Population Research and Policy Review **19:** 505–524, 2000.

The components of density and the dimensions of residential segregation

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Abstract. The purposes of this research are to examine the relationships between density and residential segregation and to propose a technique for the more precise measurement of social density. Using data from the 1990 US Census for the fifty eight largest metropolitan areas in the United States, we explore the applicability of measuring social density by examining how the dimensions of segregation are related to the components of race-specific and non-race-specific density. Findings suggest that density is an important part of our understanding of the processes involved in the segregation of race/ethnic groups and further that the measurement of social density can make a significant contribution to research on the concentration of poverty, joblessness, and violence.

Keywords: concentration of poverty, density, residential segregation

Introduction

Recent interest in the concentration of poverty thesis (Massey 1986; Massey & Denton 1993; Massey & Eggers 1990; Massey et al. 1994; Wilson 1987) and on the concentration of other social phenomenon such as joblessness (Massey & Shibuya 1995; Wilson 1996) and violence (Massey 1996; Massey, Condran & Denton 1987), to name a few important themes, raises the questions of how best to measure concentration and how concentration is related to residential segregation. Concentration is generally operationalized as the percentage of individuals within some unit of analysis such as a census tract that are, for example, poor, jobless, or violent. However, a more precise measurement of concentration is needed for a more thorough understanding of how concentration is related to residential segregation.

Beginning the late 1950s and continuing throughout the 1970s, an important area of research in sociological literature focused on urban density and its effects on the population. The bulk of this literature examined predominantly black inner city neighborhoods in large metropolitan areas such as Chicago. Analyses of urban density established positive relationships between density and white suburbanization (Taeuber & Taeuber 1969), pathological behavior (Galle et al.1972), and racial and ethnic segregation (Duncan & Duncan

1957). During the late 1970s and continuing throughout the 1990s, research on urban density declined and research on residential segregation proliferated. Research on residential segregation focused on many of the same issues as research on population density such as suburbanization (Farley 1977; Massey & Denton 1993), neighborhood effects (Wilson 1987), violence (Massey 1996; Massey, Condran & Denton 1987), and the effects of segregation on different race and ethnic groups (Bickford & Massey 1991; Massey & Denton 1980; Meyers & Lee 1996). Though these two areas of research, density and segregation, deal with many of the same issues, no one, to our knowledge, has considered how the two are related conceptually or empirically.

The purposes of the present research are to examine the relationships between density and residential segregation and to propose a technique for more precise measurement of social density. We propose that understanding the empirical relationship between the dimensions of residential segregation (Massey & Denton 1988) and density as originally conceived in the Chicago area research by Caranahan et al. (1974), Duncan (1966), and Galle et al. (1972) is the basis for the notion of social density and its relationships to the dimensions of residential segregation. To achieve these aims we first discuss the importance of residential segregation and density and the measurement of both. We then consider the empirical relationships between segregation and density using measures of density that are race-specific. Lastly, we suggest a technique for the measurement of social density and discuss its applications for future research on social concentration.

Prior research

Residential segregation – consequences and importance

Massey & Denton (1993) outline the history of residential segregation in the United States beginning in the early 1900s with the migration of rural blacks from the southern to the northern states. The settlement patterns of these migratory blacks were centered around employment which for blacks was limited to unskilled industrial labor positions (Massey & Denton 1993). As a result of the large influx of black migrants, white northerners reacted with alarm and racial hostility, and violence ensued (Massey & Denton 1993). Beginning in the 1920s and continuing throughout the 1960s and early 1970s, racial hostility manifested itself in the form of restrictive covenants to prevent black persons from moving into white neighborhoods and in the form of redlining, the practice of undervaluing black and other minority inner city neighborhoods to direct the flow of minorities away from white suburbs (Massey & Denton 1993). During the 1970s, the process of urban renewal

further amplified residential segregation as black neighborhoods adjacent to white neighborhoods were demolished and displaced blacks were relocated, often to public housing projects.

Residential segregation is of major interest because it reflects social and economic isolation and because it concentrates poverty (Massey & Eggers 1990). The result of restrictive covenants, redlining, and urban renewal was the concentration of blacks primarily in inner city areas and whites primarily in the suburbs. Beginning in the 1970s, the causes and consequences of segregation became a matter of some debate. The main questions are whether deindustrialization in the 1970s and 1980s was the preeminent reason for economic deficit in the inner city which resulted in the concentration of poverty or whether the economic consequences of deindustrialization were primarily a result of existing patterns residential segregation. Wilson (1987) concludes that the concentration of poverty is due to the movement of middle class black persons out of the inner city, because of economic changes in the 1970s and 1980s such as deindustrialization. Since the publication of Wilson's (1987) work, several researchers have expanded upon and reevaluated his thesis. In particular, the work of Massey and his colleagues on residential segregation has figured most prominently and suggests other explanations for segregation and the concentration of poverty (Massey 1996; Massey & Denton 1993; Massey & Gross 1993; Massey & Eggers 1990). Massey & Denton (1993) acknowledge the economic changes that occurred during the 1970s and 1980s, but argue that without residential segregation the effects of deindustrialization would not have resulted in such extreme patterns of concentrated poverty.

The logical basis of Massey's theory of concentrated poverty is simple: if low socioeconomic status (SES) is characteristic of a spatially isolated group, poverty is concentrated by definition (Bickford & Massey 1991). In an analysis of social class and racial differences, Reynolds Farley (1977) found that a high SES white person is more likely to live in a neighborhood with a poor white person than with a high SES black person. If social class segregation and residential segregation are combined, the concentration of poverty and spatial isolation of blacks is the inevitable result (Massey & Denton 1993). The effects of concentrated poverty include social and economic isolation (Massey & Eggers 1990; Massey & Denton 1993; Wilson 1987), a rise in black female headed households due to a lack of marriageable men (Wilson 1987), joblessness (Massey & Shibuya 1995; Wilson 1996), and violence (Massey 1996; Massey, Condran & Denton 1987).

Measurement of residential segregation

Residential segregation is defined by Massey & Denton (1988: 282) as "the degree to which two or more groups live separately from one another, in different parts of the urban environment". How best to measure residential segregation is a somewhat controversial issue within the social science community. In an attempt to bring some unity to the analysis of residential segregation both methodologically and conceptually, Massey & Denton (1988) employed factor analysis to select five different segregation indices, each of which represents a different dimension of segregation. The first dimension is evenness which is most often measured with the index of dissimilarity or D, the percentage of the minority group that would have to move to obtain an even distribution of minority and majority members throughout a geographic area. This index ranges from 0 to 1 with higher values indicating higher segregation. D is a symmetrical measure which represents the distribution of only one group relative to another. The index of dissimilarity has many shortcomings and does not provide a complete picture of segregation throughout an urban area. For example, "If one looks at inter-city differences in segregation, the interpretation of D cannot give any information about the rates of contact, or the degree of isolation among groups" (Lieberson & Carter 1982: 305). Cortese et al. (1976) noted that the dissimilarity index will be affected by the size of the unit of analysis and propose a standardized index to counter this effect. In addition, White (1987) found that *D* is particularly sensitive to population composition and mobility patterns (see White 1987). These criticisms demonstrate the need to interpret D narrowly and with caution. They also provide a strong rationale for using other indices in conjunction with D.

The second dimension is isolation, P*, the extent to which minority persons live in areas with other minority persons. This index ranges from 0 to 1 with higher values indicating more segregation. This index is a measure of exposure, i.e., the likelihood of minority individuals interacting with one another rather than with majority individuals (Massey & Denton 1988: 288). Lieberson & Carter (1982) have shown that the P* isolation index captures a compositional dimension of segregation that D does not and further that this compositional dimension is important when considering black isolation. For example, often "the level for white isolation goes down very slowly with increases in black proportion in the population; in contrast, the level of black isolation goes up very rapidly with increases in the black proportion of the population" (Lieberson & Carter 1982: 304).

A third dimension of residential segregation is concentration, the amount of land area on which minority groups reside relative to the amount of land area occupied by majority groups. The CO index ranges from -1 to 1, and

higher values indicate more segregation (Massey & Denton 1988). While the P* isolation index accounts for minority proportion of the total population, the concentration measure accounts for minority proportion of total land area. The fourth dimension is centralization, CE, which refers to the extent to which a minority group inhabits land near, or in, the geographic center of the city. This index ranges from -1 to $+1$ with higher values indicating more segregation or a greater proportion of minority members that would have to move to obtain an equal minority-majority proportions in and around the central city or central business district. The final dimension of segregation Massey & Denton (1988) identified is clustering or spatial proximity, SP. The SP index is defined as the extent to which minority groups live in neighborhoods directly adjacent to other minority neighborhoods. Any score greater than 1 on this index normally indicates a high level of clustering. Massey & Denton (1988) subtracted 1 from each of the scores so the index would range from 0 to 1, with a higher score indicating greater segregation. Each of these five indices represents a distinct pattern of persons distributed over urban space.

Importantly, it is possible to be segregated on one or all five dimensions (see Massey & Denton 1989). Massey & Denton (1989: 388) applied the five segregation indices to census tract data for 60 metropolitan areas and found that "being black not only greatly accentuates the level of segregation on any single dimension but also increases markedly the dimensionality of segregation, generating an accumulation of segregation across multiple dimensions simultaneously". Their findings demonstrate that black persons are more highly segregated than any other group, including Hispanics.

Density-consequences and importance

Density and its various components are important ecological measures of spatial arrangements. While research involving the measurement of population density and its effects is not as common now as it was from the 1950s to the early 1970's, the findings of this research remain relevant today. In addition, density is an important measurement tool and is compatible for use with modern geographic information systems equipment (see Berry 1995). Following the lead of researchers who found a strong relationship between overcrowding and pathological behavior in animals, social scientists have explored the relationship between overcrowding and social pathology in humans (Keyfitz 1966; Galle et al. 1972; Gove et al. 1979). In addition, Galle et al. (1972) found that overcrowding is positively related to mortality and positively related to fertility. Crowding in terms of housing units per structure is also related to juvenile delinquency (Galle et al. 1972). Other research has

concluded that crowding is positively related to poor interpersonal relationships and child care (Baldassare 1978; Galle et al. 1972), positively related to poor mental health (Gove, Hughes & Galle 1979), and is negatively related to physical health (Gove, Hughes & Galle 1979).

Measurement of density

Another important contribution of the overcrowding literature was the decomposition of gross density or persons per unit of land area into several different components. The same year Calhoun's (1962) work on density in rat populations was published, Winsborough (1962) published his research on the decomposition of gross population density across human populations residing in seventy-four community areas of Chicago in 1940. In the Winsborough (1962) model of gross population density, the ratio of population to total land area (P/A) is decomposed into several multiplicative components: persons per dwelling unit (P/U), units per residential structure (U/S), and residential structures per unit of land area (S/A).

$$P/A = P/U \times U/S \times S/A.$$

Duncan (1966) used the Winsborough density decomposition as an example of the path analysis procedure and concluded that the measure of residential structures per acre was the primary source of variation in gross population density, followed by units per residential structure and persons per dwelling unit. The work of Galle et al. (1972) not only expanded the work on the relationship of density to the social pathology of humans but also expanded the concept of density. In their study of seventy-four community areas in Chicago, Galle et al. identified an additional component of density: persons per room, or crowding. The four components of density identified by Galle et al. (1972) are persons per room (P/R), rooms per housing unit (R/U), housing units per structure (U/S), and residential structures per acre (S/A). Unlike earlier studies, Galle et al. (1972) found housing units per structure to account for the largest proportion of variation in gross population density followed closely by residential structures per acre. The Galle et al. model is represented by the following equation:

$$P/A = P/R \times R/U \times U/S \times S/A.$$

The Galle et al. (1972) findings differ from the Duncan path analysis results (1966) in that structures per acre was found to be the most important component of gross density in Duncan's results, while units per structure, followed by

structures per acre, was found to be the most important component of gross density in the Galle et al. (1972) results.

In a modification of the Galle et al. (1972) model, Carnahan et al. (1974) added two additional components to their density decomposition model: residential structures per unit of residential area (S/RA) and unit of residential area per unit of total area (RA/A). The Carnahan et al. (1974) model is represented by the following equation:

$$P/A = P/R \times R/U \times U/S \times S/RA \times RA/A.$$

Most recently, Berry (1995: 117) has suggested that the ratio of housing units to land area be the criterion for determining what constitutes a densely settled area. Berry (1995: 111) considers this measure to be most amenable to new monitoring technologies, particularly remote sensing and geographic information systems, as housing units are a more permanent and stable measure of population density than persons. Some empirical justification for Berry's claim can be found in the work of Duncan (1966) and the work of Abott (1982); however, whether the results of Duncan and others are generalizable beyond Chicago areas has yet to be tested.

Conceptual framework and hypotheses

The first hypothesis this research tests is that segregation is positively related to dense development. A common, and generally accurate perception, is that poor blacks are densely concentrated in multi-story multi-unit housing (apartments and flats) on relatively small tracts of land. Many of these densely developed neighborhoods developed during the 1950s as part of the urban renewal program are characterized by physical decay. One of the many ways in which this physical decay is manifested is in the preponderance of high-density housing complexes in ghetto areas (Massey & Denton 1993). John Bauman (1987), in a historical analysis of Philadelphia housing projects, found dense development to be a major characteristic of segregated urban neighborhoods.

The underlying concept for both segregation and density measures is the distribution of persons throughout urban space. Hawley (1972) suggests that density indicates not only physical proximity but also social proximity, the frequency of interaction among individuals. This concept of density is similar to the conceptualization of segregation as exposure to contact (i.e., P*). Physical proximity to neighbors is largely determined by the density of development and occupancy rates. In addition, the dense high rise development that characterizes public housing concentrates poverty (Massey & Kanaiaupuni

1993). Because concentrated poverty is strongly associated with segregation, in the present analysis, high levels of segregation at the metropolitan area level are expected to be positively related to both structures per square mile and persons per square mile, i.e., intensive land use and high occupancy rates. High levels of segregation are also expected to be positively related to units per structure. As structures per square mile and persons per square mile in metropolitan areas increase, the only way for building to continue is up.

The second hypothesis this research tests is that segregation is positively related to overcrowding. Several recent studies have found high levels of crowding among different minority groups. (Gove & Hughes 1983; Krivo 1995; Myers & Lee 1996). Early research on urban density conducted by Duncan & Duncan (1957) concluded that a high number of persons per room or "piling up" among the black population resulted from the failure of housing construction to keep pace with black population increases in the segregated black residential areas of the city. Taeuber & Taeuber (1969) replicated the Duncan & Duncan (1957) study of crowding for ten metropolitan areas and concluded that crowding was a result of the housing market and white suburbanization. Meyers & Lee's (1996) research determined that overcrowding is directly related to persons per household and rooms per unit. In the present research, segregation is expected to be negatively related to the number of rooms per unit (less rooms, less space, more crowding) and positively related to persons per room (more persons doubling up in rooms).

The third hypothesis is that the relationships between race-specific density and segregation indices are stronger than the relationships between general density (non-race-specific density) and segregation indices. Although measures of density and segregation pertain to somewhat overlapping spatial patterns, one of the main differences between the two measures is the way race is operationalized. Segregation indices compare minority and majority population distributions, while measures of density are computed for the entire population. To address this important disjuncture, we undertake separate analyses of race-specific density: the density of housing units with a black householder, and general density: the density of housing units as traditionally computed without regard to a specific race. We consider both the relationships between non-race-specific density and segregation and race-specific density and segregation so as not to presume that only the density of blacks is related to segregation. We are not suggesting that the measurement of density should necessarily take into account population composition.[1] However, the relationship between race-specific density and segregation is more consistent with regards to race thus, it is plausible that the relationship should be stronger than that of general density with segregation indices. In addition, race-specific

density may be used as a method to more precisely measure concentrated disadvantage.

Data

The data employed in this study are for the 58 largest metropolitan areas in the United States in 1990. The metropolitan area has conventionally been the focus of studies of residential segregation (e.g., Frey & Farley 1996; Massey & Denton 1988; Massey & Denton 1989). The segregation indices were drawn from a US Bureau of the Census study of residential segregation by Harrison & Weinberg (1992a, 1992b). Other data sources are Bureau of the Census *United States Summary of General Housing Characteristics* (1990) for race-specific density, the Bureau of the Census *General Housing Characteristics of Metropolitan Areas* (1990), the *State and Metropolitan Area Data Book* (1991), and the *Census Bureau Supplementary Report Metro Areas as Defined by the Office of Management and Budget* (1993) for land area.

Methods and variables

The unit of analysis for this research is the metropolitan area. The first and second hypotheses that segregation is positively related to dense development and that segregation is positively related to overcrowding are tested using both race-specific and general density measures and segregation indices in five different multiple regression analyses. The race-specific density variables will be prefaced with the letter 'B'. Further, we compare the race-specific and general density regression results to test the third hypothesis that the relationships between race-specific density and segregation indices are stronger than the relationships between general density and segregation indices.

On the basis of ecological theory and research, two controls will be included in the regressions, region and the number of new housing units. New construction has been shown to account for much of the variation in segregation patterns in urban areas. For example, Taeuber & Taeuber (1965) found new construction to be the most important variable in predicting changes in segregation patterns during the 1940s. Research on residential segregation by Frey & Farley (1996) has also used new construction as a control. Since the present research hypothesizes that density and segregation measures are related, the control of new housing units is particularly relevant. The new housing units variable is denoted as NHU.

The second control, region, is commonly used in studies of residential segregation to control for historical differences in city structure, patterns of

development, and patterns of segregation due to regional differences in the social aspects of race relations and segregation. Structures per square mile and units per structure are denoted as SPM^2 and UPS, respectively. Rooms per unit and persons per room are denoted as RPU and PPR, respectively. The reference category for region in all regressions is South.

Results

Descriptive statistics

Table 1 presents descriptive statistics for both the general and race-specific density variables. In comparing the general density summary statistics with the race-specific density summary statistics, several differences are apparent; however, most differences are not particularly large. The mean number of black persons in a metropolitan area per mile, 152.8, is substantially less than the mean number of all persons per square mile at 1041.7. The mean number of structures with a black householder per square mile, 51.1, is also much lower than the mean number of structures with all householders regardless of race at 442.1. These differences in structures per mile and persons per mile do not indicate that black persons are not crowded. On the contrary, they simply indicate that black persons often make up only a small portion of the total population. It is to be expected that, compared to the entire population of householders regardless of race, black persons are less numerous as householders occupying less land area and fewer structures per mile. Rooms per unit, units per structure, and persons per room indicate that black persons are more densely settled. On average black persons tend to live in buildings with more units per structure (apartment type buildings) than the total population and on average have less rooms per unit and more persons per room than the total population.

Table 1 also presents the descriptive statistics for the residential segregation variables of black persons in 58 metropolitan areas. The mean dissimilarity index, D, for 1990 of 0.65 indicates a high level of residential unevenness across metropolitan areas. Massey & Denton (1989) define a dissimilarity index of 0.60 or greater as a high level of residential unevenness. This measure indicates that 65% of either black or white metropolitan area residents would have to move to achieve an even ratio of black residents to white residents throughout metropolitan areas. The mean P* isolation index of 0.53 indicates a 53% chance that a black persons in metropolitan areas live in areas with other black persons. The value of the spatial proximity index, SP, the extent to which areal units inhabited by minorities are adjacent to one another is, 0.34, and indicates a fairly low degree of enclave-type formations.

Table 1. Descriptive statistics for general and race-specific density components and segregation indices, United States 1990

Variable	Mean	Standard deviation
General density		
PPM^2	1041.70	1814.70
SPM^2	442.10	745.10
RPU	5.20	0.45
PPR	0.49	0.06
UPS	0.96	0.18
Race specific density		
$BSPM^2$	51.10	110.50
$BPPM^2$	152.80	333.10
BRPU	4.70	0.42
BPPR	0.53	0.07
BUPS	1.20	0.09
Segregation		
D	0.65	0.13
P* isolation	0.53	0.19
SP	0.34	0.24
CE	0.80	0.14
CO	0.65	0.34
N	58	58

Sources: for density variables – General Housing Characteristics U.S. Summary, U.S. Bureau of the Census 1990 and for segregation indices – Harrison and Weinberg, U.S. Bureau of the Census (1992a and 1992b).

The mean centralization index, CE, of 0.80 indicates that black persons are likely to live close to the central city. Massey & Denton (1989) define a score on the centralization index of 0.80 or greater as indicative of high levels of segregation. The fact that the spatial proximity index is low while the centralization index is high indicates that there is a tendency for residential patterns at the metropolitan level to be characterized by a number of different black neighborhoods located relatively equidistant to the central city rather than in continuous enclaves. In addition, these neighborhoods are concentrated on relatively small tracts of land as reflected in the mean value for CO of 0.65. The concentration index indicates that a large number of black persons are living in small crowded neighborhoods rather than being spread out over the

Table 2. Bivariate relationships general density and segregation indices, United States 1990

Variable	PPM^2	SPM^2	RPU	PPR	UPS
D	0.18	0.16	0.30	−0.30***	−0.16
P* isolation	0.23*	0.21	0.13	−0.19	−0.02
SP	0.10	0.12	0.10	−0.19	−0.17
CE	−0.41***	−0.39***	−0.02	−0.15	−0.12
CO	0.02	−0.07	−0.42***	−0.42****	−0.06
N	58	58	58	58	58

Sources: for density variables - General Housing Characteristics U.S. Summary, U.S. Bureau of the Census 1990 and for segregation indices – Harrison and Weinberg, U.S. Bureau of the Census (1992a and 1992b).
Two Tail Test: *** $P \leqslant 0.01$, ** $P \leqslant 0.05$, * $P \leqslant 0.1$.

entire urban area. These summary statistics demonstrate that black persons were still highly segregated along several dimensions in 1990.

Bivariate relationships: components of general density and segregation indices

The bivariate analyses of the components of general density (non-race-specific density) and the segregation indices are presented in Table 2. The density component which has emerged most prominently thus far, structures per square mile, is significantly related to only one measure of segregation: index of centralization, and the correlation between these two measures is negative. The correlation between the index of centralization and persons per mile is also significant and negative −0.41. Persons per square mile is significantly and positively correlated with P* isolation.

A high number of persons per room and rooms per unit in metropolitan areas is associated with less segregation along the index of concentration. In metropolitan areas where individuals occupy homes with more rooms per unit, they tend to be less segregated along the dimension of concentration. The index of dissimilarity is positively correlated with rooms per unit and significantly and negatively correlated with persons per room. In metropolitan areas with high levels of residential unevenness, persons live in dwellings with more rooms per unit and thus are less crowded. This does not mean that blacks are less crowded, but that the metropolitan areas with more units per structure (i.e., more apartments) have higher levels of segregation as measured by P* isolation.

Table 3. Standardized effects general density and segregation indices, United States 1990

Variable	Model 1 D	Model 2 P* isolation	Model 3 SP	Model 4 CE	Model 5 CO
Density [PPM^2]					
SPM^2	0.11	0.08	0.09	−0.69***	−0.19
RPU	−0.08	−0.08	−0.13	−0.69***	−0.63***
PPR	−0.18	0.04	−0.12	−0.25	−0.66***
UPS	−0.10	−0.01	−0.18	−0.20	−0.01
Region [S]					
NE	0.24	0.16	0.02	0.35*	0.46**
MW	0.40***	0.32**	0.16	0.15	0.45***
W	−0.29**	−0.45***	0.29*	0.01	0.20
Construction					
NHU	−0.06	−0.04	0.09	0.12	−0.05
R^2	0.49	0.41	0.21	0.30	0.37
Adj. R^2	0.41	0.31	0.08	0.19	0.27
N	58	58	58	58	58

Sources: for density variables – General Housing Characteristics U.S. Summary, U.S. Bureau of the Census, 1990 and State and Metropolitan Area Data Book, 1991; for segregation indices – Harrison and Weinberg, U.S. Bureau of the Census (1992a and 1992b).
Two Tail Test: *** $P \leqslant 0.01$, ** $P \leqslant 0.05$, * $P \leqslant 0.1$.
For categorical variables, the reference categories are in brackets [ ].

Regression analysis: components of general density and segregation indices

Table 3 presents the regression coefficients with the components of general density (non-race-specific density) and the dimensions of residential segregation controlling for region and the construction of new housing units. The significant coefficients in Tables 2 and 3 reveal that in instances when segregation is high particularly in relation to the concentration and centralization indices, crowding, the number of structures per mile, and the number of persons per mile are low. Although the coefficients are not statistically significant, the index of dissimilarity, P* isolation, and spatial proximity, are all positively related to structures per mile.

Bivariate relationships: race-specific density and segregation indices

The bivariate correlations between the components of race-specific density and segregation indices are reported in Table 4. Note first that, as predicted in

Table 4. Bivariate relationships race-specific density and segregation indices, United States 1990

Variable	$BPPM^2$	$BSPM^2$	BRPU	BPPR	BUPS
D	0.28**	0.29**	0.37***	−0.27**	0.15
P* isolation	0.38***	0.38***	0.26**	−0.12	0.11
SP	0.24*	0.25*	0.33**	−0.29**	0.23
CE	−0.20	−0.19	−0.03	−0.21	0.06
CO	0.08	0.09	−0.01	−0.24*	0.16
N	58	58	58	58	58

Sources: for density variables – General Housing Characteristics U.S. Summary, U.S. Bureau of the Census, 1990 and State and Metropolitan Area Data Book, 1991; for segregation indices - Harrison and Weinberg, U.S. Bureau of the Census (1992a and 1992b).
Two Tail Test: *** $P \leqslant 0.01$, ** $P \leqslant 0.05$, * $P \leqslant 0.1$.

the third hypothesis, more significant relationships resulted from the correlation between race-specific density and the segregation indices than from the correlations between general density and the segregation indices reported in Table 2. As expected in the first hypothesis, structures per mile with a black householder is significantly and positively correlated with the segregation indices dissimilarity, P* isolation, and spatial proximity. Also as expected in the first hypothesis, persons per square mile is positively correlated with the index of dissimilarity, P* isolation, and spatial proximity. Persons per room is significantly and negatively correlated with the indices of dissimilarity, spatial proximity, and concentration.

Regression analysis: race-specific density and segregation indices

The OLS standardized regression coefficients are reported in Table 5 for residential segregation outcomes with the dimensions of segregation as the dependent variables and the components of race-specific density as the independent variables controlling for region and new housing units. As expected in the third hypothesis, the results presented in Table 5 are much stronger than those in Table 3 which includes the components of general density as the independent variables. The adjusted R^2s in Table 5 indicate that the race-specific model provides a better fit. As predicted in the first hypothesis, structures per square mile has a significant and positive net effect on the dimensions of segregation dissimilarity, P* isolation, and spatial proximity. These coefficients were not significant in Table 3, the model employing non-race-specific density. The significant results in Table 5 are consistent with the

Table 5. Standardized effects: race-specific density and segregation indices, United States 1990

Variable	Model 1 D	Model 2 P* isolation	Model 3 SP	Model 4 CE	Model 5 CO
Density [BPPM^2]					
BSPM^2	0.25**	0.39***	0.32**	−0.20	−0.05
BRPU	0.20*	0.18	0.31**	−0.11	−0.21
BPPR	−0.04	−0.02	−0.05	0.07	0.03
BUPS	0.08	0.07	0.18	0.06	0.07
Region [S]					
NE	0.06	−0.02	−0.02	−0.05	0.27
MW	0.40***	0.22	0.23	0.06	0.44**
W	0.28**	−0.41***	−0.18	−0.04	0.04
Construction					
NHU	0.02	0.08	0.06	−0.01	−0.15
R^2	0.52	0.51	0.36	0.01	0.22
Adj. R^2	0.45	0.42	0.25	0.00	0.09
N	58	58	58	58	58

Sources: for density variables – General Housing Characteristics U.S. Summary, U.S. Bureau of the Census, 1990 and State and Metropolitan Area Data Book, 1991; for segregation indices – Harrison and Weinberg, U.S. Bureau of the Census (1992a and 1992b).
Two Tail Test: *** $P \leqslant 0.01$, ** $P \leqslant 0.05$, * $P \leqslant 0.1$.
For categorical variables, the reference categories are in brackets [ ].

hypotheses and indicate that high numbers of structures per mile with a black householder are associated with high levels of segregation.

Consistent with the second hypothesis is the finding that rooms per unit is negatively related to the indices of centralization and concentration and that persons per room is positively related to these two indices. The relationships of general density to the dimensions of segregation in Tables 2 and 3, are exactly the opposite to those in Table 5.

In comparing the coefficients in Tables 3 and 5, several different patterns emerge. First, several of the signs are different in the two tables. In Table 5, units per structure is positively related to all dimensions of segregation while units per structure is negatively related to all dimensions of segregation in Table 3. Consistent with the first hypothesis, when consideration of density is limited to those households with a black householder, segregation levels across all five dimensions are positively related to a high number of units per structure across metropolitan areas. That is, the more units per structure the

more likely one will find segregated black householders. This indicates that black householders who live in more residentially segregated metropolitan areas tend to live in large apartment buildings which are highly concentrated in or near the central city.

In Table 5, the relationships between rooms per unit and the dimensions of segregation dissimilarity, P* isolation, and spatial proximity are positive, whereas, in Table 3 these relationships were negative. Focusing only on the density of blacks within metropolitan areas, a larger number of rooms per unit is associated with residential unevenness, isolation, and a high number of contiguous residential areas not located in the central city (i.e., a large number of segregated suburbs within a metropolitan area).

Discussion and conclusions

The present analysis is a call for a revisitation of density as originally conceived by the Chicago area researchers but with a different aim. Existing research focuses on the concentration of social phenomenon and measures concentration as a percentage of individuals within a unit of land area that share a particular characteristic such as poverty. This research proposes the use of density as a more precise measure of concentration that takes into account the size of the unit of land area within which individuals reside in addition to the percentage of persons in a particular category.

The applicability of a measure such as social density has been examined in this research by exploring how segregation is related to density on a race-specific basis. In addition, we also considered the relationships between general density and segregation indices. This research has shown that segregation, a measure of social concentration, and density, a measure of physical concentration measured as both race-specific and non-race-specific, are related. More specifically, this research finds density and segregation to be related in the following ways.

High levels of segregation in a metropolitan area are related to the dimensions of density that indicate dense development, structures per mile, units per structure, and persons per mile when density is measured specific to race. In metropolitan areas with a high number of structures per square mile with a black householder, the distribution of black persons throughout the city is uneven, the more likely black persons are to live in areas with other black persons rather than persons of other races, and the more likely areas with a predominantly black householders will be located directly adjacent to other areas with mostly black householders.

At first glance, it might appear that the relationship between segregation and race-specific density is 'built-in' since we are observing the relationship

between the segregation of blacks and density of black settlement. On closer reflection, such does not seem to be the case. First, segregation can, and does, emerge in the more sparsely inhabited suburbs as well as in the more densely built-up central cities, and the emergence of black suburbs is by no means a new phenomenon (Farley 1970). More important for the present purposes, at the very least, it is an empirical question as to whether each of the separate dimensions or both general and race-specific density are related in the same way to each separate measure of segregation.

High scores across all dimensions of segregation are not necessarily related to crowding on a per room and per unit basis at the metropolitan area level contrary to the second hypothesis. As expected, when the dimensions of density are isolated to black householders in metropolitan areas, crowding on a per room and per unit basis is related to high segregation along the concentration and centralization indices indicating high levels of crowding in areas such as inner cities. However, over all of the tables, a higher number of persons per room (or crowding) is negatively related to the segregation indices dissimilarity, P* isolation, and spatial proximity. This finding is consistent with the literature on segregation in metropolitan areas that are highly suburban and suggests that black persons do not gain in all respects by moving out of the central city into suburban areas (Massey & Denton 1993). Black persons may gain more rooms per unit, but lose in terms of segregation.

This analysis finds that non-race-specific density is positively related to segregation along a number of dimensions. However, the relationships between race-specific density and segregation indices are stronger than the relationships between non-race-specific density and the dimensions of segregation as predicted in the third hypothesis. This indicates that population composition need not necessarily be taken into account to understand the relationships between density and segregation, although doing so yields a better fitting model for the measurement of social outcomes such as concentrated disadvantage. Even though the computation of density on a race-specific basis improves model fit and facilitates interpretation, it remains the case that all of the measures apply to entire metropolitan areas. Now that the relationships between density and segregation indices have been established, a fruitful avenue for future research would be to focus on smaller units of analysis such as the census tract.

This research suggests that measures of density should be included in the analysis of residential segregation and that density is important part of our understanding of the processes that are involved in the segregation of individual race/ethnic groups. Recent contextual level analyses have found relationships between segregation and higher mortality for blacks (Fang 1998), segregation and poor health outcomes due to neighborhood effects (LeClere

et al. 1997), segregation and homicide (Potter 1991) to name only a few important themes. Now that we have established a conceptual and empirical framework for the relationship between the components of density and the dimensions of residential segregation, future research should expand the exploration of the association among the dimensions of segregation identified by Massey & Denton (1988) and the components of density identified by early Chicago area researchers Caranahan et al. (1974), Duncan (1966), Galle et al. (1972), and Winsborough (1962) to more precisely capture the influence of the concentration of poverty, joblessness, and violence.

Acknowledgments

The authors thank Christopher G. Ellison, Ph.D. and two anonymous reviewers for comments on an early version of this paper.

Notes

1. We thank an anonymous reviewer for prompting us to take a closer look at non-race-specific density.

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