistics for all variables by urban/rural status and we test if there is a significant difference between rural and urban counties. Several findings are notable. The percentage of confirmed COVID-19 cases in urban counties (0.62%) is significantly higher than that among rural counties (0.42%). Only 3% of urban counties are marked by a high older population ratio, in contrast to approximately 10% of rural counties. Urban counties are more racially/ethnically diverse than their rural counterparts, while the average SES score is higher among urban than rural counties. Regarding health infrastructure and population health, the percentage of uninsured population is comparable between rural and urban counties; however, urban counties have longer life expectancy and more health professionals than rural counties.

[Table 1 Here]

Urban Counties: The negative binomial regression results are summarized in Table 2. Among urban counties (Model 1a), the older population ratio has a significant yet complex relationship with COVID-19 incidence rates. Specifically, the COVID-19 prevalence rate in high-ratio counties is 29% lower (IRR=0.71) than in low-ratio counties. Time square is negatively associated with COVID-19 prevalence, which suggests that the increasing rate in COVID-19 prevalence lessens over time. Higher concentrations of blacks, Asians, and Hispanics, life expectancy, white/non-white segregation, and population density are associated with increasing COVID-19 prevalence. When analyzing the interaction between older population ratio and time (Models 2a), the interaction is significant in urban counties. Figure 1 from Model 2a demonstrates that, among urban counties, the prevalence of COVID-19 is higher among low-ratio counties than medium- and high-ratio counties at the early stage of the pandemic.

Nevertheless, low- and medium-ratio counties hit their peak around 40 days and 60 days, respectively, after their first confirmed cases, and the prevalence slows down more quickly. By contrast, the confirmed cases of high-ratio urban counties continue to increase exponentially over time.

[Table 2 Here]

Rural Counties: Rural counties (Model 1b) show that the COVID-19 prevalence rate is 33% and 53% lower in medium-ratio and high-ratio counties, respectively, than in low-ratio counties. Time square is significantly associated with COVID-19 prevalence. The percentages of blacks and Hispanics, SES, white/non-white segregation and population density are all positively related to COVID-19 cases. Figure 2 presents the incidence patterns in rural counties from Model 2b that includes the interaction between older population ratio and time. Low-ratio counties show the highest prevalence of COVID-19 at the early phase of the pandemic, followed by medium- and high-ratio counties. Although the prevalence of those counties slows down after hitting their peak around 40-50 days after their first cases, high-ratio counties show a comparable yet still prolonged recovery process from the pandemic.

[Figure 1 and 2 here]

Discussion

This study is among the first to examine the association between older population ratios and COVID-19 infections in urban and rural counties, respectively. We found that, as time increases, counties with high older population ratios report more COVID-19 cases than counties with low older population ratios in both urban and rural areas. Although low-ratio urban counties show the highest prevalence of COVID-19 at the early stage of the pandemic, high-ratio urban counties

have slower but much more severe prevalence over time. In rural areas, the high-ratio counties show prolonged recovery from the pandemic.

Our findings suggest that urban and rural counties having larger older populations are more vulnerable to COVID-19 than counties having younger populations in the long-term. These findings largely support a recent county-level study reporting a positive relationship between the percentage of older populations and confirmed cases (Zhang & Schwartz, 2020). Regarding the incidence patterns by urban/rural status, our findings echo a study that suggests more confirmed COVID-19 cases in urban counties than in rural counties (Zhang & Schwartz, 2020). However, our study is not consistent with other findings that rural counties are highly susceptible to COVID-19 (Peters, 2020) and that rural residence, compared to urban residence, has an inverse relationship with older adult health (Cohen et al., 2018).

Lifestyle and health conditions of residents may explain the number and prevalence pattern of confirmed COVID-19 cases by aging. COVID-19 might expeditiously spread in counties with low older population ratio at the pandemic's onset because younger populations may be more likely to be engaged in economic activity and social gatherings than older populations. Those counties may not only prevent the spread of COVID-19 more effectively after adopting social distancing policies but also recover from the disease more quickly, as their residents are relatively healthy with fewer pre-existing conditions. By contrast, counties with high older population ratios may experience the spread of COVID-19 for longer. Older populations in these counties, especially urban counties, tend to be exposed to continuous infection risks perhaps due to difficulties social distancing in a densely populated environment (Nikolich-Zugich et al., 2020; Peters, 2020). A prolonged recovery from the pandemic may also

be attributed to the potentially higher health vulnerability associated with the high ratio of older population in those counties.

This study is subject to several limitations. First, our findings only explore geographical variation in U.S. counties and cannot be generalized to individuals. For example, our results do not necessarily imply that older adults living in low-ratio counties have a lower likelihood of infection than those who live in high-ratio counties. Second, although confirmed case rates are strongly related to testing rates, we are unable to take into account this association as testing rates are unavailable in U.S. counties. More efforts are needed to examine if including testing rates alters our findings. Third, measuring rurality in different ways may alter these conclusions, and future research should investigate if the effect of older population ratio on COVID-19 cases varies by rurality. Fourth, given the small sample size of high-ratio counties in urban areas, the results should be interpreted with caution. Lastly, there is a growing concern about asymptomatic cases (Furukawa, Brooks, & Sobel, 2020), which is unavailable in our data.

Despite these limitations, our study contributes to the literature on COVID-19 by examining the implications of population aging on the pandemic within various geographic contexts using a county-level analysis. Our findings suggest that interventions might focus on counties with high-ratio older populations, specifically in urban areas, given their severe long-term spread of COVID-19.

References

- Ameh, G. G., Njoku, A., Inungu, J., & Younis, M. (2020). Rural America and Coronavirus epidemic: Challenges and solutions. *European Journal of Environment and Public Health*, 4(2), em0040. doi:10.29333/ejeph/8200
- Barber, S. J., & Kim, H. (2020). COVID-19 worries and behavior changes in older and younger men and women. *The Journals of Gerontology: Series B*. doi:10.1093/geronb/gbaa068
- Cohen, S. A., Cook, S. K., Sando, T. A., & Sabik, N. J. (2018). What aspects of rural life contribute to rural-urban health disparities in older adults? Evidence from a national survey. *The Journal of Rural Health*, 34(3), 293-303. doi:10.1111/jrh.12287
- Furukawa, N., Brooks, J., & Sobel, J. (2020). Evidence supporting transmission of severe acute respiratory syndrome Coronavirus 2 while presymptomatic or asymptomatic. *Emerging Infectious Diseases*, 26(7). doi: 10.3201/eid2607.201595
- Kivi, M., Hansson, I., & Bjälkebring, P. (2020). Up and about: Older adults' well-being during the COVID-19 pandemic in a Swedish Longitudinal Study. *The Journals of Gerontology: Series B*. doi:10.1093/geronb/gbaa084
- Losada-Baltar, A., Jiménez-Gonzalo, L., Gallego-Alberto, L., Pedroso-Chaparro, M. d. S., Fernandes-Pires, J., & Márquez-González, M. (2020). "We are staying at home." Association of self-perceptions of aging, personal and family resources, and loneliness with psychological distress during the lock-down period of COVID-19. *The Journals of Gerontology: Series B*. doi:10.1093/geronb/gbaa048
- Morley, J. E., & Vellas, B. (2020). COVID-19 and older adult. *The Journal of Nutrition, Health & Aging*, 24(4), 364-365. doi:10.1007/s12603-020-1349-9

- Nikolich-Zugich, J., Knox, K. S., Rios, C. T., Natt, B., Bhattacharya, D., & Fain, M. J. (2020). SARS-CoV-2 and COVID-19 in older adults: What we may expect regarding pathogenesis, immune responses, and outcomes. *GeroScience*, 1-10. doi:10.1007/s11357-020-00186-0
- Peters, D. J. (2020). Community susceptibility and resiliency to COVID-19 across the rural-urban continuum in the United States. *The Journal of Rural Health*, 36(3), 446-456. doi:10.1111/jrh.12477
- Ratcliffe, M., Burd, C., Holder, K., & Fields, A. (2016). Defining rural at the US Census Bureau. *American Community Survey and Geography Brief*, 1, 8.
- Seifert, A., Cotten, S. R., & Xie, B. (2020). A double burden of exclusion? Digital and social exclusion of older adults in times of COVID-19. *The Journals of Gerontology: Series B*. doi:10.1093/geronb/gbaa098
- Shahid, Z., Kalayanamitra, R., McClafferty, B., Kepko, D., Ramgobin, D., Patel, R., . . . Bhatt, D. (2020). COVID- 19 and older adults: What we know. *Journal of the American Geriatrics Society*, 68(5), 926-929. doi:10.1111/jgs.16472
- Smith, A., & Trevelyn, E. (2019). The older population in rural America: 2012-2016. *American Community Survey Reports*. Washington, DC: US Census Bureau.
- Stokes, E. K., Zambrano, L. D., Anderson, K. N., Marder, E. P., Raz, K. M., Felix, S. E. B., . . . Fullerton, K. E. (2020). Coronavirus disease 2019 case surveillance—United States, January 22–May 30, 2020. *Morbidity and Mortality Weekly Report*, 69(24), 759.
- Vierboom, Y. C., & Preston, S. H. (2020). Life beyond 65: Changing spatial patterns of survival at older ages in the United States, 2000–2016. *The Journals of Gerontology: Series B*, 75(5), 1093-1103. doi:10.1093/geronb/gbz160

Yang, T.-C., Choi, S.-w. E., & Sun, F. (2020). COVID-19 cases in US counties: Roles of racial/ethnic density and residential segregation. *Ethnicity & Health*, 1-11.

doi:10.1080/13557858.2020.1830036

Yen, I. H., Michael, Y. L., & Perdue, L. (2009). Neighborhood environment in studies of health of older adults: A systematic review. *American Journal of Preventive Medicine*, 37(5), 455-463. doi:10.1016/j.amepre.2009.06.022

Zhang, C. H., & Schwartz, G. G. (2020). Spatial disparities in Coronavirus incidence and mortality in the United States: An ecological analysis as of May 2020. *The Journal of Rural Health*, 36(3), 433-445. doi:10.1111/jrh.12476

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Table 1. Descriptive Statistics as of May 7th, 2020 ($N = 3,042$)

Table 2. Negative Binomial Regression Examining Number of Confirmed Cases by Older Population Ratio ($N = 3,042$)

Figure 1. Predicted Number of Confirmed Cases per 100,000 Population by Older Population Ratio and Time in Urban Counties

Figure 2. Predicted Number of Confirmed Cases per 100,000 Population by Older Population Ratio and Time in Rural Counties

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Table 1. Descriptive Statistics as of June 28th, 2020 (*N* = 3,042)

	Urban (n = 1,247)		Rural (n = 1,795)	
	Mean	SD	Mean	SD
Confirmed COVID-19 cases (%)	0.62*		0.42	
Older population ratio				
Low ratio (<15%; ref.)	40.50*		8.19	
Medium ratio (15-25%)	56.13*		81.56	
High ratio (>25%)	3.37*		10.25	
Time (range: 0-159)	98.82*	14.66	83.35	24.32
Percentage of blacks	10.08*	13.67	8.52	14.88
Percentage of Asians	2.59*	3.43	0.60	0.42
Percentage of Hispanics	14.08*	17.37	5.94	9.04
SES	0.34	0.97	-0.25	0.95
Percentage of adults without health insurance	0.11	0.05	0.12	0.05
Life expectancy	78.17	2.82	76.92	2.96
HPSA (%)				
No shortage (ref.)	13.71*		8.45	

Severe shortage	77.39*		53.25	
Moderate shortage	8.90*		38.30	
Non-white/white residential segregation	33.36*	12.02	29.26	12.66
Population density (Ln)	4.89*	1.75	3.20	1.30

Note: Original variables were used.

*Statistically significant difference at the .05 level.

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Table 2. Negative Binomial Regression Examining Number of Confirmed Cases by Older Population Ratio ($N = 3,042$)

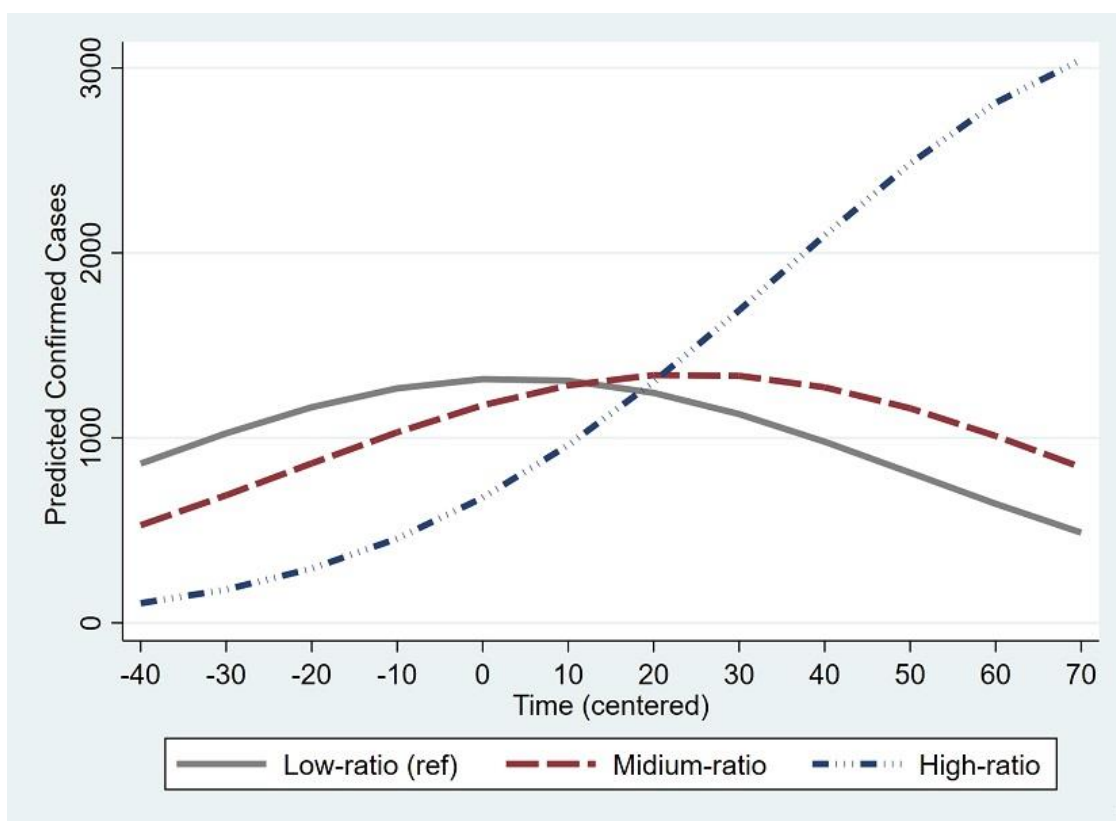
	Urban				Rural			
	Model 1a		Model 2a		Model 1b		Model 2b	
	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI
Older population ratio								
Medium ratio (ref: Low ratio)	0.98	(0.88 - 1.10)	0.89	(0.77 - 1.04)	0.67**	(0.57 - 0.78)	0.67**	(0.57 - 0.78)
High ratio	0.71*	(0.53 - 0.94)	0.51**	(0.36 - 0.72)	0.47**	(0.38 - 0.59)	0.50**	(0.40 - 0.63)
Time (centered)	1.01**	(1.00 - 1.01)	1.00	(0.99 - 1.01)	1.00	(1.00 - 1.01)	1.00	(0.99 - 1.01)
Medium ratio*Time			1.01	(1.00 - 1.02)			1.01	(0.99 - 1.02)
High ratio*Time			1.04**	(1.01 - 1.06)			1.01*	(0.99 - 1.02)
Percentage of blacks	1.34**	(1.24 - 1.44)	1.33**	(1.24 - 1.44)	1.62**	(1.53 - 1.71)	1.62**	(1.54 - 1.70)

	*	1.44)	*		*	1.71)	*	1.72)
Percentage of Asians	1.05*	(1.00 - 1.11)	1.06*	(1.01 - 1.12)	1.28	(1.00 - 1.63)	1.27	(0.99 - 1.63)
Percentage of Hispanics	1.32**	(1.23 - 1.41)	1.30**	(1.21 - 1.40)	1.52**	(1.38 - 1.67)	1.51**	(1.37 - 1.67)
SES	1.00	(0.91 - 1.10)	0.99	(0.89 - 1.09)	1.09*	(1.01 - 1.17)	1.09*	(1.01 - 1.17)
Percentage of adults without health insurance	1.06	(0.99 - 1.14)	1.05	(0.98 - 1.13)	1.05	(0.99 - 1.11)	1.05	(0.99 - 1.11)
Life expectancy	1.13**	(1.05 - 1.22)	1.13**	(1.05 - 1.22)	0.90**	(0.84 - 0.95)	0.90**	(0.85 - 0.96)
HPSA								
Severe shortage	0.81**	(0.70 - 0.94)	0.81**	(0.70 - 0.94)	0.85	(0.72 - 1.00)	0.85	(0.72 - 1.00)
(ref: No shortage)								
Moderate shortage	0.82	(0.66 - 1.02)	0.83	(0.67 - 1.03)	0.89	(0.75 - 1.06)	0.9	(0.75 - 1.07)

Non-white/white residential segregation	1.20**	(1.14 - 1.28)	1.20**	(1.13 - 1.27)	1.16**	(1.11 - 1.21)	1.16**	(1.11 - 1.21)
	*		*		*		*	
Population density (Ln)	1.05*	(1.01 - 1.10)	1.05*	(1.01 - 1.10)	1.05*	(1.00 - 1.11)	1.06*	(1.00 - 1.11)
Time*Time	1.00**	(1.00 - 1.00)	1.00**	(1.00 - 1.00)	1.00**	(1.00 - 1.00)	1.00**	(1.00 - 1.00)
	*		*		*		*	

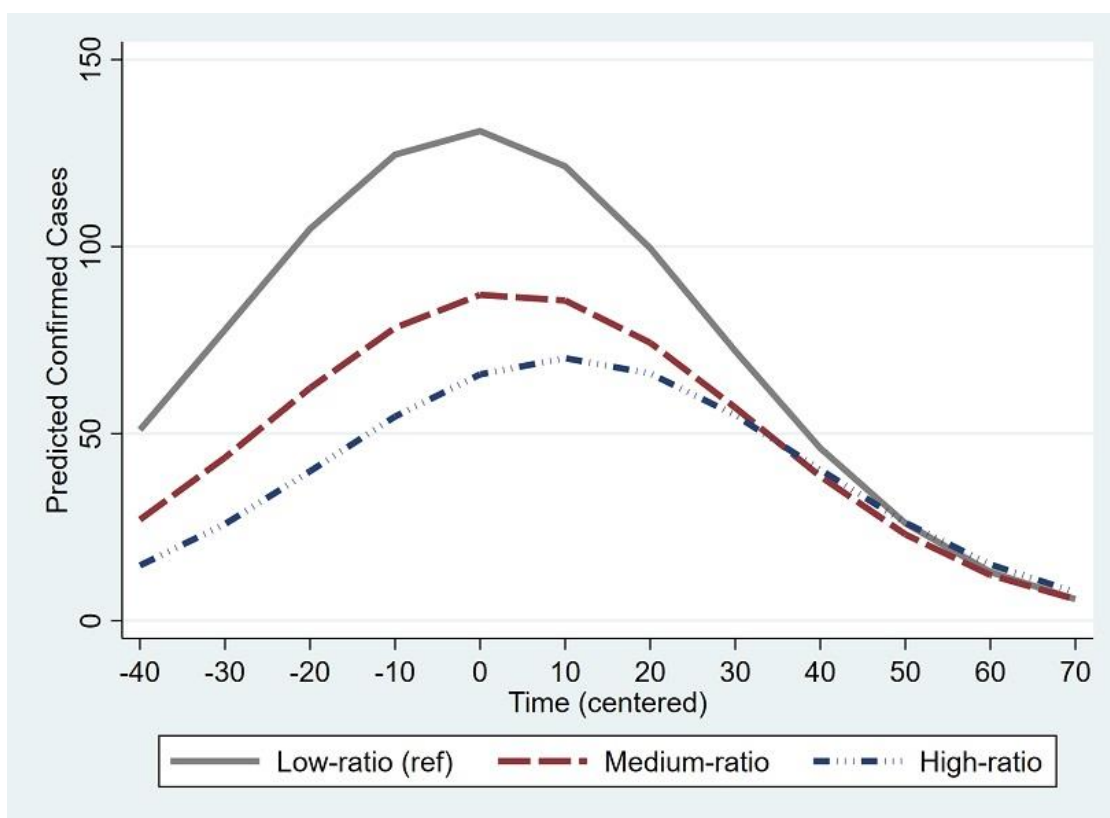
*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

Figure 1



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Figure 2



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