Ethnic Density and Premature Mortality by Skin Color/Race According to Levels of Urbanicity and Aggregation to the Metropolitan Regions of Brazilian Cities

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Abstract: *Objective:* Attributes of the social environment are associated with the health of racial groups, but it is still unknown whether ethnic density is one of the social properties of place that influence on the association between levels of urbanicity and aggregation to Metropolitan Regions (MR) of Brazilian cities, with mortality in white and dark-skinned (*pardo* and black) people.

Design: Ecological study which 508,560 deaths from 2010 according to skin color/race in white and dark-skinned people. Data from the Demographic Census of 2010 was used to establish levels of urbanicity and aggregation to MR, and categories of ethnic density for Brazilian cities. Urbanicity and aggregation to MR were grouped into six categories: *Rural in MR, Rural out of MR, "Rurban" in MR, "Rurban" out of MR, Urban in MR, Urban out of MR*. Four categories of ethnic density were used: pardo*, mixed-race with dark-skinned majority, mixed-race with white majority, white*. The risk of death was estimated by calculating Premature Mortality Rates (PMR) at 65 years of age, per 100,000 inhabitants and age-adjusted.

*Results:*To urbanicity and aggregation to MR, dark-skinned people presented the worst PMR. The highest values occurred in cities outside of MR, with increased rates in rural areas when compared to urban areas. When controlled by ethnic density, dark-skinned people had lower PMR in cities with white or mixed-race with white majority ethnic densities, and higher rates in all remaining densities and at all levels of urbanicity and aggregation to MR.

Conclusions: Ethnic density had an effect on health, it reduced the impact of place on PMR when the highest proportion of the population was of a racial group different to the racial group having the PMR measured. However, was not observed that white and dark-skinned people benefitted from an increased ethnic density of their own racial groups.

Keywords: Premature mortality, urbanicity, social capital, distribution by race or ethnic group.

1. INTRODUCTION

There has been an increase in the number of studies verifying how attributes of the social environment are associated with health measurements in different racial groups [1-3]. In these studies, racial health inequalities reflect a set of structural disadvantages and aspects of social organization within cities that influence patterns of behavior and ways of life and work, generating uneven exposure to risk and protection factors among racial groups within the different contexts of the study, thereby influencing their life trajectories and disproportionate living and health conditions [1-3].

Some characteristics, such as social cohesion, social capital and related fields, have been analyzed as being capable of interfering with the transmission of behaviors in cities, influencing access to goods and services and affecting quality of life [2,4]. These properties have been measured using census data, such as breakdown by skin color/race, which can reflect a variety of these social attributes and how they can affect health [5,6]. Ethnic density is the proportion of an ethno-racial group within a certain location and is regarded as one of the ways in which social properties of place may explain differences in health between different racial groups [7,8].

The way in which places affect health can be investigated through this attribute, being thought of as a phenomenon that reduces the impact of stress on health through defined ways, which include the reduction of racism and structural inequalities in health, encouraging the creation of social roles, improving interpersonal relations and positive health behavior [5, 6].

However, results of studies about the association between social attributes of place and mortality still vary by the ethnic density category in question [4, 9]. It is unclear whether they can also influence mortality outcomes in cities with different levels of urbanicity or urban clusters in countries with distinct characteristics of racial formation [1, 2, 9], and racial classification systems and methodologies [3, 10, 11].

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In Brazilian cities, the effects of ethnic density on mortality have not yet been evaluated; it is not known whether the risk of death according to skin color/race between cities can be altered by it, or if any racial group may benefit from a greater ethnic density to the detriment of another group. Thus, the potential impacts on health of contextual characteristics such as ethnic density, urbanicity and metropolitan areas, when evaluated simultaneously, are still unknown.

Therefore, this study verified the effect of ethnic density on the association between levels of urbanicity and aggregation to Metropolitan Regions of Brazilian cities and with Premature Mortality Rates (PMR) (<65 years) adjusted by age, in white and dark-skinned (*pardo* and black) people in 2010.

2. METHODS

This is an ecological study performed using clusters of secondary data available online on databases of Brazilian governmental institutions [12,13]. The number of Brazilian cities existing in the census year of 2010 (n=5,565) were used as units of analysis. Levels of urbanicity and aggregation to Metropolitan Regions (MR) and ethnic densities of Brazilian cities were established using the population data from Demographic Census of 2010 [12].

Urbanicity level was defined according to the criteria available in Oliveira & Luiz [3] and Veiga [14], who create categories of cities according to the combination of the characteristics of population size, demographic density (DD), and whether they belonged to a metropolitan region. The categories are as follows: Rural (<50,000 inhabitants and DD <80 inhabitants / km^2), "rurban" (from 50,000 to 100,000 inhabitants or DD ≥80 inhabitants/km^2 even with a total population <50,000) and urban (>100,000 inhabitants) aggregated or not to Metropolitan Regions (MR). The condition of aggregation to an MR was taken into consideration when the municipalities were located in MR, integrated development regions (IDR), and urban agglomerations. The defining characteristics of these locations are described in publications from the Brazilian Institute for Geography and Statistics (IBGE). Thus, the levels of urbanicity and aggregation to MR in 2010 were grouped into six categories: *Rural in MR, Rural out of MR, "Rurban" in MR, "Rurban" out of MR, Urban in MR*, *Urban out of MR.*

Then, the ethnic density of Brazilian cities was calculated from self-reported information on skin color/race. In Brazil, the IBGE uses five official categories to classify skin color/race: white, *pardo*, black, “yellow” (that is, East Asian) and indigenous [12]. In Brazil, the standard racial classification combines phenotype and socioeconomic characteristics. The color categories can be used analytically as a construct of race, which enhances the value and the social meaning of the term. In this perspective, skin color is an external indicator of race capable of revealing social discrimination and the social context through it. However, studies have recognized that racial categories are not homogeneous, that individuals do not always belong definitively to the same racial groups, and that there are differences between the classificatory system adopted by the IBGE and that defended by the Brazilian black movement [10-12]. The divergence results from the IBGE’s use of the “pardo” (or mixed-race) category, potentially referring to either white or black individuals. The Brazilian black movement claims the inclusion of both brown and black people in the same category of “black” [10-12]. The black/white binary classification has also become accepted by the media and some researchers [10-11].

The proportion of ethnic density was obtained by taking the number of residents who classified themselves as belonging to a racial group in each city and dividing that by the city’s total population. This calculation was performed separately for white, brown and black people, as well as for the sum of “yellow” (that is, East Asian) and indigenous people (the latter two being considered racial minorities). Using the parameters for classification of ethnic density categories available in Gibbons & Yang [15], and Inagami *et al*. [16], four groups of predominant ethnic density structures were created: *White, Pardo, Black* and *Minority.* These categories were obtained when each racial group had a proportion ≥60.0% of the population and the proportion of other racial groups, respectively, was lower than 20.0%). However, this approach was not sufficient as it did not allow all cities to be classified due to some of them not having a predominance of one racial group over others, according to the cutoff points established above. In such cases, the cities were subsequently stratified into two new groups: *Mixed-race with white majority* (when the proportion of white population was simply greater than the proportion of dark-skinned [pardo and black] population and *mixed-race with dark-skinned majority* (when instead the proportion of dark-skinned [pardo and black] population was simply larger than the proportion of white population). In the analysis phase, only four categories of ethnic density were used (*pardo, mixed-race with dark-skinned majority, mixed-race with white majority, and white*).

Using the combination of levels of urbanicity and aggregation to MR with ethnic density categories, the number of cities and the total population were described. To verify the effect of ethnic density on the association between levels of urbanicity and aggregation to MR with mortality by skin color/race, descriptive measurements were estimated of the PMR in individuals under 65 years old by skin color/race (white, dark-skinned [pardo and black] and total). The PMR has been increasingly used in epidemiological studies conducted in several countries in the analysis of population levels of health to verify the risk of death before old age. It is a sensitive indicator of the inequality that demonstrates the effect of multiple risk factors in levels of health of a population/community [1, 3].

Table 1: Absolute and Relative Distribution of Cities and Population in Brazil by Level of Urbanicity and Aggregation in Metropolitan Regions (MR) According to Ethnic Density Categories in 2010.

LEVELS OF URBANICITY AND AGGREGATION TO MR[3]	ETHNIC DENSITY[1]																			
	Brazil				BROWN				MIXED-RACE WITH DARK-SKINNED MAJORITY[2]				MIXED-RACE WITH WHITE MAJORITY				WHITE			
	Cities		Population[4]		Cities		Population[4]		Cities		Population[4]		Cities		Population[4]		Cities		Population[4]	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Brazil	**5,561**	**100**	**190,687,299**	**100**	**570**	**10.2**	**9,827,071**	**5.2**	**2,645**	**47.6**	**94,329,016**	**49.5**	**1,422**	**25.6**	**62,236,594**	**32.6**	**924**	**16.6**	**24,294,618**	**12.7**
Urban in MR	153	2.7	78,379,106	41.1	1	0.7	155,460	0.2	86	56.2	40,133,659	51.2	37	24.2	29,056,085	37.1	29	18.9	9,033,902	11.5
"Rurban" in MR	220	4.0	8,883,025	9.3	4	1.8	248,587	2.8	113	51.4	4,291,831	48.3	37	16.8	2,000,628	22.5	66	30.0	2,341,979	26.4
Rural in MR	323	5.8	4,006,480	2.1	27	8.4	476,095	11.9	113	35.0	1,601,551	40.0	74	22.9	831,489	20.7	109	33.7	1,097,345	27.4
Urban out of MR	130	2.3	26,052,526	13.7	4	3.1	488,425	1.9	51	39.2	9,625,203	37.0	57	43.8	12,488,602	47.9	18	13.9	3,450,296	13.2
"Rurban" out of MR	605	10.9	24,673,732	12.9	35	5.8	1,565,369	6.3	345	57.0	13,464,523	54.6	150	24.8	6,541,695	26.5	75	12.4	3,102,145	12.6
Rural out of MR	4,130	74.3	48,692,430	25.5	499	12.1	6,893,135	14.2	1937	46.9	25,212,249	51.8	1067	25.8	11,318,095	23.2	627	15.2	5,268,951	10.8

Source: 2010 Demographic Census. Available at: http://www.sidra.ibge.gov.br. (IBGE, 2011a).

Notes: 1- The brown and white ethnic density categories were obtained when each racial group had a proportion ≥60.0% of the population and the proportion of other racial groups, respectively, was lower than 20.0%). The rest were obtained when the proportion of the white population was simply greater than the dark-skinned [brown and black] population or vice versa. In 2010, four municipalities predominated by racial minorities (indigenous or "yellow" [East Asian]) were not included, and there were no black majority cities;
2- Dark-skinned represents the sum of the population self-identifying as brown or black;
3- Municipalities belonging to Metropolitan Regions (MR), or in Integrated Development Regions (IDR) or Urban Agglomerations;
Rural= population <50,000 and density <80 people per km^2; **"Rurban"=** population between 50,000 and 100,000 or density ≥80 people per km^2; **Urban=** population> 100,000.
4- Total white, brown and black population.

In 2010, the grand total of deaths registered in the Integrated Mortality System (SIM) was 1,136,947. In 1,061,113 (97.2%) of these death records, the city of residence and skin color/race of the individual was included, with 1,052,031 (99.1%) deaths reported as being of white or dark-skinned individuals. The categories “yellow” (n=6,162; 0.6%) and indigenous (n=2,920; 0.3%) were excluded from the analysis. Before the calculation of the PMR, a correction was performed on the number of deaths in each municipality with the proportional redistribution of the number of deaths without a recorded skin color/race to those with a declared skin color/race. After redistribution, the final total of deaths in the study of white, Brown and black individuals was 1,123,337 (99.8%), with 508,560 (45.3%) of these deaths occurring in individuals under 65 years of age. This correction assumes that the distribution of deaths without a declared skin color/race will have the same distribution as those with a declared skin color/race and therefore can be proportionally redistributed among the three racial groups studied. Corrections of this type have already been implemented by other Brazilian authors [17-19].

After this correction, the PMR was age adjusted, per 100,000 inhabitants, made directly [20] using Brazil’s population in the demographic census of 2010 as a standard.

3. RESULTS

In Brazil in 2010, most cities (47.6% with a dark-skinned majority and 25.6% with a white majority) and populations (49.5% with a dark-skinned majority and 32.6% with a white majority) were classified as mixed-race, and a minority were classified as *pardo*. Aside from the urban cities outside of MR that were predominantly mixed-race with a white majority, all other levels of urbanicity and aggregation to MR showed cities and populations which were predominantly mixed-race with a dark-skinned majority. The white ethnic density accounted for 16.6% of cities and 12.7% of Brazil's population. The *pardo* ethnic density was higher in rural municipalities out of MR (12.1% of the cities and 14.2% of the population) and lower in urban areas (only one city), while the white ethnic density was higher in rural municipalities in MR (33.7% of the cities and 27.4% of the population) and "rurban" municipalities in MR (30.0% of cities and 26.4% of the population) (Table **1**).

Figure **1** showed box plots of PMR for white and dark-skinned people according to the ethnic density of Brazilian cities in 2010. There are outliers in all groups of ethnic density of Brazilian cities in 2010. We observed differences in the distribution of premature death risk in white and dark-skinned people between ethnic density categories. White people had a lower median PMR in the *pardo* density and a higher median in the mixed-race (with white majority) density, with

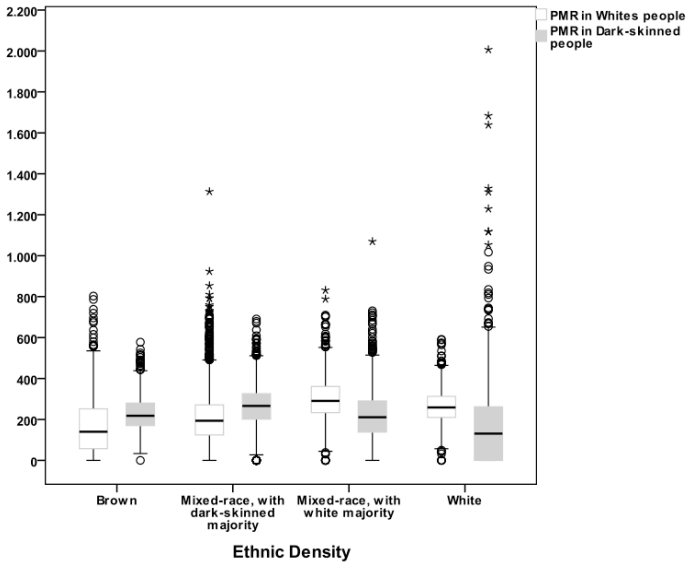

Figure 1: Box plot of the Premature Mortality Rates (PMR) in dark-skinned and white people according to the ethnic density of Brazilian cities in 2010.

Source: PMR age-adjusted, by 100,000 inhabitants, by direct method using the Brazilian population in the 2010 census as a standard and corrected by skin color/race deaths ignored also in 2010.

Table 2: Premature Mortality Rates (PMR) by Skin Color/Race in Dark-Skinned and White People According to the Level of Urbanicity and Aggregation in Metropolitan Regions (MR) of Brazilian Cities in 2010.

Levels of urbanicity and aggregation to MR[1]	Skin color/race[2]	PMR age-adjusted, per 100.000 hab[3].						
		Mean	Standard deviation	Minimum	1st quartile	Median	3rd quartile	Maximum
Urban in MR	Whites	259.9	76.2	103.2	203.8	253.4	315.0	519.1
	dark-skinned	279.3	84.3	53.3	227.0	279.3	330.7	481.8
"Rurban" in MR	Whites	246.7	100.4	0.0	187.5	249.9	309.7	591.8
	dark-skinned	254.0	122.6	0.0	171.6	261.0	329.0	636.2
Rural in MR	Whites	249.9	126.1	0.0	162.9	250.5	314.1	788.3
	dark-skinned	212.6	192.5	0.0	101.4	204.9	296.2	2006.7
Urban out of MR	Whites	254.4	64.6	94.2	220.5	257.4	298.6	396.1
	dark-skinned	280.3	76.4	132.3	221.9	280.1	326.4	588.6
"Rurban" out of MR	Whites	233.9	95.8	0.0	170.0	227.9	294.0	710.0
	dark-skinned	268.7	102.7	0.0	207.6	272.8	327.5	810.4
Rural out of MR	Whites	234.0	136.1	0.0	139.2	227.3	313.2	1313.1
	dark-skinned	227.4	134.9	0.0	151.6	223.0	299.3	1683.7

Notes:
1 – Municipalities belonging to Metropolitan Regions (MR), or in Integrated Development Regions (IDR) or Urban Agglomerations; **Rural=** population <50,000 and density <80 people per km^2; **"Rurban"=** population between 50,000 and 100,000 or density ≥80 people per km^2; **Urban=** population> 100,000.
2- Dark-skinned represents the sum of the population self-identifying as brown or black;
3- PMR age-adjusted, by 100.000 inhabitants., by direct methods using the Brazilian population in the 2010 census as a standard and corrected by skin color/race deaths ignored also in 2010.

these cities having the most homogeneous rates. Dark-skinned people had a higher median PMR in the mixed-race (with dark-skinned majority) density, and a lower median in the white density, though it was in these cities that rates were more dispersed and we observed outlying values.

Table **2** shows the PMR for white and dark-skinned people, according to the level of urbanicity and aggregation to MR of Brazilian cities in 2010. In general, dark-skinned people have had worse mean and medians of PMR than whites in urban and "rurban" cities and lower rates in rural cities, but there were larger differences in cities outside of MR than MR.

Table 3: Premature Mortality Rate (PMR) for white people, according to the level of urbanicity and aggregation to Metropolitan Region (MR) and specific to the ethnic density categories of Brazilian cities in 2010.

Levels of urbanicity and aggregation to MR[1]	Ethnic density[2]	PMR adjusted for age, per 100,000 inhabitants[3]. WHITE						
		Mean	Standard deviation	Minimum	1st quartile	Median	3rd quartile	Maximum
Urban in MR	**White**	270.9	52.7	188.2	231.0	251.7	315.6	405.1
	Mixed-race with white majority	307.0	67.4	201.0	260.1	287.3	329.9	519.1
	Mixed-race with dark-skinned majority	237.1	76.9	103.2	176.7	222.0	297.8	402.0
	Brown	170.4	0.0	170.4	170.4	170.4	170.4	170.4
"Rurban" in MR	**White**	275.5	64.7	134.1	232.5	264.3	320.3	448.4
	Mixed-race with white majority	318.6	70.1	219.8	267.2	298.7	350.5	489.6
	Mixed-race with dark-skinned majority	207.8	101.6	0.0	130.9	194.4	275.8	591.8
	Brown	206.5	245.1	42.7	49.1	109.2	364.0	565.2
Rural in MR	**White**	247.6	81.4	86.9	178.1	251.9	298.5	485.7
	Mixed-race with white majority	326.2	120.3	31.7	250.5	296.3	389.0	788.3
	Mixed-race with dark-skinned majority	226.8	139.7	0.0	132.8	202.1	290.1	702.2
	Brown	146.4	121.8	0.0	64.6	123.9	229.6	392.5
Urban out of MR	**White**	290.6	49.2	211.3	249.3	294.3	315.9	396.1
	Mixed-race with white majority	284.2	46.0	182.5	249.8	277.0	313.7	391.5
	Mixed-race with dark-skinned majority	216.6	60.4	94.2	174.9	220.5	257.7	335.7
	Brown	150.0	42.2	100.8	122.5	147.7	177.5	203.7
"Rurban" out of MR	**White**	273.5	64.2	119.8	227.0	281.6	318.9	393.6
	Mixed-race with white majority	292.9	61.2	150.8	254.4	288.8	325.8	460.6
	Mixed-race with dark-skinned majority	202.9	95.0	0.0	144.9	189.6	248.4	710.0
	Brown	201.2	129.0	0.0	111.1	189.0	275.6	598.0
Rural out of MR	**White**	259.3	93.5	0.0	200.9	255.4	312.6	591.2
	Mixed-race with white majority	297.0	116.6	0.0	220.7	292.2	367.0	831.3
	Mixed-race with dark-skinned majority	208.7	138.6	0.0	114.7	189.6	272.1	1313.1
	Brown	165.9	149.2	0.0	50.5	138.3	252.1	802.7

Notes:
1 - Municipalities belonging to metropolitan areas (MR) or integrated development regions (IDR) or to urban agglomerates; **Rural=** population <50,000 and density <80 people per km^2; **"Rurban"=** population between 50,000 and 100,000 or density ≥80 people per km^2; **Urban=** population> 100,000;
2-The Brown and white ethnic density categories were obtained when each racial group had a proportion ≥60.0% of the population and the proportion of other racial groups, respectively, was lower than 20.0%). The rest were obtained when the proportion of the white population was simply greater than the dark-skinned [Brown and black] population or vice versa.
3- PMR age-adjusted, per 100,000 inhabitants, by direct method using the Brazilian population in the 2010 census as a standard.

White people always showed higher mean and median PMR values in urban cities and lower values in "rurban" cities, with cities in MR having higher rates than those out of them. The PMR in dark-skinned people increased as increased as urbanicity increased, going from rural to urban, and in cities aggregated or not to MR, being greater when out of MR.

Table **3** shows the PMR for white people according to the level of urbanicity and aggregation to MR and specific to the ethnic density categories of Brazilian cities in 2010. Considering the effect of ethnic density, it was observed that in general, the PMRs were higher in mixed-race (with white majority) cities and lower in *pardo* density cities. However, a gradient effect in the magnitude of these rates was found, increasing the risk of death from urban to rural cities, always with higher PMR in cities in MR.

Table **4** shows the PMR for dark-skinned people according to the level of urbanicity and aggregation to MR and specific to the ethnic density categories of Brazilian cities in 2010. When considering ethnic density, we observed that PMR became more likely in the mixed-race (with dark-skinned majority) and *pardo* ethnic densities respectively, and it was less likely in the white ethnic density. In general, in the mixed-race (with dark-skinned majority) and *pardo* ethnic densities in MR, the magnitude of PMR decreased as the level of urbanicity decreased. In the *pardo* ethnic density category, the risk of death was lower than in mixed-race (with dark-skinned majority) densities.

4. DISCUSSION

The spatial distribution of cities and population in Brazil by the combination of levels of urbanicity and aggregation to MR with ethnic density reflects important aspects of the country related to colonization, settlement policies, mobility between areas of attraction and repulsion of populations, internal migration and intra- and inter-regional migrations over time in Brazil [14, 21, 22].

Table 4: Premature Mortality Rate (PMR) for Dark-Skinned Color/Race According to Level of Urbanicity and Aggregation to Metropolitan Regions (RM) and Specific to the Ethnic Density Categories of Brazilian Cities in 2010.

PMR adjusted for age, per 100,000 inhabitants[3].								
		DARK-SKINNED[4]						
Levels of urbanicity and aggregation to MR[1]	Ethnic density[2]	Mean	Standard deviation	Minimum	1st quartile	Median	3rd quartile	Maximum
Urban in MR	**White**	218.7	104.4	53.3	145.7	198.7	288.3	431.6
	Mixed-race with white majority	241.6	63.0	139.0	207.5	231.6	277.4	449.1
	Mixed-race with dark-skinned majority	315.8	64.8	191.5	272.1	308.2	352.5	481.8
	Brown	299.5	0.0	299.5	299.5	299.5	299.5	299.5
Rurban in MR	**White**	171.4	135.0	0.0	66.9	144.8	278.3	636.2
	Mixed-race with white majority	212.4	95.3	28.0	148.2	203.6	259.0	505.7
	Mixed-race with dark-skinned majority	316.3	85.8	144.1	251.9	303.5	367.8	570.8
	Brown	244.8	31.1	214.0	220.6	240.4	269.0	284.2
Rural in MR	**White**	165.3	284.9	0.0	0.0	83.3	229.5	2006.7
	Mixed-race with white majority	173.3	122.6	0.0	85.7	168.0	256.3	561.8
	Mixed-race with dark-skinned majority	280.7	97.8	0.0	213.0	288.3	338.9	521.8
	Brown	224.4	78.4	86.7	172.8	250.6	279.6	399.7
Urban out of MR	**White**	269.6	109.8	148.4	196.6	260.8	306.1	588.6
	Mixed-race with white majority	251.6	59.9	132.3	210.7	247.7	301.2	366.8
	Mixed-race with dark-skinned majority	318.5	63.7	202.7	265.8	321.8	356.7	498.5
	Brown	248.5	73.4	142.5	199.6	273.5	297.3	304.3
Rurban out of MR	**White**	193.0	139.3	0.0	84.6	186.3	270.2	810.4
	Mixed-race with white majority	242.5	97.1	0.0	181.7	234.1	293.2	547.7
	Mixed-race with dark-skinned majority	298.0	85.9	0.0	246.4	294.6	347.1	590.8
	Brown	253.9	66.9	150.9	207.5	233.4	307.1	424.3
Rural out of MR	**White**	167.2	214.5	0.0	0.0	117.3	255.4	1683.7
	Mixed-race with white majority	216.6	135.3	0.0	124.8	204.4	293.7	1069.4
	Mixed-race with dark-skinned majority	252.9	99.0	0.0	187.9	247.3	312.7	690.7
	Brown	227.2	93.3	0.0	166.8	211.6	276.2	577.5

Notes:

1 - Municipalities belonging to metropolitan areas (MR) or integrated development regions (IDR) or to urban agglomerates; **Rural=** population <50,000 and density <80 people per km^2; **"Rurban"=** population between 50,000 and 100,000 or density ≥80 people per km^2; **Urban=** population> 100,000;

2-The brown and white ethnic density categories were obtained when each racial group had a proportion ≥60.0% of the population and the proportion of other racial groups, respectively, was lower than 20.0%). The rest were obtained when the proportion of the white population was simply greater than the dark-skinned [brown and black] population or vice versa.

3- PMR age-adjusted, per 100,000 inhabitants, by direct method using the Brazilian population in the 2010 census as a standard;

4- Represent the sum of brown and black people.

There were important differences in PMR by skin color/race according to the level of urbanicity and aggregation to MR of Brazilian cities in 2010. Similar to what has been observed in other countries [2, 18, 23, 4, 25], dark-skinned people had worse PMR relative to white people, and these higher values occurred in cities outside of MR, with an increase in the risk of death from rural to urban environments. However, the results also suggest that ethnic density had different effects on the PMR of Brazilian racial groups and that the magnitude of this effect was not the same between levels of urbanicity and aggregation to MR.

Dark-skinned people had attenuated PMR in cities with a white and mixed-race (with white majority) ethnic density, and an increased level in the other types of ethnic density. Among white people, these effects worked in the opposite way. White people had lower PMR in cities with *pardo* and mixed-race (with dark-skinned majority) densities. These results occurred at all levels of urbanicity and aggregation to MR, but white people became the group with the worst mean and median rates in cities out of MR, and dark-skinned people in MR.

Studies held in other countries demonstrate that ethnic density tends to mitigate disadvantages in health that could be associated with the standard of social cohesion of the community race relations in cities or exacerbate these inequalities when racial support may be reduced or weakened [2-7, 9, 26]. However, even in countries that have more analyses on this topic, the effects of ethnic density on mortality are still rarely explored, and the mechanisms that explain its effects are not yet consistently defined in different contextual analysis units [2, 4].

Among the analyses available on this topic in relation to mortality, Inagami *et al*, [16] found a lower risk of death for whites, blacks and Latinos in New York City when these ethnic groups were living in neighborhoods where they were the majority population, but black people had a higher risk of death regardless of ethnic density. The magnitude of death rates varied between age groups of both sexes, but always showed advantages to racial groups when they resided in neighborhoods with a higher concentration of people from the same racial group. Diez-Roux & Mair [2], in a systematic review, found that, out of seven studies, one found that lower support and social cohesion was associated with higher mortality, two found it was with increased risk of cardiovascular disease, and in two others it was less security, increasing violence and higher levels of disorder being associated with higher mortality. In another review, Bécares *et al*. [4] found in three studies that, in Hispanics aged 25-64, increased ethnic density was associated with lower mortality. While in other studies, no association was found between ethnic density and infant mortality among black Americans and not even among Hispanics of both sexes and over 65 years old. Another study observed a context-dependent effect, with a protective effect of ethnic density observed in non-metropolitan areas, and insignificant in metropolitan areas.

Our results were paradoxical to these previous works. This is because neither white nor dark-skinned people benefited from a higher proportion of people of the same racial group in cities, nor from the potential social capital and mutual social support associated with these ethnic densities, which also suggests that in the context of the cities and the Brazilian reality, the effects of ethnic density on the mortality of Brazilian racial groups proved to be distinct from that observed in other countries. It was observed that white and dark-skinned people had a higher risk of death in the cities where they are in the majority, and controlling by ethnic density indicated that cities with higher levels of urbanicity in MR were the ones that harbored the highest unfavorable inequalities for dark-skinned people, and those out of MR did so for white people.

In part, these findings may indicate that ethnic density simultaneously would indicate the socioeconomic inequalities and characteristics used for racial classification in these cities [3,5,7,22]. Studies have shown that in Brazil, black people historically live in contexts with socioeconomic, social infrastructure and services deprivation [2,3,10,11,22]. Thus, evidence shows disadvantages to health arising from exposure to low socioeconomic, sanitary and health conditions present in the areas where there is a high concentration of certain ethnic groups. Areas with a higher concentration of the same ethnic density have greater material deprivation with adverse effects on the health of the population [3,8,27]. This condition indicates that the characteristics of cities and the populations that occupy them interact, being the most vulnerable populations who suffer the complex effects of this combination.

In both the USA and the UK it was also observed that contexts with a high proportion of dark-skinned

people are more exposed to higher rates of crime, poverty and health degradation [3, 28] and that these levels of disadvantages are associated with whether the cities are located in metropolitan areas or not [28]. Metropolitan areas tend to offer greater access to services and social and health facilities, but they are also places that have higher levels of spatial segregation and racial discrimination. With that, dark-skinned people in metropolitan areas with *pardo* and mixed-race (with dark-skinned majority) ethnic densities may have higher mortality rates because of the accumulation of social and health-related disadvantages in comparison with white people.

Thus, in Brazil, material and health inequalities of life in the poorest and most vulnerable settings which are occupied mostly by dark-skinned people can also explain why dark-skinned people have the highest risk of death among levels of urbanicity and aggregation to MR. This in part may occur for two reasons. One is that it is likely that the influence of socioeconomic deprivation is so defined in cities of *pardo* and mixed-race (with dark-skinned majority) densities that they do not allow for the greater social cohesion arising from these densities to be able to mitigate the negative impacts of social and structural stress factors on the health of dark-skinned people. Second, there may be the fact that the city is a contextual analysis unit which is too large in relation to neighborhoods or census to sectors which have such an important and noticeable effect of ethnic density being an indicator of physical health as PMR in the Brazilian context.

In the case of results on mortality of this study, it may be argued that the high PMR in cities where dark-skinned people are a majority may indicate structural inequalities in access to social and health services in relation to white people, where the latter, by having a higher socioeconomic level, can overcome the vulnerability in these cities, which can be one of the mechanisms that reduce PMR in white people. Moreover, it is possible that in cities of white and mixed-race (with white majority) densities, the PMR for white people may be higher than in dark-skinned people due to factors related to the system of racial classification, where the definition of racial groups is carried out better, mainly in population data, besides the fact that dark-skinned people may benefit from the better socioeconomic and health conditions in these cities offered to whites, especially in more urban cities.

Thus, it is possible that ethnic density represents the influence of the social reproduction structure of inequalities associated with health, indicating the acute and chronic risks in the PMR. In this study, ethnic density has not yet represented an attribute of the social support network and social capital that could have a mitigating effect on socioeconomic deprivation, reducing the impact of inequalities at an individual level, as observed in some studies [3-7].

This study showed important racial differences in PMR between levels of urbanicity and aggregation to MR in Brazilian cities. The ethnic density had an effect on health, it reduced the impact of place on PMR when the highest proportion of the population was the racial group opposed to the racial group that had the PMR measured. However, these results do not show that white and dark-skinned people benefitted from the increased ethnic density to which they belong and the possible social capital associated with these densities. Rather that ethnic density may act as a proxy of deprivation and deterioration of the material conditions of life and health that occur inside the cities.

Some caveats should be mentioned. The first is related to the risk of death in dark-skinned and white people being directly related to the increase in the racial proportion of these groups in populations. This correlation may be due to limitations associated with the classification of the death or the population during its respective registration in the demographic censuses. It is likely that the coverage of death records would be better and higher in municipalities with the highest proportion of white people, with higher urbanicity and in MR, which are the cities with better socioeconomic and health conditions. Moreover, racial identification can be facilitated in contexts where most of the population is white, making it easier to discern the individuals who belong to their respective skin color/race groups. Therefore, there may be a higher volume of death records or populations in white or dark-skinned people, making PMR higher among these groups when they reside in ethnic densities in which they are the majority. Another limitation is the racial classification used in the census to create ethnic density categories. This is because the official Brazilian racial classification system differs from the popular system and from that proposed by the country's social movements [22, 29], which can make the classification of individuals in racial categories arbitrary, different from those in which they prefer to be classified. Therefore, racial classification is not definitive. Individuals may belong to racial groups on a basis that is not irreversible over time, and racial categories may not form particularly homogeneous groups.

On the other hand, when calculating the PMR for dark-skinned people, we attempted to overcome the influences of the racial classification system in Brazil. As this racial classification is recognized for being dynamic and fluid, potentially migrating *pardo* individuals to the white category, or migrating black individuals to the *pardo* category [12,22,29,30]. However, despite these issues, the Brazilian racial classification system in five categories used by the IBGE covers the most common racial categories in the country [12, 30] and the inequalities that arise between these categories still remain.

DISCLOSURE STATEMENT

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