International Journal of Public Health (2020) 65:29–36
https://doi.org/10.1007/s00038-019-01321-1

ORIGINAL ARTICLE

Blurred lines: racial misclassification in death certificates in Brazil

Hellen Geremias dos Santos[1] · Carla Ferreira do Nascimento[2] · Yeda Aparecida de Oliveira Duarte[3] · Ichiro Kawachi[4] · Alexandre Dias Porto Chiavegatto Filho[2]

Received: 19 July 2019 / Revised: 29 November 2019 / Accepted: 4 December 2019 / Published online: 17 December 2019
© Swiss School of Public Health (SSPH+) 2019

Abstract

Objectives To analyze the agreement between self-reported race and race reported on death certificates for older (≥ 60 years) residents of São Paulo, Brazil (from 2000 to 2016) and to estimate weights to correct mortality data by race.

Methods We used data from the Health, Well-Being and Aging Study (SABE) and from Brazil's Mortality Information System. Misclassification was identified by comparing individual self-reported race with the corresponding race on the death certificate ($n = 1012$). Racial agreement was analyzed by performing sensitivity and Cohen's Kappa tests. Multinomial logistic regressions were adjusted to identify characteristics associated with misclassification. Correction weights were applied to race-specific mortality rates.

Results Total racial misclassification was 17.3% (13.1% corresponded to whitening, and 4.2% to blackening). Racial misclassification was higher for self-reported *pardos/mixed* (63.5%), followed by blacks (42.6%). Official vital statistics suggest highest elderly mortality rates for whites, but after applying correction weights, black individuals had the highest rate (45.85/1000 population), followed by *pardos/mixed* (42.30/1000 population) and whites (37.91/1000 population).

Conclusions Official Brazilian data on race-specific mortality rates may be severely misclassified, resulting in biased estimates of racial inequalities.

Keywords Heath indicators · Numerator/denominator bias · Racial inequalities · Death certificate · Self-reported race · Racial classification

Introduction

Information on race or skin color can be obtained through different methods, such as self-reporting or decided by an external observer. Although there are several ways to measure race, racial self-classification is included in the Census of most countries (Morning 2008; Loveman 2009; Office for National Statistics 2012; Statistics New Zealand - Tatuaranga Aotearoa 2013; Strmic-Pawl et al. 2018) and is frequently considered an appropriate racial information source for studying health disparity from vital statistics, disease and illness rates as well as demographic changes on racial information (Roth 2016). However, vital health statistic indicators rely on numerator data from death certificates, which frequently use the race assigned by the person who filled out the form (e.g., the attending physician). This may lead to a numerator/denominator bias when measuring racial inequalities in health, where the denominator comes from self-reported race (frequently the Census), while the numerator is provided from death certificates (Travassos and Williams 2004; Chiavegatto Filho et al. 2014).

Despite reports of racial misclassification for some minority groups, racial segregation in most developed countries has limited the number of interracial relationships, and racial boundaries are still relatively well-defined

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s00038-019-01321-1) contains supplementary material, which is available to authorized users.

✉ Hellen Geremias dos Santos
hellen.santos@fiocruz.br

1 Carlos Chagas Institute, Oswaldo Cruz Foundation, Rua Professor Algacyr Munhoz Mader, 3775, Cidade Industrial, Curitiba, Paraná CEP 81350-010, Brazil

2 Department of Epidemiology, School of Public Health, University of São Paulo, São Paulo, Brazil

3 Department of Medical-Surgical Nursing, School of Nursing, University of São Paulo, São Paulo, Brazil

4 Department of Social and Behavioral Sciences, Harvard T.H. Chan School of Public Health, Boston, USA

(Travassos and Williams 2004). Brazil, on the other hand, has a long history of interracial marriage, despite the frequently reported presence of 'interviewer whitening', where the race of an individual is whitened when described by another person (Bastos et al. 2008). If this is the case for death certificates, whites will have an artificially higher mortality rate, and therefore, a lower life expectancy.

Chiavegatto Filho et al. (2014) applied a correction factor based on a survey conducted by the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística - IBGE*) to correct racial life expectancy at birth. While, originally, mixed races in Brazil had higher life expectancy than whites, despite having much lower socioeconomic indicators, this correction led to a considerably higher life expectancy at birth for whites (Chiavegatto Filho et al. 2014).

However, it is still unknown if interviewer whitening is happening on death certificates, and if the tendency is similar to the one found on surveys. The present study sought to analyze the agreement between self-reported race and race reported on death certificates from older (≥ 60 years) residents of São Paulo, Brazil, and then, to estimate weights to correct mortality data by race.

Methods

Study design and participants

We used data from the Health, Well-Being and Aging Study (SABE), and from the Mortality Information System (MIS) of São Paulo, Brazil. SABE is a representative sample of community-dwelling older adults (≥ 60 years) of the municipality of São Paulo, Brazil. Details of the sampling approach have been previously described (Lebrão and Duarte 2003). Briefly, a sample of elderly residents was interviewed in three waves: 2143 older adults in 2000; 1413 in 2006 (1115 reassessed individuals and a new probabilistic cohort of 298); and 1345 in 2010 (978 reassessed individuals and a new probabilistic cohort of 367), totaling 2808 older adults interviewed. The MIS is the official Brazilian death registration system coordinated by the Ministry of Health and its main source of information is the death certificate (DC), completed by a physician according to the model provided by the International Classification of Diseases (ICD) (World Health Organisation 2016).

For the present study, we considered the individuals who died up to September 2016. Mortality data for the SABE study was obtained by probabilistic linkage between SABE and the MIS of the municipality of São Paulo, using the indirect method and the phonetic algorithm Soundex, both from Link Plus software (available in https://www.cdc.gov/cancer/npcr/tools/registryplus/lp.htm). For this procedure, we considered the subject's name, birth date, and mother's name as matching variables, and gender as a blocking variable. All pairs with score above 1 where manually checked and, when necessary, the address was also added as a matching variable. We performed a manual review since we did not have information about death occurrences for SABE participants before the linkage procedure. A total of 39.7% ($n = 1115$) of the 2.808 elderly previously interviewed where paired with MIS records. Among paired individuals, 43.8% reported ≥ 4 years of formal education and 31.0% sufficient income, while for non-paired individuals, these values were 54.0% and 36.8%, respectively. Regarding self-reported racial distribution, paired individuals were 71.6% whites, 18.3% *pardos* and 5.8% blacks, while non-paired were 64.6%, 26.2% and 5.3%, respectively (supplementary Table 1).

We considered race as a social construct, therefore subject to changes over time, depending on the situational context and political definition (i.e., influenced by historic, economic, cultural factors and other individual and collective characteristics) (Williams 1997). Since the SABE study is composed of three follow-up waves, the same individual may have been interviewed in different waves (supplementary Table 2). For racial comparisons with DC data, we used the last reported race/skin color, as it is the closest to the moment of death.

The official classification of race/skin color in Brazil consists of five categories—white (*branco*), *pardo* (official term for the admixed population), black (*preto*), Asian (*amarelo*) and indigenous (*indígena*). In the SABE Study, race was self-reported and obtained from the question: '*Which of the following races/skin colors best describes you*?' If the response was 'some other race' (not included in the official classification) or 'not known'/'no answer' racial categories, we used the self-reported race/skin color from the immediately preceding wave ($n = 15$, 1.3%). Individuals whose most recent self-classification defined as indigenous ($n = 4$, 0.4%) or Asian ($n = 37$, 3.3%) were excluded from the misclassification analyses because of low prevalence. Additionally, self-reported race/skin colors that were not recognized by the official classification were discarded ($n = 11$, 1.0%). The same procedures were adopted for MIS racial classification records ($n = 52$, 4.7%).

Statistical analyses

We first performed descriptive analyses to investigate longitudinal changes in self-reported race. The analysis of racial misclassification considered race self-reported on SABE as the reference for comparison with the DC classification. Racial misclassification was also subdivided into whitening (self-reported *pardo* or black that had their race reported as white in the DC; and self-reported black that had their race reported as *pardo*) and blackening (self-reported white that had their race reported as *pardo* or black in the DC; and self-reported *pardo* that had their race reported as black in the DC).

Two statistical estimates of DC misclassification were calculated. First, record-level agreement was estimated between SABE and the DC through sensitivity, i.e., the percentage of respondents in a SABE self-identified racial group who are correctly identified on the DC (Arias et al. 2016). Second, we analyzed agreement between the SABE and MIS racial information with Cohen's kappa (k) statistics with a 95% confidence interval (95% CI). We used the judgment for the estimated kappa on the extent of agreement given by Landis and Koch (1977): $k < 0.00$ (no agreement), from 0.00 to 0.20 (slight agreement), from 0.21 to 0.40 (fair agreement), 0.41 to 0.60 (moderate agreement), 0.61 to 0.80 (substantial agreement), 0.81 to 1.00 (almost perfect agreement).

Additionally, we used multinomial logistic regression to identify possible associations of individual characteristics with racial misclassification, such as self-rated health, presence of health insurance, number of noncommunicable diseases, demographic (sex and age at death) and socioeconomic (schooling and assessment of sufficient income) characteristics, and the underlying cause of death from the DC.

Finally, to calculate official mortality rates (per 1000 population) for whites, *pardos* and blacks, we used population data from the 2010 Census and death records from the 2015 MIS data, totaling 1,277,711 individuals (950,919 whites, 248,216 *pardos* and 78,576 blacks) and 50,149 deaths (39,650 whites, 7583 *pardos* and 2916 blacks) of elderly residents of the municipality of São Paulo. For the adjusted race-specific mortality rates, the number of death records from each racial category was corrected by a weighted sum based on each classification error (supplementary Table 3). For example, for those self-reported as whites, we calculated three correction weights: one corresponding to those who had their race correctly informed as white in the DC (ω_1 = white on SABE and DC divided by total white race on DC records = 732/(732 + 107 + 8) = 0.86), another to those misclassified as *pardo* on the DC (ω_2 = white on SABE and *pardo* in the DC divided by total *pardo* on DC records = 27/(27 + 70 + 18) = 0.23), and another to those that had their race informed as black (ω_3 = white on SABE and black in the DC divided by total black in DC = 0.00). Therefore, the number of white deaths was adjusted as 0.86 * white deaths + 0.23 * *pardo* deaths + 0.00 * black deaths; and then a new mortality rate for whites was calculated (Chiavegatto Filho et al. 2014). The correction weights were used to adjust the number of race-specific deaths for the overall elderly population ($\geq$ 60 years) and for age groups 60–74, 75–79 and $\geq$ 80 years. All analyses were performed using the R software.

The SABE Study received approval from the National Ethics Commission and the Human Research Ethics Committee of the Public Health School of the University of São Paulo, protocol numbers 315/99, 83/06 and 2044. All subjects gave informed consent, and individual anonymity was preserved.

Results

From the total of 1115 individuals, 51.7% were female, mean education was 3.2 years of schooling (SD 3.4), 69.0% of individuals considered their income insufficient to cover their daily expenses, 29.0% reported having health insurance, 45.5% mentioned two or more noncommunicable diseases, and 60.0% self-rated their health as regular or poor/very poor. Mean age at death was 82.9 years (SD 8.8) and the most frequent underlying causes of death were those related to the circulatory system (39.7%).

Regarding changes over time on self-reported race (supplementary Table 4), 79.2% (n = 415) of the reassessed elderly maintained the same race/skin color. For the most recent self-reported race, 71.1% (n = 793) of individuals classified themselves as white, 18.5% (n = 206) as *pardo*, and 5.7% (n = 63) as black, with these three representing 95.2% (n = 1062) of total records (n = 1115).

Of these individuals, 1012 had their race classified in the DC, and racial misclassification was 17.3% (n = 175): 13.1% (n = 133) corresponded to whitening and 4.2% (n = 42) to blackening. There was a higher frequency of racial misclassification for *pardo* self-reported race (63.5%), followed by blacks (42.6%). Self-reported *pardo* was more frequently erroneous classified in the DC as white (n = 107, 55.7%), followed by self-reported black as *pardo* (n = 18, 29.5%) (supplementary Table 3).

Agreement was higher for individuals with age at death $\geq$ 85 years (k = 0.54), schooling $\geq$ 4 years (k = 0.57) that considered their income sufficient to cover daily expenses (k = 0.55) (Table 1), with health insurance (k = 0.57), without noncommunicable diseases (k = 0.56) and with good/very good self-rated health (k = 0.56) (supplementary Table 5).

Record-level agreement based on sensitivity was close to 100% only for whites. There was also a general tendency toward whitening in cases of inconsistency: for self-reported *pardo*, the white category was declared 7 times more often than black; and for self-report black, *pardo* category was declared twice more than white.

Table 1 Agreement between self-reported race on Health, Well-Being and Aging Study (SABE) and racial information on the death certificate according to demographic and socioeconomic characteristics, Brazil, São Paulo, 2000–2016

Self-reported race	*n*	Race on death certificate (%)[a]			Kappa	CI 95%
		White	Pardo	Black		
Whole sample						
White	759	96.4	3.6	0.0	0.50	0.44; 0.57
Pardo	192	55.7	36.5	7.8		
Black	61	13.1	29.5	57.4		
Sex						
Male						
White	365	96.7	3.3	0.0	0.50	0.40; 0.60
Pardo	89	55.1	34.8	10.1		
Black	31	22.6	19.4	58.1		
Female						
White	394	96.2	3.8	0.0	0.50	0.41; 0.60
Pardo	103	56.3	37.9	5.8		
Black	30	3.3	40.0	56.7		
Age at death, years						
60–74						
White	115	93.0	7.0	0.0	0.47	0.32; 0.61
Pardo	40	55.0	40.0	5.0		
Black	15	20.0	26.7	53.3		
75–84						
White	260	96.5	3.5	0.0	0.50	0.34; 0.58
Pardo	64	56.2	32.8	10.9		
Black	17	11.8	41.2	47.1		
≥ 85						
White	384	97.4	2.6	0.0	0.54	0.45; 0.64
Pardo	88	55.7	37.5	6.8		
Black	29	10.3	24.1	65.5		
Schooling, years						
< 4						
White	379	94.5	5.5	0.0	0.46	0.38; 0.54
Pardo	137	56.2	35.0	8.8		
Black	45	13.3	31.1	55.6		
≥ 4						
White	362	98.8	1.1	0.0	0.57	0.43; 0.70
Pardo	43	58.1	34.9	7.0		
Black	15	13.3	20.0	66.7		
Sufficient income						
Yes						
White	249	98.0	2.0	0.0	0.55	0.41; 0.69
Pardo	41	51.2	41.5	7.3		
Black	11	27.3	18.2	54.5		
No						
White	500	95.6	4.4	0.0	0.48	0.41; 0.56
Pardo	143	57.3	34.3	8.4		
Black	49	10.2	30.6	59.2		

[a]Principal diagonal represents sensitivity measure

Both whitening and blackening in the DC was more frequent among elderly with low education and without health insurance (Table 2). Additionally, a higher frequency of whitening was observed among individuals who considered their income insufficient to cover their daily expenses, that mentioned regular or poor/very poor self-rated health, and with age of death between 60 and 74 years.

Overall, the correction weights indicate that there were more white individuals (and therefore less *pardo*/black) in the DC than it was expected based on SABE records. Figure 1 compares the official mortality age-specific rates unadjusted and adjusted for the correction weights found for this study. Originally, whites had higher overall mortality rates than *pardo* and blacks. After applying the correction weights, black individuals had the highest mortality rates (45.85/1000 population), followed by *pardo* (42.30/1000 population) and whites (37.91/1000 population).

Discussion

The study brings new insights to the literature on racial inequalities in health in an increasingly multiracial world. Agreement between self-reported race and death certificate information was found to be considerably higher for

Table 2 Distribution of deaths according to misclassification and individual characteristics, Brazil, São Paulo, 2000–2016

Variable	Total	Racial misclassification			
		Whitening		Blackening	
		n (%)	OR (95% CI)	*n* (%)	OR (95% CI)
Total	1012	133 (13.1)		42 (4.2)	
Sex					
Male	485	62 (12.8)	0.94 (0.65; 1.36)	21 (4.3)	1.08 (0.58; 2.01)
Female	527	71 (13.5)	Reference	21 (4.0)	Reference
Age at death, years					
60–74	170	33 (19.4)	2.03 (1.26; 3.27)*	10 (5.9)	2.26 (0.99; 5.15)
75–84	341	45 (13.2)	1.26 (0.82; 1.92)	16 (4.7)	1.64 (0.80; 3.37)
≥ 85	500	55 (11.0)	Reference	15 (3.0)	Reference
Schooling, years					
< 4	561	97 (17.3)	2.87 (1.87; 4.43)**	33 (5.9)	4.20 (1.83; 9.61)**
≥ 4	420	30 (7.1)	Reference	7 (1.7)	Reference
Sufficient income					
Yes	301	26 (8.6)	Reference	8 (2.7)	Reference
No	692	102 (14.7)	1.88 (1.20; 2.97)*	34 (4.9)	2.04 (0.93; 4.47)
Health insurance					
Yes	283	18 (6.4)	Reference	5 (1.8)	Reference
No	729	115 (15.8)	2.88 (1.72; 4.83)**	37 (5.1)	3.33 (1.30; 8.58)*
Self-rated health					
Good, very good	401	40 (9.8)	Reference	15 (3.7)	Reference
Regular, poor, very poor	608	93 (15.3)	1.65 (1.11; 2.45)*	27 (4.4)	1.28 (0.67; 2.44)
Number of noncommunicable diseases					
None	209	25 (12.0)	Reference	5 (2.4)	Reference
One	301	42 (14.0)	1.24 (0.73; 5.28)	16 (5.3)	2.36 (0.85; 6.55)
Two or more	461	56 (12.1)	1.04 (0.63; 1.73)	21 (4.6)	1.96 (0.73; 2.11)
Underlying cause of death, ICD—10					
II. Neoplasms	173	17 (9.8)	Reference	7 (4.0)	Reference
IX. Diseases of the circulatory system	400	62 (15.5)	1.71 (0.97; 3.02)	20 (5.0)	1.34 (0.55; 3.24)
X. Diseases of the respiratory system	250	31 (12.4)	1.28 (0.65; 2.47)	8 (3.2)	0.94 (0.32; 2.74)
Others	189	23 (12.2)	1.29 (0.69; 2.41)	7 (3.7)	0.81 (0.29; 2.27)

*p value < 0.05; **p value < 0.001

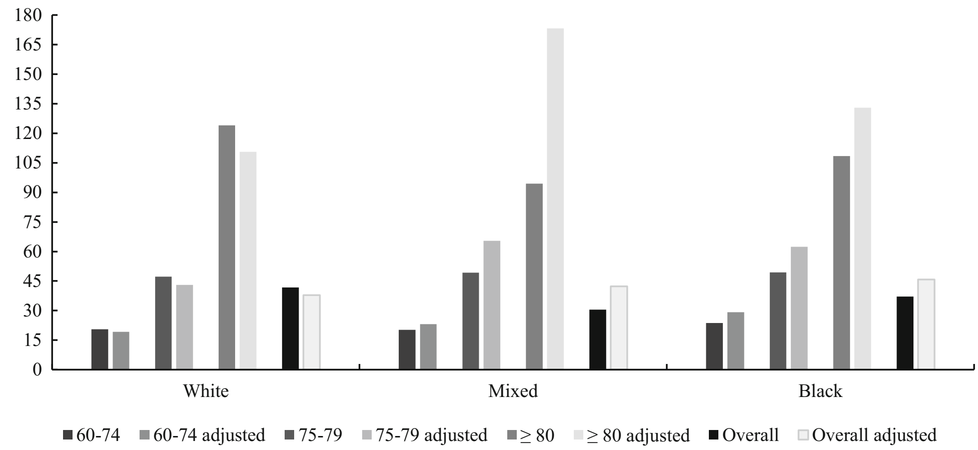

Fig. 1 Mortality age-specific rates (number of deaths per 1000 population) for whites, mixed population and blacks according to unadjusted and adjusted official data, Brazil, São Paulo, 2015

whites, but poor for the other racial categories. Regarding individual characteristics, we found higher agreement between SABE and MIS for individuals with better socioeconomic and health status. After applying the correction weights, black individuals had the highest mortality rate, followed by *pardos* and whites, respectively.

Previous studies show that racial classification performed by an interviewer tends to overestimate the number of whites when compared to self-reported data. Bastos et al. (2008) performed a study in the urban area of the municipality Pelotas, Brazil, to compare self-reported and interviewer-classified race/skin color for individuals aged 20 years or older. Although the results indicated an overall good agreement, a tendency was observed for whitening individuals with better socioeconomic status, as well as a higher chance of being categorized as *pardo* or black among those with lower education and family income (Bastos et al. 2008). Our results found a higher frequency of whitening than blackening on death certificates, and both racial misclassifications were more prevalent among individuals with worse socioeconomic status.

When analyzing official data, we observed a higher mortality rate for whites when compared to black and *pardo* elderly. These results are inconsistent with the large socioeconomic disparities in race in Brazil. Both black and *pardo* individuals are historically socio-economically disadvantaged compared to whites. According to the last national Census from 2010, whites earned an average monthly income 1.95 times higher than black individuals and 2.13 times higher than *pardo* ones (Instituto Brasileiro de Geografia e Estatística 2018). After correction for misclassification on the death certificate, our results showed a higher mortality rate for blacks, followed by *pardos* and whites, respectively.

Since information about vital statistics is of great interest in public health planning, correction weights could help monitoring the racial inequality burden as well as in formulating public policies for reducing these inequalities (Mays et al. 2003; Chiavegatto Filho et al. 2014).

Similarly, in the USA, although the average socioeconomic status of Hispanics is lower than that of non-Hispanic whites, unadjusted mortality rates for the former are lower than those for the latter (Ruiz et al. 2013), which is known as the Hispanic mortality paradox. It is hypothesized that this could be due to the numerator/denominator bias, nonetheless, unlike our results, Arias et al. (2010) did not observe a large effect on mortality rates for the Hispanic and non-Hispanic population derived from correction weights. Other studies also investigated, as a possible explanation, the migratory hypothesis, where healthy individuals are more likely to emigrate and sick migrants to return to their country of origin, also with weak or no associations (Abrafdo-Lanza et al. 1999; Turra and Elo 2008).

Arias et al. (2016) analyzed the validity of racial reporting on death certificates in the USA over a three decades period (1979–1989, 1990–1998 and 1999–2011). The authors found that self-reported American Indian or Alaska Native populations were more frequently erroneously classified on the death certificate as white in all three periods. These results are similar to those observed in our analysis for the self-reported *pardo* population.

A series of analyses focused on the numerator–denominator bias was also performed for New Zealand mortality rate and cancer incidence statistics (Blakely et al. 2002; Shaw et al. 2009; Boyd et al. 2016). Overall, lower proportions of Māori, Pacific and Asian events, were observed when compared to Europeans, resulting in an underestimation of mortality rates and cancer incidence statistics (Shaw et al. 2009; Boyd et al. 2016).

Regarding individual and collective contexts influencing self-reported race, a recent study in Brazil (Chor et al. 2019), analyzed the association of genomic ancestry, racial composition of census tracts and individual socioeconomic factors with self-reported race. The authors found that the probability of an individual self-reporting as black or *pardo* increased according to the proportion of African ancestry, but was also associated with the racial composition of the area of residence, as well as educational and income individual levels. In census tracts with less than 60% blacks and *pardos*, high educational and per capita income levels reduced the odds of self-declaring as black by 63% and 49%, respectively. On the other hand, in census tracts with 60% or more blacks and browns, these socioeconomic characteristics were not associated significantly with self-declaring as black.

Possible solutions to dealing with biases regarding the absence of self-reported racial data include demanding the health provider to ask a family member about the race of the individual who died, or to use linkage techniques between census data and death certificates, considering the self-reported census data as the reference racial information (Chiavegatto Filho et al. 2014).

Our study has some limitations. First, records from SABE were linked to death certificates available on MIS and unmatched cases were presumed to be alive. Mortality follow-up studies are vulnerable to failures of the algorithm linking the survey to death records. Second, the SABE study at this time contained a sample of only 253 linked death certificate records that were self-classified as *pardo* or black according to survey responses, so is it possible that correction weights may be affected by the small sample size. Third, the correction weights were calculated from a sample of elderly living in a specific city and time periods. The degree of misclassification might be different in other Brazilian regions and the degree of racial misclassification may also change over time.

The study confirms that Brazil's blurred racial boundaries have an important effect on local racial disparities in health. As the number of interracial marriages continues to grow throughout the world, it is likely that the same challenges of measuring racial inequalities in health identified in this study will become increasingly important in other countries.

Acknowledgements We thank the Lemann Brazil Research Fund (Lemann Foundation) that funded our research.

Funding This study was funded by the Lemann Brazil Research Fund (Lemann Foundation).

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

References

Abrafdo-Lanza AF, Dohrenwend BP, Ng-Mak DS, Turner BJ (1999) The Latino mortality paradox: a test of the “Salmon Bias” and healthy migrant hypotheses. Am J Public Health 89:1543–1548

Arias E, Eschbach K, Schauman WS et al (2010) The Hispanic mortality advantage and ethnic misclassification on US death certificates. Am J Public Health 100:S171–S177. https://doi.org/10.2105/AJPH.2008.135863

Arias E, Heron M, Hakes JK (2016) The validity of race and Hispanic-origin reporting on death certificates in the united states: an update. Vital Heal Stat 2(2):1–21

Bastos JL, Peres MA, Peres KG et al (2008) Socioeconomic differences between self- and interviewer-classification of color/race. Rev Saude Publica 42:324–334

Blakely T, Robson B, Atkinson J et al (2002) Unlocking the numerator-denominator bias. I: adjustments ratios by ethnicity for 1991–1994 mortality data. The New Zealand census-mortality study. N Z Med J 114:39–43

Boyd M, Atkinson J, Blakely T (2016) Ethnic counts on mortality, New Zealand cancer registry and census data: 2006–2011. N Z Med J 129:22–39

Chiavegatto Filho ADP, Beltrán-Sánchez H, Kawachi I (2014) Racial disparities in life expectancy in Brazil: challenges from a multiracial society. Am J Public Health 104:2156–2162. https://doi.org/10.2105/AJPH.2013.301565

Chor D, Pereira A, Pacheco AG et al (2019) Context-dependence of race self-classification: results from a highly mixed and unequal middle-income country. PLoS ONE 14:1–17. https://doi.org/10.1371/journal.pone.0216653

Instituto Brasileiro de Geografia e Estatística (2018) Censo 2010. In: SIDRA—Banco Tabelas Estatísticas

Landis JR, Koch GG (1977) The measurement of observer agreement for categorical data. Biometrics 33:159–174

Lebrão ML, Duarte YA de O (2003) O projeto SABE no município de São Paulo: uma abordagem inicial. Organ. Pan-Americana Saúde

Loveman M (2009) Whiteness in Latin America: measurement and meaning in national censuses (1850–1950). J Soc Am 95:207–234. https://doi.org/10.4000/jsa.11085

Mays VM, Ponce NA, Washington DL, Cochran SD (2003) Classification of race and ethnicity: implications for public health. Annu Rev Public Health 24:83–110. https://doi.org/10.1146/annurev.publhealth.24.100901.140927

Morning A (2008) Ethnic classification in global perspective: a cross-national survey of the 2000 census round. Popul Res Policy Rev 27:239–272. https://doi.org/10.1007/s11113-007-9062-5

Office for National Statistics (2012) Ethnicity and national identity in England and Wales, pp 1–15. https://www.ons.gov.uk. Accessed 1 Feb 2018

Roth WD (2016) The multiple dimensions of race. Ethn Racial Stud 39:1310–1338. https://doi.org/10.1080/01419870.2016.1140793

Ruiz JM, Steffen P, Smith TB (2013) Hispanic mortality paradox: a systematic review and meta-analysis of the longitudinal literature. Am J Public Health 103:e52–e60. https://doi.org/10.2105/AJPH.2012.301103

Shaw C, Atkinson J, Blakely T (2009) (Mis)classification of ethnicity on the New Zealand cancer registry: 1981–2004. N Z Med J 122:10–22

Statistics New Zealand - Tatuaranga Aotearoa (2013) Individual form New Zealand census of population and dwellings. Census 13–16

Strmic-Pawl HV, Jackson BA, Garner S (2018) Race counts: racial and ethnic data on the U.S. census and the implications for tracking inequality. Sociol Race Ethn 4:1–13. https://doi.org/10.1177/2332649217742869

Travassos C, Williams DR (2004) The concept and measurement of race and their relationship to public health: a review focused on Brazil and the United States. Cad Saude Publica 20:660–678. https://doi.org/10.1590/S0102-311X2004000300003

Turra CM, Elo IT (2008) The impact of salmon bias on the Hispanic mortality advantage: new evidence from social security data. Popul Res Policy Rev 27:515–530. https://doi.org/10.1007/s11113-008-9087-4

Williams R (1997) Race and health. Lancet 1:410–411. https://doi.org/10.1016/S0140-6736(85)91438-2

World Health Organisation (2016) ICD-10 Version: 2016. Who http://apps.who.int/classifications/icd10/browse/2. Accessed 1 Feb 2018

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.