Contents

Short Paper

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Peer-Review Reports

Anonymous

Ayman Allam

Authors’ Response to Peer Reviews of “Evaluating Population Density as a Parameter for Optimizing COVID-19 Testing: Statistical Analysis” (e27258)
Karim Budhwani, Henna Budhwani, Ben Podbielski
Short Paper


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Abstract

Background: SARS-CoV-2 transmission risk generally increases with the proximity of those shedding the virus to those susceptible to infection. Thus, this risk is a function of both the number of people and the area they occupy. However, the latter continues to evade the COVID-19 testing policy.

Objective: The aim of this study is to analyze per capita COVID-19 testing data reported for Alabama to evaluate whether testing realignment along population density, rather than density agnostic per capita, would be more effective.

Methods: Descriptive statistical analyses were performed for population, density, COVID-19 tests administered, and positive cases for all 67 Alabama counties.

Results: Tests reported per capita appeared to suggest widespread statewide testing. However, there was little correlation ($r=0.28$, $P=0.02$) between tests per capita and the number of cases. In terms of population density, new cases were higher in areas with a higher population density, despite relatively lower test rates as a function of density.

Conclusions: Increased testing in areas with lower population density has the potential to induce a false sense of security even as cases continue to rise sharply overall.

(JMIRx Med 2021;2(1):e22195) doi:10.2196/22195

KEYWORDS
infectious diseases; testing; per capita; population density; policy; coronavirus; SARS-CoV-2; COVID-19
**Introduction**

COVID-19 testing is typically measured per capita; tests and cases are reported per million globally while local authorities report counts per 100,000 people [1-3]. This approach is simple and generally well accepted both in economic spheres and in health care research. However, this simplicity may shroud an underlying fallacy in applying per capita models to test the transmission characteristics of SARS-CoV-2. The transmission risk profile for 20 people in an elevator is substantially different from that of 20 people spread across a football field; this was the fundamental premise for social distancing and lockdowns to “flatten the curve.” Moreover, population density can impede [4] implementation of protective distancing measures. Population density has also been implicated [5] in COVID-19 mortality. In this two-part study, we analyze per capita COVID-19 testing data reported for Alabama to evaluate whether testing realignment along population density, rather than density agnostic per capita, would be more effective, as Alabama is one of several states currently experiencing notable increases in new cases.

**Methods**

Population characteristics and population density for all 67 Alabama counties were obtained from the 2018 American Community Survey (US Census Bureau). The number of tests administered and positive cases of COVID-19 are updated daily by the Alabama Department of Public Health. These data were obtained on May 18, 2020, for initial assessment and again on June 15, 2020, for prospective analysis. Descriptive statistical analyses were performed to calculate the total number of tests per 100,000 people using the county population as the denominator, and subsequently dividing this by county population density, density squared, and square root of density as illustrative proxies [6,7] of more complex population density test rate models. All study data were publicly available, thereby obviating institutional review board approval.

**Results**

The first heatmap presented in Figure 1 appears to indicate widespread testing per 100,000 people [8] by county. However, this heatmap does not distinguish sparsely populated areas that could inherently provide spatial distancing from those that are densely populated (Figure 1B) [9]. Overlaying the two (Figure 1C) provides a sense of magnitude by which we may be overtesting in areas with a natural spatial defense against transmission while severely undertesting in areas with an elevated risk of transmission.

In the second part of the study, conducted during the phased economic re-engagement, data were collected to prospectively analyze the distribution of tests and cases vis-à-vis population density. Tests reported per 100,000 during this period, once again, appeared to indicate widespread statewide testing. However, there was little correlation ($r=0.28$, $P=.02$) between tests per capita and the number of cases. As anticipated [10], new cases were disproportionately more prevalent in densely populated areas (Figure 2), despite relatively fewer tests per population density, suggesting that cases in these areas may be understated.
COVID-19 testing during the phased reopening of the Alabama economy from May 18 to June 15, 2020. Tests reported per 100,000 during this period also appeared to indicate widespread statewide testing. However, there was little correlation ($r=0.28, P=0.02$) between tests per capita and the number of cases. In terms of population density, new cases were higher in areas with higher population density, despite relatively lower test rates as a function of density. This suggests that a population density–driven testing strategy would not only allow for more effective allocation but could also reduce the risk of understating cases in areas with high population density.

Discussion

The current standard of population density agnostic per capita reporting could induce a sense of false security while simultaneously accelerating infection in economic nerve centers. The contrast among the heatmaps, as well as subsequent prospective analysis of tests and cases, unveil the scale of testing disparity. A robust testing strategy would presumably figure prominently in the calculus for any phased reopening of economies and associated near-term paths to societal normalcy and economic recovery. Consequently, disparities in testing induced by a density agnostic testing approach could undermine balancing measures aimed at saving lives and livelihoods, thereby leading to a prolonged recession, or dare we say, a depression [11,12].

Although we use Alabama for illustration, most states report statistics in this manner, making our processes replicable in other states. This said, limitations of our approach should be considered when extending findings. Namely, population density–driven testing has not be extensively evaluated for feasibility and acceptability, and, during this pandemic, gaps in public health monitoring and surveillance data [5], particularly from rural communities, have emerged, leading to concerns related to data reliability.

On a positive note, resolving this is not intractable. Heatmaps of retail and payroll activity are unsurprisingly similar to population density. This is where the innate intertwining of public health and economic well-being around the “location, location, location” axis can be synergistic. For instance, by adjusting the distribution of testing capacity to also account for population density, we could improve monitoring and response to blunt the speed and spread of the virus while also safeguarding both retail activity and economic nerve centers across the country.

Authors’ Contributions

All authors contributed to the writing of this manuscript and have approved the final version.
Conflicts of Interest
None declared.

References

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(JMIRx Med 2021;2(1):e27103) doi:10.2196/27103

KEYWORDS
infectious diseases; testing; population density; policy; coronavirus; COVID-19; SARS-CoV-2

This is a peer review submitted for the paper “Evaluating Population Density as a Parameter for Optimizing COVID-19 Testing: Statistical Analysis.”

Round 1 Review

General Comments
This paper [1] signals the need for a more nuanced COVID-19 testing strategy. The authors propose using population density–driven testing to help address this need. Testing strategies certainly have room for improvement and continuous assessment, especially in emergent situations like COVID-19. Maps are great visualization tools.

Specific Comments

Major Comments
This paper communicates that adjusting testing strategies by population density will save lives and livelihoods. While I think there is merit to finding effective ways to account for population density, especially in contexts with high-quality census and robust public health surveillance data, there is a host of other dynamic factors that play into the complicated pathway between population density, testing, and saving lives and livelihoods that are not accounted for in the current version of this paper. This draft also uses absolute terms and expressions that do not seem appropriate given the scope of the study. The authors might benefit from speaking in less absolute terms, remove anecdotal examples such as the elevator vs football field in exchange for more standardized epidemiological measures, and include in the paper a discussion about the limitations of using their proposed population density–driven testing. The paper should also speak more to the nature (eg, challenges) of public health data, monitoring and surveillance, and the role of testing in this context. As a policy-oriented paper, it should also discuss more of the potential impacts of modifying a testing strategy (pros and cons), including the costs associated with changing the current testing strategy. The paper might also want to address whether or not adjusted testing strategies based on population density (or similar measures) have successfully been done elsewhere.

Conflicts of Interest
None declared.

Reference

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(JMIRx Med 2021;2(1):e27257) doi:10.2196/27257

KEYWORDS
infectious diseases; COVID-19; SARS-CoV2; coronavirus

This is a peer review submitted for the paper “Evaluating Population Density as a Parameter for Optimizing COVID-19 Testing: Statistical Analysis.”

Round 1 Review

General Comments
In this paper [1], the authors prospectively analyzed COVID-19 data obtained from 67 Alabama counties using testing realignment along population density instead of density agnostic per capita. They concluded that adjusting the distribution of testing capacity to also account for population density will improve monitoring and response to blunt the speed and spread of the virus.

Generally, the manuscript is properly structured and well understood.

Specific Comments

Minor Comments
1. Change the subtitle “Policy Proposal” to “Introduction” or “Background.”

Conflicts of Interest
None declared.

Reference

Edited by E Meinert; submitted 18.01.21; this is a non-peer-reviewed article; accepted 18.01.21; published 03.02.21.

Please cite as:
Allam AA
JMIRx Med 2021;2(1):e27257
URL: https://med.jmir.org/2021/1/e27257/
doi:10.2196/27257
PMID:
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(JMIRx Med 2021;2(1):e27258) doi:10.2196/27258

KEYWORDS
infectious diseases; testing; per capita; population density; policy; coronavirus; SARS-CoV-2; COVID-19


Response to Round 1 Reviews

Reviewer: Anonymous

General Comments

Dear anonymous reviewer [1], we would like to begin by conveying to you our deep appreciation for your assistance in refining this short paper [2] so that it is suitable for broader consumption. It is our aspiration that this paper will contribute positively to advancing knowledge in this domain. We have fully addressed all your recommendations and are pleased to submit a revised manuscript. Thank you for your expert assistance in this endeavor.

Specific Comments

Major Comments

You raise excellent points. We are happy to note that some of these points are a result of automatically transferring our manuscript from the preprint server. We submitted our manuscript originally to a preprint server with the goal of sharing our analysis and viewpoint in a timely and nonintimidating manner by way of a short report. The title, format, and manuscript text were rapidly copied from the general preprint server edition during the automatic transfer process.

The revised manuscript addresses the following:

2. Absolute terms from the preprint report have been modified.
3. The elevator vs football field “visual” expression was included deliberately in the original report as a means to make the role of density in SARS-CoV-2 viral transmission readily apparent to a broad audience. In order to address your concern, we have removed a reference to this expression in the Results section; however, in keeping with the original intent of reaching a broader audience, we would prefer to retain the expression in the Introduction.

4. We have included statements on limitations. Thank you for noting this gap.

5. We agree that a cost-effectiveness analysis is warranted after feasibility and acceptability have been established, but due in part to the word limit for short papers, we are unable to explore these differences. We believe that a paper on the costs and financial consequences of different testing strategies is warranted, potentially in follow-up analyses. Thank you for this recommendation.

6. In response to whether or not adjusted testing strategies based on population density (or similar measures) have been successfully done elsewhere: population density–based testing is novel, having (to our knowledge) only been employed in HIV research through network tracing in urban metropolitan areas. This gap in knowledge in terms of the benefit of population density testing is likely because we have not encountered many agents that are as infectious and persistent as SARS-CoV-2. This short paper is an initial step to illustrate to the scientific community that targeted approaches may be warranted when community spread occurs through close contact that is more likely in tightly packed communities.

Reviewer: AAA

General Comments

Dear reviewer AAA [3], we would like to begin by conveying to you our deep appreciation for your assistance in refining this short paper so that it is suitable for broader consumption. It is our aspiration that this paper will contribute positively to advancing knowledge in this domain. We have fully addressed all your recommendations and are pleased to submit a revised manuscript. Thank you for your expert assistance in this endeavor.

Specific Comments

Minor Comments

1. Your recommended heading change has been made in the revised manuscript.

Conflicts of Interest

None declared.

References


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