



Interpretational Limitations of Global and Local Indices in the Measurement of Residential Isolation

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Abstract

The P^* index has been commonly referred to as the “isolation” index in segregation studies because it isolates (more generally, separates) the distributional pattern of a particular group from other mutually exclusive groups. Since the P^* index has been conceived to possess useful mathematical properties for capturing the exposure dimension of residential segregation, its spatial versions have been developed by different researchers. However, these isolation indices may be susceptible to differences in population size and their upper-bound has been known to vary across mutually exclusive groups. To shed light on such interpretational limitations, which have not been clearly demonstrated in the literature, population estimates by race and ethnicity in the State of California at three time periods were assessed in this study. Whether aspatial or spatial in nature, both global and local isolation indices showed that racial and ethnic majority groups were more isolated (or, more generally, “segregated”) than their minority counterparts. For comparative and trend analyses, therefore, further considerations are needed to address the interpretational limitations of aspatial and spatial isolation indices by maintaining the essential meaning of isolation in segregation studies (i.e., the extent of group members’ exposure to the same group).

Keywords

Exposure dimension; Residential segregation; Population size; Upper-bound; Aspatial indices; Spatial indices

1. Introduction

Residential segregation has been a topic of interest to social scientists in the United States (US) and other developed countries (Lloyd et al., 2014; Musterd, 2020; Schwanen & van Kempen, 2019; Skifter Andersen, 2019). While various segregation indices have been developed by different researchers (Yao et al., 2019), the P^* index, which was initially developed by Shevky and Williams (1949), modified by Bell (1954), and popularized by Lieberson (1981), has been widely regarded as the only index capable of capturing the exposure dimension of residential segregation (Brown & Chung, 2006; Johnston et al., 2007; Massey & Denton, 1988; Massey et al., 1996; Reardon & O'Sullivan, 2004). By and large, the P^* index has been referred to as the “isolation” index in segregation studies because it isolates (more generally, separates) the distributional pattern of a particular group from other mutually exclusive groups.

Using census tracts as the basic unit of calculation in a given study area of the US (e.g., demarcated by a city boundary, a county boundary, two or more contiguous county boundaries, or a state boundary), the degree of residential isolation by a particular group has been quantified as

$$P^* = \sum_{i=1}^n \left[\frac{g_i}{G} \times \frac{g_i}{t_i} \right] \quad (\text{Equation 1})$$

where g_i and t_i refer to the population count of a particular group and a total population (i.e., all mutually exclusive groups) in census tract i ($i = 1, 2, 3, \dots, n$), respectively, G refers to the overall population count of a particular group in an entire study area (i.e., $G = \sum_{i=1}^n g_i$), and $\sum_{i=1}^n []$ refers to the aggregation of n number of values into a single value. Since the P^* index is a global index that summarizes the degree of residential isolation by a particular group within a study area, its local index (denoted here as P_i^*) can be formulated as

$$P_i^* = \frac{g_i}{G} \times \frac{g_i}{t_i} \quad (\text{Equation 2})$$

where the notations are the same as Equation 1. By removing the aggregation process of $\sum_{i=1}^n []$, therefore, the P_i^* index quantifies the degree of residential isolation by a particular group across census tracts in a study area.

As a technical note on the structural components of Equations 1 and 2, the term “ g_i/G ” corresponds to the relative frequency of a particular group across census tracts within a study area and the term “ g_i/t_i ” corresponds to the proportion of a particular group across census tracts in a study area. By multiplying these two components, the P^* index summarizes the extent of group members’ exposure to (or potential contact with) the same group within a study area, whereas the P_i^* index quantifies the extent of group members’ exposure to (or potential contact with) the same group for each census tracts in a study area. With a possibility of their minimum value being zero (0) and their maximum value being one (1), values derived from these indices are anchored at the theoretical range between zero and one (0-1), regardless of the numbers of mutually exclusive groups and census tracts under study. While the P^* index summarizes the overall pattern of residential isolation and the P_i^* index describes how each census tract contributes to that overall pattern, both indices capture the exposure dimension of residential segregation: the higher the derived value, the greater the exposure, and the lower the derived value, the lesser the exposure.

While the P^* index (and thus the P_i^* index) has been conceived to possess useful mathematical properties by Morrill (1991) and Reardon and O’Sullivan (2004), the effectiveness of segregation indices lies not only in its mathematical properties, but also in its ability to be sensitive to the spatial arrangement of population distributions (Wong, 2016). Otherwise, segregation indices would obscure the essence of geography (Tobler, 1999): “the phenomenon external to an area of interest affects what goes on in the inside” (p. 87). In other words, the P^* index and the P_i^* index are aspatial (not “non-spatial”) in nature that overlook the importance of spatial relationships between census tracts. From a conceptual and methodological perspective, all aspatial segregation indices assume that people’s exposure to (or potential contact with) their neighbors take place only within the confined boundary of each census tract. With reference to a scoping review of activity space research (Perchoux et al., 2013), however, such an assumption would be inappropriate because physical spaces where people engage in daily activities typically extend beyond their census tract of residence into one or more adjacent census tracts (Basta et al., 2010; Jones & Pebley, 2014; Zenk et al., 2011). Particularly for people living near or at the edge of a census tract, they tend to cross a

street or a road into adjacent census tracts for household-, recreational-, social-, and travel-related activities (collectively, routine activities) on a daily basis.

To address the aspatial nature of the P^* index and the P_i^* index, Oka and Wong (2019) formulated their spatial version, which they referred to as the SI index and the SI_i index, respectively, based on the concept of composite population count developed by Wong (1998) (see Wong (2002, 2008) for a family of spatial segregation indices formulated using this concept). In brief, Wong (1998) developed the c_{ij} function to remove census tract boundaries as the absolute barriers for activity spaces (or routine activities). Building upon the basic concepts of modeling spatial autocorrelation (Anselin, 1995; Getis & Ord, 1992), the c_{ij} function is a spatial binary matrix where $c_{ij} = 1$ indicates census tract i and j are adjacent to one another (i.e., share a common boundary), which corresponds to the first-order adjacency of census tracts, and $c_{ij} = 0$ otherwise. Unlike common spatial weight matrices used in spatial autocorrelation studies, however, i can be equal to j and thus $c_{ii} = 1$ (i.e., c_{ii} is a reference unit).

Based on the c_{ij} function, for example, the composite population count of a particular group and a total population (i.e., all mutually exclusive groups) in census tract i (cg_i and ct_i , respectively) is calculated as

$$cg_i = \sum_j c_{ij} g_j \quad (\text{Equation 3})$$

$$ct_i = \sum_j c_{ij} t_j \quad (\text{Equation 4})$$

where g_j and t_j refer to the population count of a particular group and a total population in census tract j (with respect to a square matrix of i rows and j columns), respectively. In other words, the composite population count of a particular group in census tract i (cg_i) refers to the population count of a particular group in census tract i plus the population count of a particular group in one or more adjacent census tracts j . By the same token, the composite population count of a total population in census tract i (ct_i) refers to the population count of a total population in census tract i plus the population count of a total population in one or more adjacent census tract j . Closely reflecting the extent of activity spaces (or routine activities) demonstrated in different geographic areas of the US (Basta et al., 2010; Jones & Pebley, 2014; Zenk et al., 2011), therefore, the c_{ij} function provides a more realistic portrayal of people's daily experiences in their neighborhood of residence for the measurement of residential segregation.

Similar to how Wong (2002, 2008) spatialized traditionally aspatial segregation indices for capturing the evenness dimension of residential segregation, Oka and Wong (2019) formulated the SI index and the SI_i index as

$$SI = \sum_{i=1}^n \left[\frac{cg_i}{G} \times \frac{cg_i}{ct_i} \right] \quad (\text{Equation 5})$$

$$SI_i = \frac{cg_i}{G} \times \frac{cg_i}{ct_i} \quad (\text{Equation 6})$$

where the notations are the same as those in Equations 1-4. Therefore, whether aspatial or spatial, a set of isolation indices comprises two components attributed to the same group: the relative frequency of a particular group across census tracts within a study area and the proportion of that group across census tracts in a study area. Equally importantly, the SI index summarizes the extent of group members' exposure to (or potential contact with) the same group within a study area, whereas the SI_i index quantifies the extent of group members' exposure to (or potential contact with) the same group for each census tracts in a study area.

By maintaining the same mathematical property of the P^* index and the P_i^* index described above, the SI index and the SI_i index hold the possibility of their minimum value being zero (0). However, the maximum value of the SI index can be greater than one (1), whereas the maximum value of the SI_i index remains anchored at the theoretical value of one (1). While the SI index summarizes the overall pattern of residential isolation and the SI_i index describes how each census tract contributes to that overall pattern, both indices capture the exposure dimension of residential segregation: the higher the derived value, the greater the exposure, and the lower the derived value, the lesser the exposure.

From a measurement perspective, the term “ g_i/G ” in Equations 1 and 2 or the term “ cg_i/G ” in Equations 5 and 6 is of particular importance because the population size of census tracts typically ranges between 1,200 and 8,000 people (with an optimum size of 4,000 people) (United States Census Bureau, 2026f) but ranges much greater in reality (Oka, 2023). For example, the proportion of a particular group in one census tract (e.g., $1,500 / 3,000 = 0.50$) and in another census tract (e.g., $2,500 / 5,000 = 0.50$) may be the same. However, the degree of that group’s exposure to (or potential contact with) the same group in the former census tract (e.g., $0.50 \times [1,500 / 1,000,000] = 0.00075$) and in the latter census tract (e.g., $0.50 \times [2,500 / 1,000,000] = 0.00125$) can be quite different from each other (e.g., a 0.60- or 1.67-fold difference). Since census tracts are not uniform in size or shape (United States Census Bureau, 2026f), the relative frequency of a particular group within a study area adjusts for the compositional differences of census tracts (Oka, 2023).

Despite the usefulness of these isolation indices, values derived from the P^* index and the SI index as well as those derived from the P_i^* index and the SI_i index are not directly comparable in magnitude because aspatial and spatial indices (global and local indices alike) are not on the same scale. More concerning, the population size of two or more mutually exclusive groups would differ from one another and thus the degree of residential isolation by such groups of different sizes would not be comparable to each other. In order to better understand the severity of such analytical implications in the measurement of residential isolation, the purpose of this study was to assess how aspatial and spatial indices would be affected by population size. To this end, the State of California was used as the study area and population estimates by race and ethnicity were considered at three time periods. For analytical clarity, a sequence of non-graphical and graphical techniques was used to compare global and local indices and to understand whether a temporal change in the racial and ethnic makeup of California would also affect the measurement of residential isolation by race and ethnicity. While aspatial and spatial indices were considered in this study, the performance of global and local indices was assessed for each index to understand their susceptibility to population size (i.e., comparing values derived from the same index, not comparing values derived from aspatial and spatial indices).

2. Methods

2.1 Study Area

The State of California is located on the west coast of the US and is bordered by the Pacific Ocean in the west, the State of Oregon in the north, the State of Nevada and Arizona in the east, and the United Mexican States in the south. Encompassing a land area of approximately 403,553 km² (United States Census Bureau, 2026b), California has been the most populous state (United States Census Bureau, 2026c) and the second most racially and ethnically diverse state (trailing behind the State of Hawaii) during the past two decades (United States Census Bureau, 2021b).

2.2 Population Estimates

Census-tract-level population estimates by race and ethnicity for 2000, 2010, and 2020 were obtained from the US Census Bureau's website (United States Census Bureau, 2026c). Following the guidelines provided by the US Office of Management and Budget, racial and ethnic categories included in the census questionnaire reflect a social construct of race and ethnicity and do not reflect any anthropological, biological, or genetic aspect of respondents (United States Census Bureau, 2026d, 2026e). By separating the concepts of race from that of ethnicity, eight self-identified categories in the census questionnaire were treated as eight mutually exclusive groups: non-Hispanic White, non-Hispanic Black, Hispanic or Latino, Asian, American Indian or Alaska Native, Native Hawaiian or Other Pacific Islander, Some Other Race, and Two or More Races.

To provide a grasp on the difference in population size among racial and ethnic groups, their overall population count and their overall percentage at three time periods are shown in Table 1. Since census tracts have been updated every ten years to reflect the population change of local areas (e.g., a census tract may be split into two to account for population growth or census tracts may be merged into one to compensate for population decline), the number of census tracts was 7,036 in 2000, 8,004 in 2010, and 9,081 in 2020. Note that census tracts with no population were excluded in this study.

2.3 Computing Composite Population Counts

For implementing the c_{ij} function (Wong, 1998) in the SI index and the SI_i index (Oka & Wong, 2019) (Equations 5 and 6, respectively), the 2000, 2010, and 2020 cartographic boundary shapefiles of census tracts were obtained from the US Census Bureau's website (2026a). To improve the spatial configuration of these three cartographic boundary shapefiles, which include or extend into rivers, streams, lakes and ponds, such bodies of water were removed from the original shapefiles using the Erase tool in ArcGIS Pro (ESRI Inc., Redlands, CA, USA). The shapefile of bodies of water was obtained from the Data & Maps Collection for ArcGIS on DVD and all shapefiles were projected using the NAD 1983, State Plane Coordinate System during these processes. By removing bodies of water, therefore, three modified cartographic boundary shapefiles provide a more realistic depiction of the spatial relationship between census tracts.

When computing composite population counts in Equations 5 and 6, the boundary value problem (Griffith, 1983), often referred to as the border or edge effect in geospatial analysis, has been known to arise from an inadequate specification of spatial relationships between census tracts. In the context of this study, this problem would under-estimate the composite population count of racial and ethnic groups as well as their total population in census tracts along the border or edge of California. For handling such a computational bias, Oka and Wong (2019) recommended including census tracts surrounding a study area and using them to create a buffer zone to prevent the misspecification of spatial relationships between census tracts along the border or edge of a study area. This simple, yet effective way of handling the boundary value problem (Griffith & Amrhein, 1983) is justifiable because the c_{ij} function (Wong, 1998) corresponds to the first-order adjacency of census tracts. Following Oka and Wong's (2019) recommendation, therefore, census tracts along the border or edge of Arizona, Nevada, and Oregon that share a common boundary with census tracts in California (after removing bodies of water from the shapefiles as described above) were included for the computation of composite population counts. After computing all necessary composite

population counts, only census tracts within the State of California (i.e., omitting those in the buffer zone) were considered for the SI index and the SI_i index.

2.4 Data Analysis

In conjunction with algebraic and matrix operations, a combination of functions in the *spdep* package (Bivand, 2023) of R (R Foundation for Statistical Computing, Vienna, Austria) was used for implementing the c_{ij} function (Wong, 1998) into the modified 2000, 2010, and 2020 cartographic boundary shapefiles (after removing bodies of water) for computing the composite population count of racial and ethnic groups as well as their total population. Otherwise, basic algebraic operations were used for the calculation of residential isolation by race and ethnicity based on the P^* index and the SI index (Equations 1 and 5, respectively) or the P_i^* index and the SI_i index (Equations 2 and 6, respectively). For comparing aspatial and spatial global indices at three time periods, aspatial and spatial measures of state-level residential isolation by race and ethnicity are shown in Table 2. To provide a grasp on the difference between aspatial and spatial local indices at three time periods, descriptive statistics of aspatial and spatial measures of census-tract-level residential isolation by race and ethnicity are shown in Tables 3-5 and their relationship with Pearson's correlation coefficient (r) are shown in Figures 1-3. While manual adjustments were applied to improve readability, a combination of basic commands and functions in R was used for creating these tables and figures.

As an interpretation note, values derived from the P^* index, the P_i^* index, and the SI_i index are bounded between zero and one (0-1). However, values derived from the SI index can be greater than one, depending on the distributional pattern of mutually exclusive groups under study. Equally importantly, because aspatial and spatial indices are not on the same scale, values derived from the SI index and the SI_i index are not directly comparable in magnitude to those derived from the P^* index and the P_i^* index, respectively. Therefore, any comparison between the degree of residential isolation by race and ethnicity in Tables 2-5 and Figures 1-3 must be based on the same index.

3. Results

Table 1 shows the steady population growth in California during the first two decades of the twenty-first century. Its total population increased from about 33.9 million in 2000 to about 36.4 million in 2010 and then to about 39.3 million in 2020. As noted above, the number of census tracts increased from 7,036 in 2000 to 8,004 in 2010 and then to 9,081 in 2020 in relation to the steady population growth in California.

Table 1. Description of racial and ethnic groups in the State of California at three time periods

	2000	2010	2020
Overall Population Count			
Total Population	33,871,648	36,637,290	39,346,023
Non-Hispanic White	15,771,163	15,107,042	14,365,145
Non-Hispanic Black	2,147,885	2,163,955	2,142,371
Hispanic or Latino	10,969,132	13,456,157	15,380,929
Asian	3,642,542	4,683,828	5,743,983
American Indian or Alaska Native	181,167	153,430	131,724
Native Hawaiian or Other Pacific Islander	103,712	131,505	135,524

	2000	2010	2020
Some Other Race	68,040	109,184	124,148
Two or More Races	988,007	832,189	1,322,199
Overall Percentage			
Total Population	100.00	100.00	100.00
Non-Hispanic White	46.56	41.23	36.51
Non-Hispanic Black	6.34	5.91	5.44
Hispanic or Latino	32.38	36.73	39.09
Asian	10.75	12.78	14.60
American Indian or Alaska Native	0.53	0.42	0.33
Native Hawaiian or Other Pacific Islander	0.31	0.36	0.34
Some Other Race	0.20	0.30	0.32
Two or More Races	2.92	2.27	3.36

Despite the overall population increase of about 5.5 million in California, the overall population count of non-Hispanic White residents decreased from about 15.8 million in 2000 to about 15.1 million in 2010 and then to about 14.4 million in 2020 and the overall population count of non-Hispanic Black residents remained fairly the same: about 2.1 million in 2000, about 2.2 million in 2010, and about 2.1 million in 2020. On the other hand, the overall population count of Hispanic or Latino residents increased from about 11.0 million in 2000 to about 13.5 million in 2010 and then to about 15.4 million in 2020 and the overall population count of Asian residents increased from about 3.6 million in 2000 to about 4.7 million in 2010 and then to about 5.7 million in 2020. In addition to these four major racial and ethnic groups, the overall population count of American Indian or Alaska Native residents decreased slightly from about 181 thousand in 2000 to about 153 thousand in 2010 and then to 132 thousand in 2020 and the overall population count of Native Hawaiian or Other Pacific Islander residents increased slightly from about 104 thousand in 2000 to about 132 thousand in 2010 and then to about 136 thousand in 2020. With regard to the remaining two groups, the overall population count of residents who identified themselves as “some other race” increased from about 68 thousand in 2000 to about 109 thousand in 2010 and then to about 124 thousand in 2020, whereas those who identified themselves as “two or more races” decreased from about 988 thousand in 2000 to about 832 thousand in 2010, but increased to about 1.3 million in 2020.

With a temporal change in the overall population count of each racial and ethnic group, non-Hispanic White residents were the largest racial or ethnic group in 2000 and 2010 (representing 46.56 percent and 41.23 percent of the total population, respectively) but became the second largest racial or ethnic group in 2020 (representing 36.51 percent of the total population). In contrast, Hispanic or Latino residents were the second largest racial or ethnic group in 2000 and 2010 (representing 32.38 percent and 36.73 percent of the total population, respectively) but became the largest racial or ethnic group in 2020 (representing 39.09 percent of the total population). However, Asian residents were the third largest racial or ethnic group in 2000, 2010, and 2020 (representing 10.75 percent, 12.78 percent, and 14.60 percent of the total population, respectively) and non-Hispanic Black residents were the fourth largest racial or ethnic group in 2000, 2010, and 2020 (representing 6.34 percent, 5.91 percent, and 5.44 percent of the total population, respectively). Otherwise, American Indian or Alaska Native residents and Native Hawaiian or Other Pacific Islander residents

represented less than one percent of the total population between 2000 and 2020. While the overall population count of residents who identified themselves as “some other race” and “two or more races” increased, they represented less than one percent and about three percent of the total population between 2000 and 2020, respectively.

Mostly reflecting the increasing or decreasing trend of each racial and ethnic group in Table 1, Table 2 shows that the degree of residential isolation by race and ethnicity based on the P^* index increased or decreased between 2000 and 2020. In relation to the decreasing overall population count of non-Hispanic White residents (Table 1), state-level non-Hispanic White isolation decreased from 0.63205 in 2000 to 0.58629 in 2010 and then to 0.53501 in 2020. While the overall population count of non-Hispanic Black residents increased slightly in 2010 (Table 1), state-level non-Hispanic Black isolation decreased from 0.25051 in 2000 to 0.21481 in 2010 and then to 0.17842 in 2020. Corresponding to the increasing overall population count of Hispanic or Latino residents and Asian residents (Table 1), state-level Hispanic or Latino isolation increased from 0.52805 in 2000 to 0.55611 in 2010 and then to 0.56898 in 2020 and state-level Asian isolation increased from 0.26508 in 2000 to 0.30203 in 2010 and then to 0.33087 in 2020. Contrary to the decreasing overall population count of American Indian or Alaska Native residents (Table 1), state-level American Indian or Alaska Native isolation increased from 0.03416 in 2000 to 0.04205 in 2010 and then to 0.05099 in 2020. For Native Hawaiian or Other Pacific Islander residents, its overall population count increased between 2000 and 2020, but state-level Native Hawaiian or Other Pacific Islander isolation increased from 0.01928 in 2000 to 0.03536 in 2010 and decreased slightly to 0.03356 in 2020. Otherwise, mirroring the increasing overall population count of residents who identified themselves as “some other race” and the decreasing and increasing number of residents who identified themselves as “two or more races” between 2000 and 2020, state-level Some Other Race isolation increased from 0.00755 in 2000 to 0.01912 in 2010 and then to 0.02764 in 2020 and state-level Two or More Races isolation decreased from 0.04040 in 2000 to 0.03871 in 2010 and increased to 0.05771 in 2020.

When using the SI index, Table 2 shows that temporal changes in the degree of residential isolation by race and ethnicity followed the same trend as those based on the P^* index: state-level non-Hispanic White isolation decreased from 4.35332 in 2000 to 4.02614 in 2010 and then to 3.65598 in 2020; state-level non-Hispanic Black isolation decreased from 1.53903 in 2000 to 1.27920 in 2010 and then to 1.04948 in 2020; state-level Hispanic or Latino isolation increased from 3.47015 in 2000 to 3.72062 in 2010 and then to 3.86566 in 2020; state-level Asian isolation increased from 1.71123 in 2000 to 1.97128 in 2010 and then to 2.19868 in 2020; state-level American Indian or Alaska Native isolation increased from 0.09657 in 2000 to 0.10648 in 2010 and then to 0.11912 in 2020; state-level Native Hawaiian or Other Pacific Islander isolation increased from 0.06243 in 2000 to 0.08622 in 2010 and decreased to 0.08444 in 2020; state-level Some Other Race isolation increased from 0.02128 in 2000 to 0.04594 in 2010 and then to 0.05320 in 2020; and state-level Two or More Races isolation decreased from 0.25718 in 2000 to 0.21235 in 2010 and increased to 0.31353 in 2020.

Table 2. Aspatial and spatial measures of state-level residential isolation by race and ethnicity in the State of California at three time periods

	2000	2010	2020
P^*			
Non-Hispanic White	0.63205	0.58629	0.53501
Non-Hispanic Black	0.25051	0.21481	0.17842
Hispanic or Latino	0.52805	0.55611	0.56898

	2000	2010	2020
Asian	0.26508	0.30203	0.33087
American Indian or Alaska Native	0.03416	0.04205	0.05099
Native Hawaiian or Other Pacific Islander	0.01928	0.03536	0.03356
Some Other Race	0.00755	0.01912	0.02764
Two or More Races	0.04040	0.03871	0.05771
<i>SI</i>			
Non-Hispanic White	4.35332	4.02614	3.65598
Non-Hispanic Black	1.53903	1.27920	1.04948
Hispanic or Latino	3.47015	3.72062	3.86566
Asian	1.71123	1.97128	2.19868
American Indian or Alaska Native	0.09657	0.10648	0.11912
Native Hawaiian or Other Pacific Islander	0.06243	0.08622	0.08444
Some Other Race	0.02128	0.04594	0.05320
Two or More Races	0.25718	0.21235	0.31353

Note: P^* and SI refer to aspatial and spatial global isolation indices shown in Equation 1 and 5, respectively. Also, values derived from the P^* index and the SI index are not directly comparable in magnitude because aspatial and spatial indices are not on the same scale.

While the P^* index and the SI index yielded the same trend of state-level residential isolation by race and ethnicity in Table 2, both global indices yielded greater degrees of state-level residential isolation for larger racial and ethnic groups or, conversely, lesser degrees of state-level residential isolation for smaller racial and ethnic groups. In simplest terms, for instance, the degree of non-Hispanic White isolation was highest in 2000 and 2010, but the degree of Hispanic or Latino isolation was highest in 2020, whereas the degree of Some Other Race isolation was consistently lowest between 2000 and 2020. Despite the difference in scale, therefore, both global indices suggest that racial and ethnic majority groups were more isolated (or, more generally, “segregated”) than their minority counterparts in the State of California at three different time periods.

With regard to the P_i^* index and the SI_i index, Tables 3-5 show that both local indices also suggest racial and ethnic majority groups to be more isolated (or, more generally, “segregated”) than their minority counterparts in the State of California at three different time periods. These are indicated by wider ranges of their frequency distributions. However, the maximum values of census-tract-level non-Hispanic White isolation were consistently lower than those of census-tract-level non-Hispanic Black isolation, Hispanic or Latino isolation, and Asian isolation. In addition, the maximum values of census-tract-level American Indian or Alaska Native isolation were consistently highest or second highest in spite of its skewed frequency distribution. Therefore, comparing census-tract-level residential isolation by race and ethnicity in Tables 3-5 are not as straightforward as comparing state-level residential isolation by race and ethnicity in Table 2.

Table 3. Five-number summary and mean of aspatial and spatial measures of census-tract-level residential isolation by race and ethnicity in the State of California based on the 2000 data

	Minimum	First Quartile	Median	Mean	Third Quartile	Maximum
P_i^*						
Non-Hispanic White	0.0000000	0.0000145	0.0000668	0.0000898	0.0001412	0.0007430
Non-Hispanic Black	0.0000000	0.0000001	0.0000012	0.0000356	0.0000080	0.0024453
Hispanic or Latino	0.0000000	0.0000039	0.0000191	0.0000751	0.0000945	0.0011682
Asian	0.0000000	0.0000006	0.0000041	0.0000377	0.0000217	0.0014375
AIAN	0.0000000	0.0000000	0.0000002	0.0000049	0.0000012	0.0095558
NHOPI	0.0000000	0.0000000	0.0000000	0.0000027	0.0000004	0.0008322
Some Other Race	0.0000000	0.0000000	0.0000000	0.0000011	0.0000005	0.0001369
Two or More Races	0.0000000	0.0000010	0.0000032	0.0000057	0.0000074	0.0001495
SI_i						
Non-Hispanic White	0.0000000	0.0001477	0.0005035	0.0006187	0.0009527	0.0037227
Non-Hispanic Black	0.0000000	0.0000025	0.0000135	0.0002187	0.0000787	0.0127880
Hispanic or Latino	0.0000002	0.0000465	0.0001882	0.0004932	0.0006463	0.0057026
Asian	0.0000000	0.0000081	0.0000404	0.0002432	0.0001990	0.0055062
AIAN	0.0000000	0.0000009	0.0000027	0.0000137	0.0000072	0.0073736
NHOPI	0.0000000	0.0000002	0.0000010	0.0000089	0.0000041	0.0013921
Some Other Race	0.0000000	0.0000004	0.0000015	0.0000030	0.0000040	0.0000570
Two or More Races	0.0000000	0.0000138	0.0000278	0.0000366	0.0000472	0.0006088

Note: P_i^* and SI_i refer to aspatial and spatial local isolation indices shown in Equation 2 and 6, respectively. Also, values derived from the P_i^* index and the SI_i index are not directly comparable in magnitude because aspatial and spatial indices are not on the same scale. Abbreviations: AIAN = American Indian or Alaska Native; NHOPI = Native Hawaiian or Other Pacific Islander.

Table 4. Five-number summary of aspatial and spatial measures of census-tract-level residential isolation by race and ethnicity in the State of California based on the 2010 data

	Minimum	First Quartile	Median	Mean	Third Quartile	Maximum
P_i^*						
Non-Hispanic White	0.0000000	0.0000088	0.0000493	0.0000732	0.0001172	0.0008534
Non-Hispanic Black	0.0000000	0.0000001	0.0000011	0.0000268	0.0000093	0.0019754
Hispanic or Latino	0.0000000	0.0000051	0.0000257	0.0000695	0.0000990	0.0008396
Asian	0.0000000	0.0000006	0.0000048	0.0000377	0.0000236	0.0011339
AIAN	0.0000000	0.0000000	0.0000000	0.0000053	0.0000006	0.0093743
NHOPI	0.0000000	0.0000000	0.0000000	0.0000044	0.0000001	0.0011544
Some Other Race	0.0000000	0.0000000	0.0000000	0.0000024	0.0000004	0.0008004
Two or More Races	0.0000000	0.0000003	0.0000018	0.0000048	0.0000058	0.0001663
SI_i						
Non-Hispanic White	0.0000000	0.0000911	0.0003750	0.0005030	0.0007910	0.0038344
Non-Hispanic Black	0.0000000	0.0000028	0.0000138	0.0001598	0.0000711	0.0115570
Hispanic or Latino	0.0000003	0.0000579	0.0002230	0.0004648	0.0006643	0.0045410
Asian	0.0000000	0.0000100	0.0000464	0.0002463	0.0001970	0.0066796

	Minimum	First Quartile	Median	Mean	Third Quartile	Maximum
AIAN	0.0000000	0.0000002	0.0000013	0.0000133	0.0000052	0.0079467
NHOPI	0.0000000	0.0000000	0.0000006	0.0000108	0.0000043	0.0015951
Some Other Race	0.0000000	0.0000002	0.0000015	0.0000057	0.0000051	0.0008675
Two or More Races	0.0000000	0.0000070	0.0000183	0.0000265	0.0000375	0.0002336

Note: P_i^* and SI_i refer to aspatial and spatial local isolation indices shown in Equation 2 and 6, respectively. Also, values derived from the P_i^* index and the SI_i index are not directly comparable in magnitude because aspatial and spatial indices are not on the same scale. Abbreviations: AIAN = American Indian or Alaska Native; NHOPI = Native Hawaiian or Other Pacific Islander.

Table 5. Five-number summary of aspatial and spatial measures of census-tract-level residential isolation by race and ethnicity in the State of California based on the 2020 data

	Minimum	First Quartile	Median	Mean	Third Quartile	Maximum
P_i^*						
Non-Hispanic White	0.0000000	0.0000064	0.0000365	0.0000589	0.0000936	0.0008515
Non-Hispanic Black	0.0000000	0.0000001	0.0000011	0.0000196	0.0000085	0.0019044
Hispanic or Latino	0.0000000	0.0000058	0.0000257	0.0000627	0.0000944	0.0005614
Asian	0.0000000	0.0000005	0.0000047	0.0000364	0.0000256	0.0013041
AIAN	0.0000000	0.0000000	0.0000000	0.0000056	0.0000003	0.0128657
NHOPI	0.0000000	0.0000000	0.0000000	0.0000037	0.0000001	0.0011242
Some Other Race	0.0000000	0.0000000	0.0000000	0.0000030	0.0000003	0.0011404
Two or More Races	0.0000000	0.0000004	0.0000023	0.0000064	0.0000074	0.0003904
SI_i						
Non-Hispanic White	0.0000000	0.0000679	0.0002776	0.0004026	0.0006315	0.0033001
Non-Hispanic Black	0.0000000	0.0000031	0.0000140	0.0001156	0.0000638	0.0081798
Hispanic or Latino	0.0000000	0.0000592	0.0002200	0.0004257	0.0006342	0.0038173
Asian	0.0000000	0.0000079	0.0000451	0.0002421	0.0001911	0.0062799
AIAN	0.0000000	0.0000001	0.0000009	0.0000131	0.0000037	0.0106785
NHOPI	0.0000000	0.0000000	0.0000005	0.0000093	0.0000039	0.0012233
Some Other Race	0.0000000	0.0000002	0.0000012	0.0000059	0.0000045	0.0007803
Two or More Races	0.0000000	0.0000088	0.0000241	0.0000345	0.0000489	0.0003131

Note: P_i^* and SI_i refer to aspatial and spatial local isolation indices shown in Equation 2 and 6, respectively. Also, values derived from the P_i^* index and the SI_i index are not directly comparable in magnitude because aspatial and spatial indices are not on the same scale. Abbreviations: AIAN = American Indian or Alaska Native; NHOPI = Native Hawaiian or Other Pacific Islander.

When visualizing the relationships between local indices, Figures 1-3 show that the P_i^* index and the SI_i index captured similar distributional patterns of census-tract-level non-Hispanic White isolation (Figures 1a, 2a, and 3a), census-tract-level non-Hispanic Black isolation (Figures 1b, 2b, and 3b), census-tract-level Hispanic or Latino isolation (Figures 1c, 2c, and 3c), and census-tract-level Asian isolation (Figures 1d, 2d, and 3d) as indicated by strong positive correlations with some degree of dispersion. However, the P_i^* index and the SI_i index captured slightly different distributional patterns of census-tract-level American Indian or Alaska Native isolation (Figures 1e, 2e, and 3e), census-tract-level Native Hawaiian or Other Pacific Islander isolation (Figures 1f, 2f, and 3f), census-tract-level Some Other Race isolation (Figures 1g, 2g, and 3g), and census-tract-level Two or More Races isolation

(Figures 1h, 2h, and 3h) as indicated by weak or modest positive correlations with noticeably high dispersion. Note that Pearson's correlation coefficients in Figures 1e, 2e, and 3e were affected by the presence of an outlier but removing this outlier yielded a very similar relationship as Figures 1f, 2f, and 3f at each respective time period (data not shown). Compared to the P_i^* index, therefore, the SI_i index (or, more specifically, the c_{ij} function) was more sensitive to the spatial arrangement of racial and ethnic minority groups than their majority counterparts.

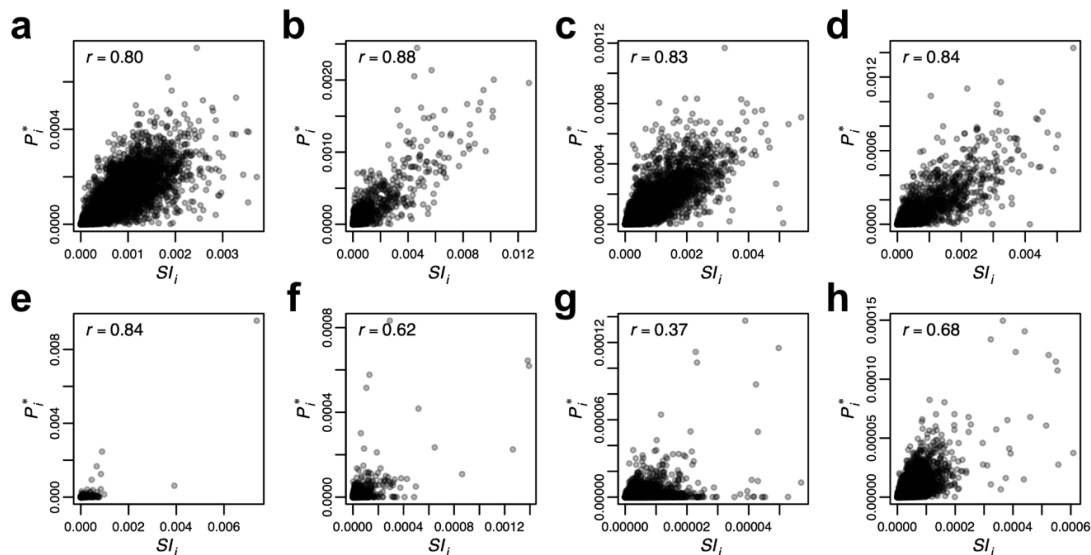


Figure 1. Relationship between aspatial and spatial measures of census-tract-level residential isolation by race and ethnicity in the State of California based on the 2000 data. (a) Non-Hispanic White; (b) Non-Hispanic Black; (c) Hispanic or Latino; (d) Asian; (e) American Indian or Alaska Native; (f) Native Hawaiian or Other Pacific Islander; (g) Some Other Race; and (h) Two or More Races. In these scatterplots, P_i^* and SI_i refer to aspatial and spatial local isolation indices shown in Equation 2 and 6, respectively.

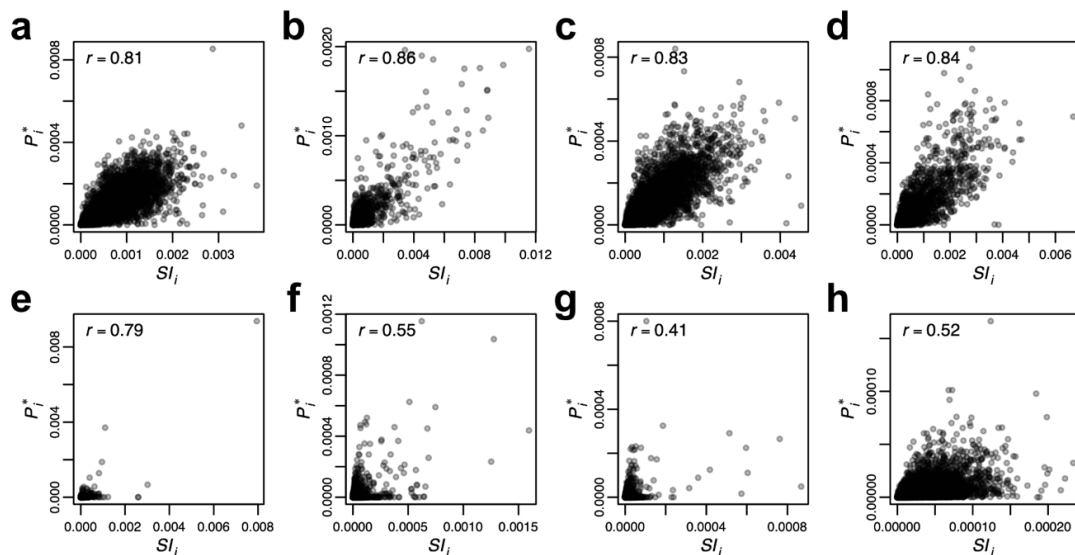


Figure 2. Relationship between aspatial and spatial measures of census-tract-level residential isolation by race and ethnicity in the State of California based on the 2010 data. (a) Non-Hispanic White; (b) Non-Hispanic Black; (c) Hispanic or Latino; (d) Asian; (e) American Indian or Alaska Native; (f) Native Hawaiian or Other Pacific Islander; (g) Some Other Race; and (h) Two or More Races. In these scatterplots, P_i^* and SI_i refer to aspatial and spatial local isolation indices shown in Equation 2 and 6, respectively.

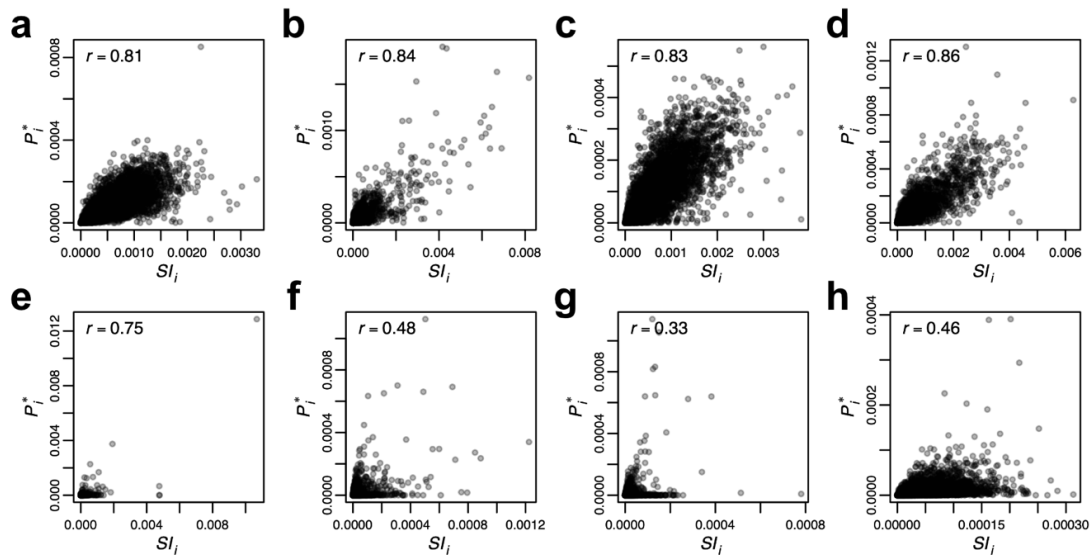


Figure 3. Relationship between aspatial and spatial measures of census-tract-level residential isolation by race and ethnicity in the State of California based on the 2020 data. (a) Non-Hispanic White; (b) Non-Hispanic Black; (c) Hispanic or Latino; (d) Asian; (e) American Indian or Alaska Native; (f) Native Hawaiian or Other Pacific Islander; (g) Some Other Race; and (h) Two or More Races. In these scatterplots, P_i^* and SI_i refer to aspatial and spatial local isolation indices shown in Equation 2 and 6, respectively.

4. Discussion

The results of state-level residential isolation by race and ethnicity in Table 2 suggest that racial and ethnic majority groups were more isolated (or, more generally, “segregated”) than their minority counterparts in the State of California at three different time periods. However, these results assert the opposite intensities and trends of residential segregation by race and ethnicity (or contradict with the conventional wisdom of residential segregation). Particularly in the US, racial and ethnic minority groups have been known to be more isolated (or, more generally, “segregated”) than their majority counterparts due to a consequence of benign market forces (e.g., incomes, preferences, and job locations) and illegal discriminatory forces (e.g., restrictive covenants by state-regulated agencies and discriminatory acts by realtors and financial institutions) (Clark, 1988; Galster, 1988; Rothstein, 2017). Since segregation indices have been known to be susceptible to differences in population size (Krupka, 2007), which may be heightened or lessened by the size of human settlements, the P^* index and the SI index would be subject to the same source of measurement bias.

As shown in Equations 1 and 5, the P^* index and the SI index summarize the product of relative frequency and proportion across census tracts. Whether aspatial or spatial in nature, both global indices would be susceptible to differences in population size because a majority group or majority groups would inevitably “fill up” more census tracts than their minority counterparts. In the simplest of terms, for instance, census tracts are designed to contain an optimum size of 4,000 people (United States Census Bureau, 2026f) and thus quite a large number of census tracts would be necessary for containing 15.0 million people than 13.3 million people (i.e., the three-time-period average of non-Hispanic White and Hispanic or Latino populations in Table 1, respectively) and for containing 4.7 million people than 2.2 million people (i.e., the three-time-period average of Asian and non-Hispanic Black populations in Table 1, respectively). Even between 155,440 and 123,580 people (i.e., the three-time-period average of American Indian or Alaska Native and Native Hawaiian or Other Pacific Islander populations in Table 1, respectively), a difference of few census tracts would lead to a greater or lesser degree of state-level residential isolation between the two groups.

Given the natural tendency of larger overall population counts to occupy more census tracts, therefore, the degree of residential isolation by race and ethnicity based on the P^* index and the SI index would be greater for racial and ethnic majority groups than their minority counterparts.

To handle the difference in population size among racial and ethnic groups (or, more generally, two or more mutually exclusive groups), a family of P^* -type indices (James, 1986; Lieberman & Carter, 1982) has been proposed during the 1970s and 1980s to take into account for the space- and time-varying nature of compositional effects in its measurement. However, these P^* -type indices are not only aspatial in nature but were formulated for capturing the interaction aspect of exposure (not the isolation aspect of exposure). Using the basic formulae provided on US Census Bureau's website (United States Census Bureau, 2021a), which summarized the review article of Massey and Denton (1988), for example, the isolation of a majority group (${}_xP_x^*$) and a minority group (${}_yP_y^*$) as well as the interaction between majority and minority groups (${}_xP_y^*$) and between minority and majority groups (${}_yP_x^*$) are defined as

$${}_xP_x^* = \sum_{i=1}^n \left[\frac{x_i}{X} \times \frac{x_i}{t_i} \right] \quad (\text{Equation 7})$$

$${}_yP_y^* = \sum_{i=1}^n \left[\frac{y_i}{Y} \times \frac{y_i}{t_i} \right] \quad (\text{Equation 8})$$

$${}_xP_y^* = \sum_{i=1}^n \left[\frac{x_i}{X} \times \frac{y_i}{t_i} \right] \quad (\text{Equation 9})$$

$${}_yP_x^* = \sum_{i=1}^n \left[\frac{y_i}{Y} \times \frac{x_i}{t_i} \right] \quad (\text{Equation 10})$$

where x_i and y_i refer to the population count of majority group and minority group in census tract i ($i = 1, 2, 3, \dots, n$), respectively, X and Y refers to the overall population count of majority group and minority group in an entire study area (i.e., $X = \sum_{i=1}^n x_i$ and $Y = \sum_{i=1}^n y_i$), respectively, and the other notations are the same as those in Equation 1.

By definition, Equations 7 and 8 are same as Equation 1 and thus both ${}_xP_x^*$ and ${}_yP_y^*$ comprise two components attributed to the same group: the relative frequency of a majority group within a study area and the proportion of that group across census tracts in a study area (Equation 7); and the relative frequency of a minority group within a study area and the proportion of that group across census tracts in a study area (Equation 8). With regard to Equations 9 and 10, however, both ${}_xP_y^*$ and ${}_yP_x^*$ comprise two components attributed to different groups: the relative frequency of a majority group within a study area and the proportion of a minority group across census tracts in a study area (Equation 9); and the relative frequency of a minority group within a study area and the proportion of a majority group across census tracts in a study area (Equation 10). Instead of these formulae, a more appropriate way of quantifying the degree of interaction between majority and minority groups would be to formulate as ${}_xP_x^* \times {}_yP_y^* (\neq {}_xP_y^*)$ and between minority and majority groups would be to formulate as ${}_yP_y^* \times {}_xP_x^* (\neq {}_yP_x^*)$. Because of such inappropriate specifications in existing interaction indices (global and local indices alike), different modification approaches considered in the past (James, 1986; Lieberman & Carter, 1982) would not be applicable for addressing the susceptibility of the P^* index and the SI index to population size.

Even among different modification approaches considered in recent years (Alonso-Villar & del Río, 2010; del Río & Alonso-Villar, 2022; Mora & Ruiz-Castillo, 2011), these so-called generalized or standardized (or normalized) segregation indices have been formulated for capturing the evenness dimension of residential segregation. While such modified versions of

dissimilarity indices and of diversity indices may provide insights into modifying the P^* index and the SI index, generalized or standardized (or normalized) segregation indices (Alonso-Villar & del Río, 2010; del Río & Alonso-Villar, 2022; Mora & Ruiz-Castillo, 2011) assume that their maximum value is definable. As shown in Tables 3-5, however, the minimum value of the P_i^* index and the SI_i index sits at zero (0.0000000), which indicates the absence of each respective racial and ethnic group, but the maximum value of these local indices tends to vary by the population size of two or more mutually exclusive groups. For example, two census tracts of equal size may be exclusively occupied by majority and minority groups (i.e., the proportion of majority and minority groups in two census tracts is 1.00), but the degree of census-tract-level residential isolation in two census tracts would differ from each other (e.g., $1.00 \times [4,000 / 4,000,000] = 0.001$ and $1.00 \times [4,000 / 1,000,000] = 0.004$) depending on the overall population count of each group (i.e., the term “ G ” in Equations 2 and 6). Because of such indefinable maximum values of the P_i^* index and the SI_i index, different modification approaches considered in recent years (Alonso-Villar & del Río, 2010; del Río & Alonso-Villar, 2022; Mora & Ruiz-Castillo, 2011) would not be applicable for addressing the susceptibility of the P^* index and the SI index to population size.

While global and local indices have been developed and used in segregation studies for different purposes, the interpretability of segregation indices matters for gaining a grasp on what is being measured. As pointed above, the P^* index and the SI index as well as the P_i^* index and the SI_i index possess useful mathematical properties and thus provide a clear understanding on the intrinsic meaning of their formula. From a measurement perspective, however, the usefulness of segregation indices also rests on its ability to provide a meaningful comparison of its derived values not only within a given geographic area at a certain time period, but also across different geographic areas and over different time periods (Johnston et al., 2014). Therefore, further considerations are needed to address the interpretational limitations of local indices by maintaining the essential meaning of isolation in segregation studies (i.e., the extent of group members’ exposure to the same group). With reference to the basic ideas of different modification approaches considered by different researchers (Alonso-Villar & del Río, 2010; del Río & Alonso-Villar, 2022; James, 1986; Lieberson & Carter, 1982; Mora & Ruiz-Castillo, 2011), for example, adding a term “ $\times 1/G$ ” to take into account for differences in the overall population count of a particular group of interest and/or adding a term “ $\times 1/n$ ” to take into account for differences in the number of census tracts may be useful for the P^* index and the SI index, but adding either one or both terms would obscure the interpretation of values derived from the P_i^* index and the SI_i index. For this reason, exploring effective ways of addressing the susceptibility of the P_i^* index and the SI_i index to population size and the context-specific nature of their upper-bound may hold the key for a better understanding of residential isolation across space and over time.

As a supplementary note, Reardon and O’Sullivan (2004) and Feitosa et al. (2007) also developed a spatial version of the P^* index and the P_i^* index using a spatial density function (denoted here as sd_{ij}) and a spatial kernel function (denoted here as sk_{ij}), respectively. Unlike the c_{ij} function (Wong, 1998) incorporated into the SI index and the SI_i index by Oka and Wong (2019), the sd_{ij} function and the sk_{ij} function obtain information on the spatial relationship between census tracts based on a spatial distance between centroids (i.e., geometric centers) by which the population counts closer to a reference census tract are weighted more and those farther away are weighted less. From a conceptual and methodological perspective, spatial indices developed by Reardon and O’Sullivan (2004) and Feitosa et al. (2007) have been considered to more closely reflect the very essence of geography (Tobler, 1970): “everything is related to everything else, but near things are more

related than distant things” (p. 236). However, their indices also inherent the same interpretational limitations discussed above. Therefore, further considerations may focus on modifying spatial indices developed by Reardon and O'Sullivan (2004) and Feitosa et al. (2007), instead of the SI index and the SI_i index developed by Oka and Wong (2019).

As with all segregation indices, the results of this study (Tables 1-5 and Figures 1-3) would be affected by the survey design and methodology implemented by the US Census Bureau and changes in statistical quality standards over time (United States Census Bureau, 2023, 2024, 2025) and would be subject to the modifiable areal unit problem (MAUP) (Openshaw, 1984; Wong, 2004, 2009). To ensure the quality of population estimates, the US Census Bureau handles different types of sampling bias (e.g., selection bias, self-selection bias, non-response bias, and coverage bias) by incorporating sampling weights. While sampling weights have been known to improve the efficacy of survey data (Haziza & Beaumont, 2017; Pfeffermann, 1993; Solon et al., 2015), they do not eliminate sampling bias associated with census-tract-level population estimates by race and ethnicity used in this study. Even if the data had been collected from complete surveys (though unrealistic), census tract and state boundaries used in this study are demarcated artificially onto a geographic space and thus their spatial size, shape, and orientation are modifiable in nature. Coined by geographers during the 1970s, the MAUP has been known to arise when different ways of drawing a boundary yield different patterns in the data (i.e., the zone effect of the MAUP) and manifest itself through different ways of aggregating the same data (i.e., the scale effect of the MAUP). Because no solution has been found to enhance the quality of population estimates nor to address the MAUP, a curtain of uncertainty casts over the values derived from aspatial and spatial indices used in this study.

5. Conclusion

The P^* index (Bell, 1954; Lieberman, 1981; Shevky & Williams, 1949) has been widely regarded as the only index capable of capturing the exposure dimension of residential segregation (Brown & Chung, 2006; Johnston et al., 2007; Massey & Denton, 1988; Massey et al., 1996; Reardon & O'Sullivan, 2004). It has been commonly referred to as the “isolation” index in segregation studies because it isolates (more generally, separates) the distributional pattern of a particular group from other mutually exclusive groups. Since the P^* index (and thus the P_i^* index) has been conceived to possess useful mathematical properties (Morrill, 1991; Reardon & O'Sullivan, 2004), Oka and Wong (2019) developed its spatial version by incorporating the c_{ij} function (Wong, 1998) to more realistically portrayal people's daily experiences in their neighborhood of residence for the measurement of residential isolation. Whether aspatial or spatial in nature, local indices have been shown to take into account for the difference in population size across census tracts (Oka, 2023), which typically ranges between 1,200 and 8,000 people (United States Census Bureau, 2026f) but ranges much greater in reality (Oka, 2023). Therefore, the P^* index and the SI index would be useful for understanding the distributional pattern of residential isolation by a particular group within a given study area, whereas the P_i^* index and the SI_i index would be useful for understanding the distributional pattern of residential isolation by a particular group across census tracts in a given study area.

Despite the usefulness of these isolation indices, Table 2 shows that the P^* index and the SI index yielded greater degrees of state-level residential isolation for racial and ethnic majority groups than their minority counterparts. From an interpretational perspective, these in turn imply that racial and ethnic majority groups were more isolated (or, more generally,

“segregated”) than their minority counterparts. By comparing with the overall population count of racial and ethnic groups at three time periods in Table 1, however, both global indices appear to be susceptible to differences in population size. Regardless of the difficulty of comparisons, Table 3-5 collectively show that the P_i^* index and the SI_i index also yielded greater degrees of census-tract-level residential isolation for racial and ethnic majority groups than their minority counterparts (see also the x- and y-axes in Figures 1-3). In addition to such interpretational limitations, the context-specific nature of upper-bound on these global and local indices also undermine a straightforward understanding on the intensities and trends of residential isolation by race and ethnicity. For these reasons, both global and local indices in their current form hinder a meaningful comparison of its derived values not only within a given geographic area at a certain time period, but also across different geographic areas and over different time periods.

While different modification approaches have been considered for formulating so-called generalized or standardized (or normalized) segregation indices (Alonso-Villar & del Río, 2010; del Río & Alonso-Villar, 2022; James, 1986; Lieberman & Carter, 1982; Mora & Ruiz-Castillo, 2011), such techniques would not be applicable for addressing the interpretational limitations of the P^* index and the SI index as well as the P_i^* index and the SI_i index because most, if not all, of them would obscure the intrinsic meaning of their formula and their derived values. In other words, an inappropriate or ineffective modification to isolation indices would obscure a meaningful understanding of what is being measured. This is of particular importance because isolation has been conceived as a multi-contextual and multi-faceted phenomenon in stratified societies (Oka & Wong, 2019). Therefore, further considerations are needed to address the interpretational limitations of global and local indices by maintaining the essential meaning of isolation in segregation studies (i.e., the extent of group members’ exposure to the same group). Since the P^* index and the P_i^* index have been used in organizational settings (e.g., schools and workplaces) (Reardon, 2017), exploring effective ways of improving the interpretability of isolation indices may provide an avenue for gaining a better grasp on the patterns, trends, and consequences of organizational isolation and residential isolation across space and over time.

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Conflicts of Interest

The author(s) declare no conflicts of interest regarding the publication of this paper.

Ethics Statement

Not applicable.

Data Availability

The datasets analyzed in this study are publicly available from the United States Census Bureau at <https://www.census.gov/data.html>.

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