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ORIGINAL RESEARCH

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Geospatial evaluation of access to otolaryngology care in the United States

Michael Pozin MSE[1] | **Mark Nyaeme BS**[1] | **Nicholas Peterman BS**[1] | **Ashok Jagasia MD, PhD**[1,2]

[1]Carle Illinois College of Medicine, Urbana, Illinois, USA

[2]Department of Otolaryngology-Head and Neck Surgery, Rush University Medical Center, Chicago, Illinois, USA

Correspondence
Michael Pozin, Carle Illinois College of Medicine, University of Illinois at Urbana-Champaign, 506 S Mathews Ave, Urbana, IL 61801.
Email: mapozin2@illinois.edu

Abstract

Objectives: This county-level epidemiological study evaluated the travel distance to the nearest otolaryngologist for continental US communities and identified socioeconomic differences between low- and high-access regions.

Methods: Geospatial analysis of publicly available 2015–2022 NPI records was combined with US census data to identify geospatial gaps in otolaryngologist distribution. Moran's index geospatial clustering in distance to the nearest county with an otolaryngologist was used as the core metric for differential access determination. Univariate logistic analysis was conducted between low- and high-access counties for 20 socioeconomic and demographic variables.

Results: Nationally, the average person was 22 miles from an otolaryngologist. 444 counties were identified as geospatially "low access" with increased travel distance in the Midwest, Great Planes, and Nevada with a median of 47 miles. 1231 counties in the Eastern United States and Western Coast were identified as "high access" with a 3-mile median travel distance. Areas of low access to otolaryngological care had smaller median populations (12,963 vs. 558,306), had smaller percent Black and Asian populations (2% vs. 11%, 1% vs. 5%, respectively), had a greater percent American Indian population (2% vs. 1%), were less densely populated (8 vs. 907 people per square mile), had fewer percent college graduates (20% vs. 34%), and fewer otolaryngologists per county (median: 0.01–20).

Conclusion: These findings highlight disparity in otolaryngology care in the United States and the need for otolaryngology funding initiatives in the Midwest and Great Plains regions.

Level of Evidence: Level 3.

KEYWORDS
geospatial analysis, healthcare disparities, otolaryngology access

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1 | INTRODUCTION

Access to otolaryngology care (ATOC) is important to provide patients timely diagnosis and adequate treatment of diseases requiring otolaryngology-specific management, yet the availability of such care is influenced by a myriad of factors including economic, geographic, and demographic.[1,2] Although several workforce analyses have raised concerns of a reduced otolaryngology workforce, follow-up studies have observed that the overall and per-capita number of otolaryngologists are increasing rather than dwindling.[3–5] Albeit, the availability of otolaryngology specialist care is nonhomogeneous across the United States with some regions having a surplus of otolaryngologists meanwhile others have a shortage.[6–8] While it has been observed that advanced practice providers have helped reduce the disparity, the disproportionality of otolaryngologic care continues to be concerning.[9]

Geographic ATOC has been associated with differences in outcomes. Patients with Esthesioneuroblastoma exhibit higher survival if they are from the West or East as opposed to the Midwest or South.[9] Head and neck cancer survivability disparities are exacerbated by rural status.[10] Oropharyngeal cancer has a >20% discrepancy in survival rate amongst patients living in low socioeconomic counties despite adjustment for disease- and treatment-specific markers.[11] Although county-level SES was the most predictive metric of head and neck cancer outcomes, rural residence was implicated in more advanced staging at time of diagnosis, and the number of practicing otolaryngologists in the area was associated with improved patient survivability.[12] However, a minority of studies has observed that rural populations who travel for care had better outcomes and have referred to these unexpected phenomena as the "referral bias."[13]

Geospatial analysis is a tool for identifying and observing healthcare disparities by identifying geographic areas with low access to healthcare services. Several studies have used geospatial analysis to map the distribution of otolaryngology care and identify areas with low access.[6,7] However, few studies have compared the population demographics of those with high versus low accessibility to otolaryngology care. This study aims to address this gap in the literature by conducting a geospatial analysis with robust clustering between low- and high-access populations and compare the demographic characteristics of the two populations based upon ATOC. In this study, geographic areas with poorer access to otolaryngology will be referred to as "low access" populations/regions, whereas areas with a surplus of otolaryngology specialists will be referred to as "high-access" populations/regions.

2 | METHODS

Public access data sources including the National Plan and Provider Enumeration System (NPPES) NPI registry, Center for Medicare Services (CMS), and US Census data were concatenated to generate a list of practicing otolaryngologists and the demographic constitution of their patient population for years 2015–2022. The public access nature of the data sources made this study IRB exempt. Alaska and Hawaii were excluded from the analysis to reduce the introduction of geographic anomalies as the unique and isolated geography would distort the study results and limit the generalizability of this study. Of the 3109 counties in the continental United States, 3108 were used for analysis. Conflicting data between databases were averaged, and only one county was excluded due to lack of data across all three sources. Twenty variables including population, race, education, and economic factors were selected as variables of comparison (Table 1). The outcome variable was ATOC and was intended to measure the ease of accessibility for an individual in a specific county reach an otolaryngologist. This measurement was determined by calculating the shortest distance from the geographic center (centroid) of a county to the closest location where at least one otolaryngologist practices. For any county with at least one otolaryngologist, this distance was zero (Figure 1). GeoDa, an open-source geospatial analysis program, was used to conduct a network-based analysis on the ATOC and identify regions with statistically significant ($\alpha = .05$ with Bonferroni corrected $p < .001$ and standardized mean difference [SMD] >0.5) high- or low-access regions based upon distance of travel (Figure 2).[14] Moran's Index is a statistical measure used to assess and quantify statistically significant similarity or dissimilarity amongst neighboring spatial units in a geographic area. The null hypothesis that ATOC is geospatially random was evaluated using Moran's Index and allowed for identification of counties in which ATOC is statistically significantly nonrandom. County clusters identified as relatively low or high ATOC were used to compare socioeconomic factors of their constitutive populations. Univariate logistic analysis was conducted across variables of comparison evaluating the population demographics in low- and high-ATOC populations (Table 1). A separate univariate logistic analysis was performed to evaluate the total number of otolaryngologists and the average distance of travel compared between identified low- and high-ATOC populations (Table 2). Statistical significance for the Univariate Analysis was selected at an alpha level (α) of .05, which represents the probability of incorrectly rejecting the null hypothesis. A Bonferroni correction was applied to reduce the risk of a false positive error due to the multitude of comparisons considered simultaneously and therefore a $p < .001$ was considered significant. An SMD >0.5 was required for a result to be considered statistically significant in this study to mitigate error in effect size interpretation and grouped comparison.

3 | RESULTS

The results of our study identified 1231 counties as high access and 444 counties as low access. People living in high-access regions, primarily located in the East Coast, east-of-Mississippi Midwest (primarily Michigan, Wisconsin, Illinois, Indiana, Ohio, Kentucky, and Tennessee), and populous regions of the West Coast, had a median travel of 3 miles to the nearest otolaryngologist meanwhile those living in low-access regions, including the Great Plains, Rocky Mountain, and Southwest regions of the United States, were found to have a median travel distance of 47 miles to their nearest otolaryngologist ($p < .001$). Nationally, the average person was 22 miles from a practicing otolaryngologist (Figures 1 and 2). Low-access regions of ATOC

TABLE 1 Univariate logistic analysis of otolaryngologist access.

	Low access		High access			
Variables	**Median**	**IQR**	**Median**	**IQR**		
Number of counties	**444**		**1231**		***p*-Value**	**SMD**
Total population	**12,963**	**17,535**	**558,306**	**1,067,660**	**<.001**	**0.611**
Median age	39.6	10.1	38.3	4.4	.001	0.188
Population density	8.0	12.9	906.5	1937.8	<.001	0.405
Race						
Percent White	**92.6**	**9.1**	**75.4**	**25.1**	**<.001**	**0.834**
Percent Black	**1.5**	**2.8**	**11.4**	**15.7**	**<.001**	**1.103**
Percent American Indian	**2.3**	**3.1**	**1.0**	**0.6**	**<.001**	**0.692**
Percent Asian	**0.9**	**0.9**	**5.4**	**7.4**	**<.001**	**0.846**
Percent Hispanic	10.2	34.8	10.6	17.7	<.001	0.386
Education						
Percent of adults with less than a high school diploma	10.9	11.3	10.1	5.3	.013	0.506
Percent of adults with a high school diploma only	31.8	5.9	25.9	9.9	.001	0.656
Percent of adults completing some college or associate degree	**34.0**	**8.0**	**27.6**	**6.2**	**<.001**	**0.988**
Percent of adults with a bachelor's degree or higher	**20.4**	**8.1**	**33.9**	**14.9**	**<.001**	**1.095**
Economic factors						
Percent of housing in mobile homes	**10.2**	**9.6**	**2.2**	**5.0**	**<.001**	**0.903**
Percent of housing in rent	28.2	10.1	34.7	15.5	.054	0.578
Percent of households without a vehicle	4.7	3.1	6.6	4.5	<.001	0.457
Percent of households without a telephone	1.7	1.3	1.4	0.5	.073	0.511
Median rent	**709**	**156**	**1160**	**552**	**<.001**	**1.143**
Unemployment rate	4.0	3.2	5.2	1.9	<.001	0.416
Average travel time to work (minutes)	**18.3**	**5.3**	**27.8**	**7.7**	**<.001**	**1.628**
Percent of workers in service industry	17.5	5.2	17.0	3.6	.001	0.350
Percent of workers in sales or office work	**19.2**	**4.3**	**21.4**	**2.1**	**<.001**	**0.858**
Percent of workers in food production or mining	**12.0**	**11.2**	**0.5**	**0.8**	**<.001**	**2.393**
Percent of workers in construction	7.5	2.9	5.9	2.2	.428	0.682
Percent of workers in manufacturing	**5.9**	**5.6**	**9.3**	**6.3**	**<.001**	**0.522**
Percent of workers in transportation, warehousing, or utilities	5.7	2.8	5.3	2.2	.004	0.305
Percent of workers in education, healthcare, or social assistance	22.7	7.4	22.9	4.4	<.001	0.072
Percent of workers in government	**18.4**	**7.7**	**12.7**	**4.6**	**<.001**	**1.082**
Median household income	**52,146**	**10,987**	**69,023**	**25,090**	**<.001**	**0.948**
Percent without health insurance	**10.8**	**9.3**	**7.0**	**4.2**	**<.001**	**1.139**
Percent of children without health insurance	**8.0**	**7.2**	**3.5**	**2.5**	**<.001**	**1.246**
Percent of families in poverty	13.2	6.0	11.7	5.8	.148	0.536
Average family size	3.1	0.5	3.2	0.3	<.001	0.119
Percent veterans	8.4	3.4	6.4	3.3	.148	0.560
Percent of households not english speaking	9.7	22.1	15.3	26.5	.002	0.159
Percent of households spanish speaking	6.4	21.2	7.7	13.7	.001	0.256
Percent of households with a computer	**88.7**	**5.8**	**93.0**	**4.3**	**<.001**	**0.966**
Percent of households with internet	**79.2**	**7.8**	**87.0**	**6.3**	**<.001**	**1.175**
2013 Rural–urban continuum code	**7.0**	**2.0**	**1.0**	**1.0**	**<.001**	**2.297**
Percent adults in poverty (<20 percentile)	12.6	5.5	11.1	5.2	.005	0.574

Note: Univariate logistic analysis of demographic characteristics amongst low- and high-access regions. Bolded values are statistically significant, $\alpha = .05$ with Bonferroni corrected $p < .001$ and standardized mean difference (SMD) >0.5. Abbreviations: IOR, interquartile range, SES, socioeconomic status.

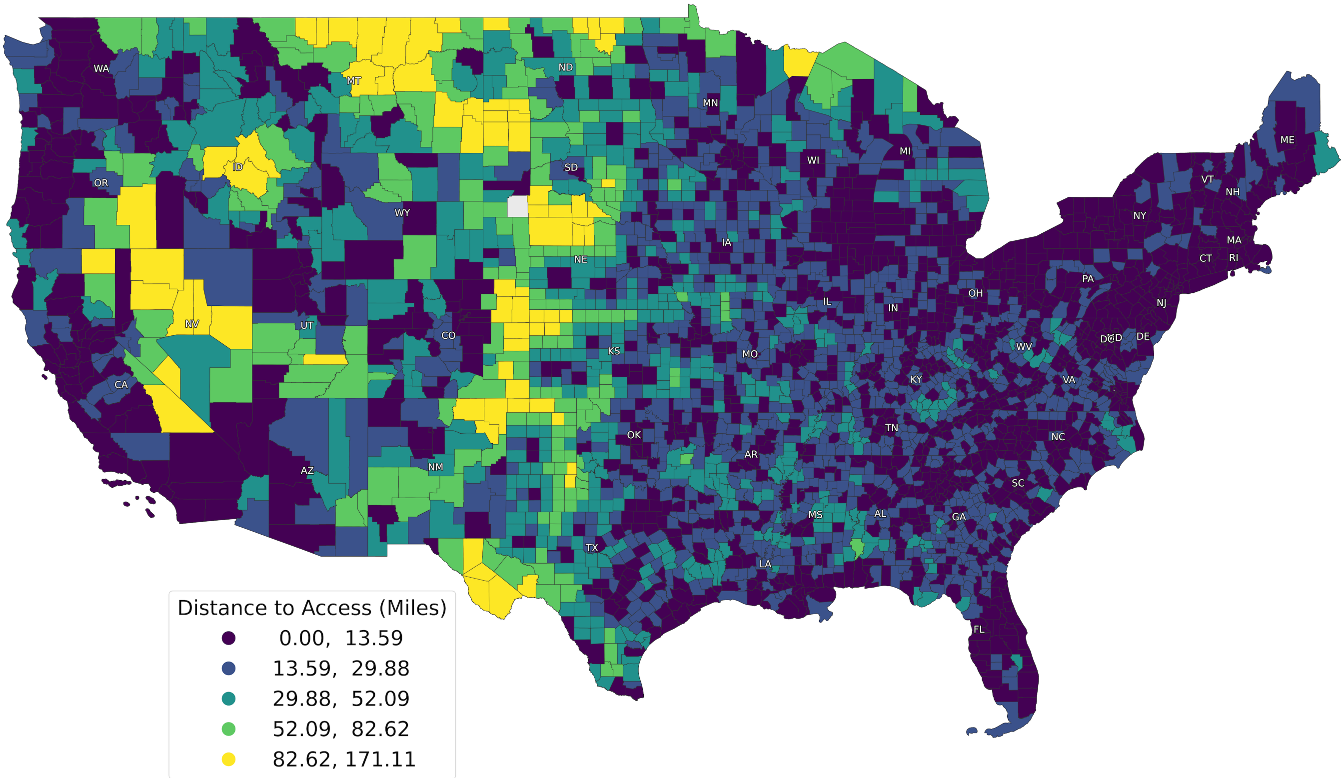

FIGURE 1 Choropleth map of accessibility to otolaryngologists. County-level otolaryngologist accessibility is described by the county-county centroid distance (miles) from the closest county with otolaryngologist access.

had relatively smaller median populations (12,963 vs. 558,306, $p < .001$), (1.5% vs. 11.4%, $p < .001$), had smaller percent Black and Asian populations (1.5% vs. 11.4%, 0.9% vs. 5.4%, respectively, $p < .001$), had a greater percent American Indian population (2.3% vs. 1.0%), and had fewer percent college graduates (20.4% vs. 33.9%, $p < .001$). Economic factors differentiable between low- and high-ATOC include a nearly 5-fold increase in median percent living in mobile housing (10.2 vs. 2.2, $p< .001$), a 24-fold increase in median percent working in food production or mining (12.0 vs. 0.5, $p < .001$), and more than 2-fold increase in median percent children without health insurance (8.0 vs. 3.5, $p < .001$). Areas of ATOC disparity were in concordance with the 2013 Rural–Urban Continuum Code, with the continuum metric demonstrating a 7-fold increase in low ATOC (7.0 vs. 1.0, $p < .001$; Table 1).

4 | DISCUSSION

The results of this study reveal a striking inequality in the accessibility to otolaryngology care across the continental United States. Regions of the East Coast, east-of-Mississippi Midwest, and populous regions of the West Coast were found to have statistically significantly shorter travel distances to the nearest practicing otolaryngologist when compared with those living in the Great Plains, Rocky Mountain, and Southwest regions of the United States. Rural access to care is the most cited predictive factor poor outcomes and disease progression.[13] While accessibility to care is multifactorial and cannot be fully appreciated solely based upon the distance to nearest ENT, challenges in obtaining care due to travel distances ought to be considered when evaluating public health initiatives and in attempts to combat disparities of healthcare as a whole. The effect of physical access upon otolaryngology care has been a topic of debate in literature. Counterintuitive consequences including the "referral bias" or "distance bias," which describe those patients who travel farther for care are more likely to achieve more favorable outcomes, have been investigated across various fields of medicine including in otolaryngology.[15–17] Higher costs, outdated methodology, less peer influence, and poor practice efficiency are just some of the numerous factors confounding a purely physical explanation to healthcare outcomes.[18]

Our study revealed that compared with regions with high accessibility, regions of low ATOC were less population dense counties. Total population of low-access counties had a median population of 12,963 and median population density of 8.0 people per square mile, meanwhile high-access counties had a median population of 558,306 and a median population density of 1937.8 people per square mile. Similarly, low access regions were observed to have a median 2013 Rural–Urban Continuum Code of 7.0 compared with high-access regions which had a median of 1.0, consistent with prior work identifying strong adherence between national Urban–Rural Continuum and otolaryngology accessibility.[19] The nearly 250-fold increase in population density between high- and low-access populations is consistent with prior reports that identify true "rural" populations as more prone to geographically driven care compared with "metropolitan" versus

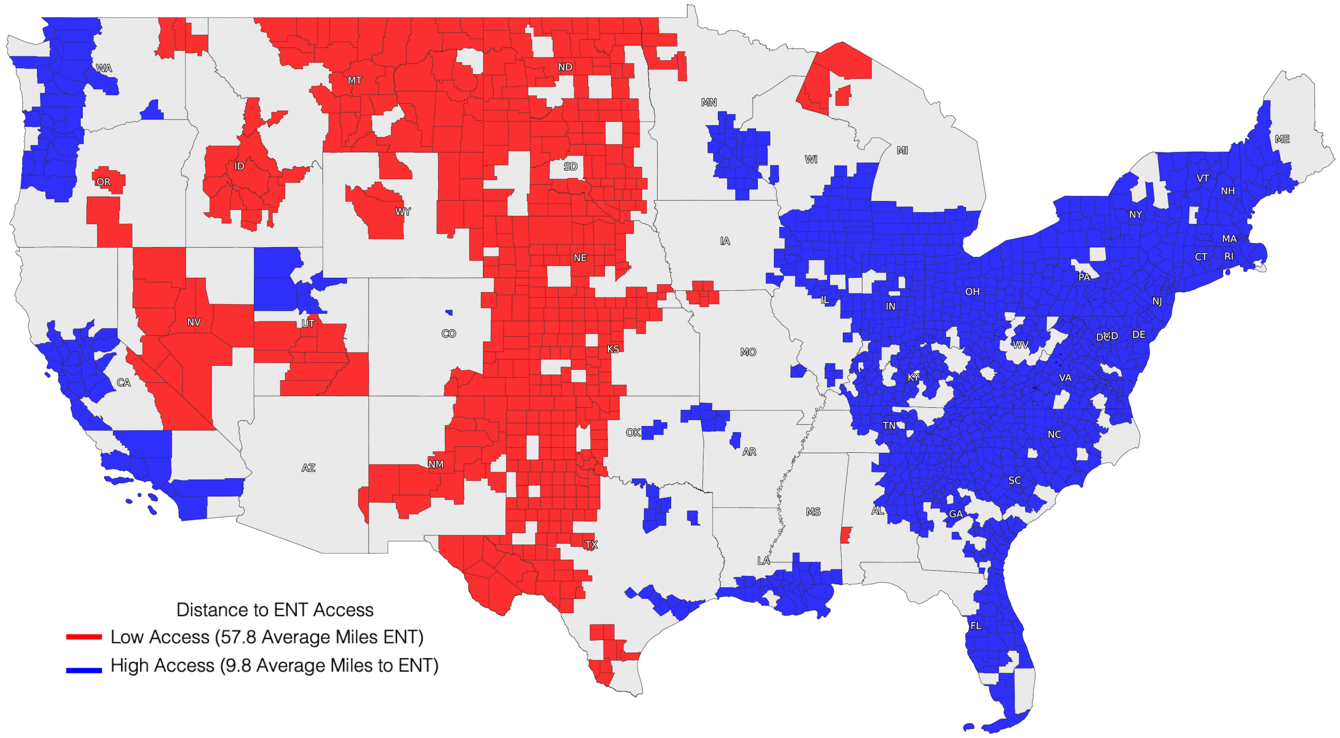

FIGURE 2 Moran's index clusters of otolaryngologist accessibility. Moran's index cluster analysis of otolaryngologist accessibility. Low-access regions (red) represent increased traveling distance to otolaryngologists. High-access regions (blue) indicate decreased traveling distance to otolaryngologists.

TABLE 2 Univariate logistic analysis of otolaryngologist access using Moran's index.

	Low access		High access			
Variables	Median	IQR	Median	IQR		
Number of counties	444		1231		*p*-Value	SMD
Total otolaryngologist	**0**	**0**	**20**	**51**	**<.001**	**0.64**
Distance to access	**47**	**31**	**3**	**3**	**<.001**	**3.52**

Note: Univariate logistic analysis of total otolaryngologists and distance to access in high- and low-access regions. Bolded values are statistically significant, $p < .05$ and standardized mean difference (SMD) >0.5.
Abbreviations: IQR, interquartile range.

"nonmetropolitan" areas.[20] This continues to be a topic of inconsistency as some studies suggest that "nonmetropolitan" or alternatively referred to as suburban populations are overtreated for certain procedures even when compared with more urban populations.[21] A major limitation of similar population-based studies is the inability to account for rural communities within urban counties as current methods for database aggregation do not provide data granularity beyond the county level.

The findings of our study identified that geographic areas with poorer access to otolaryngology are significantly more American Indian (Median percent population 2.3 vs. 1.0). However, low-access counties are also drastically less Black (Median percent population 1.5 vs. 11.4) and less Asian (Median percent population 5.4 vs. 0.9).

Economic factors of inequality have been implicated in many healthcare disparities. Our findings suggest that counties with poorer ATOC have higher percentages of people living in mobile homes, higher percent of workers in food production or mining industries, a lower median household income, and higher percent of people without health insurance. These findings are consistent with known social determinants of health and highlight the importance of maintaining awareness that geographic isolation continues to be a major contributor to healthcare inequality and socioeconomic disparities of healthcare access.

The findings of this study have important implications for addressing healthcare disparities and improving ATOC. The findings highlight the need for targeted interventions to address geographic disparities in otolaryngology care. Increasing the number of otolaryngologists in low-access areas, potentially with provider incentives for rural residence or travel, and new health delivery technology such as telemedicine services used in tandem with traditional methods may improve access to care in rural settings. Additionally, the findings suggest that interventions targeted at improving access to care in geographically isolated regions may improve accessibility to otolaryngology care for low-income populations. While this study measures access to general otolaryngology care, it is likely that additional factors such as access to subspecialty otolaryngologist further exacerbate the inequality with urban residents having relative ease of access to otolaryngology subspecialists meanwhile rural populations face significant challenges in accessibility even to general otolaryngology care.

Several limitations to the findings of this study must be acknowledged. Data from 2015 to 2022 were averaged for the purpose of this study. This data may not be most representative of otolaryngology access distribution in 2023. Census data included 2020 but did not include 2010 census data. The utilization of Medicare data limits the study population to eligible populations and may not be reflective of the general population. The utilization of county-level data is limited in generalizability as size of county amongst other factors cannot be accounted for. While like all geospatial analysis, the generalizability of this study is limited, this study contributes the most granular and therefore generalizable study in otolaryngology care accessibility to the authors' best knowledge.

5 | CONCLUSION

This study provides important insight into the disparity in ATOC in the United States. The findings suggest that certain counties are "low access" for otolaryngology care accessibility and that these counties tend to have smaller median populations, lower median income, and a higher percentage of American Indian populations. Addressing these disparities will require targeted interventions to increase access to care in low-access areas and will improve access to care for minority and low-income populations. Overall, improving ATOC is essential for improving patient outcomes and ensuring equitable healthcare to all.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest to disclose.

ORCID

Michael Pozin https://orcid.org/0000-0002-9069-7440

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