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Increasing Black:White disparities in breast cancer mortality in the 50 largest cities in the United States

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ABSTRACT

Introduction: This paper presents race-specific breast cancer mortality rates and the corresponding rate ratios for the 50 largest U.S. cities for each of the 5-year intervals between 1990 and 2009. *Methods*: The 50 largest cities in the U.S. were the units of analysis. Numerator data were abstracted from national death files where the cause was malignant neoplasm of the breast (ICD-9 = 174 and ICD-10 = C50) for women. Population-based denominators were obtained from the U.S. Census Bureau for 1990, 2000, and 2010. To measure the racial disparity, we calculated non-Hispanic Black:non-Hispanic White rate ratios (RRs) and confidence intervals for each 5-year period. *Results*: At the final time point (2005–2009), two RRs were less than 1, but neither significantly so, while 39 RRs were >1, 23 of them significantly so. Of the 41 cities included in the analysis, 35 saw an increase in the Black:White RR between 1990–1994 and 2005–2009. In many of the cities, the increase in the disparity occurred because White rates improved substantially over the 20-year study period, while Black rates did not. There were 1710 excess Black deaths annually due to this disparity in breast cancer mortality, for an average of about 5 each day. *Conclusion*: This analysis revealed large and growing disparities in Black:White breast cancer mortality in the U.S. and many of its largest cities during the period 1990–2009. Much work remains to achieve equality in breast cancer mortality outcomes.

1. Introduction

It is estimated that 232,340 women will be diagnosed with breast cancer this year and 39,620 will die from it [1]. Racial disparities are prominent. For example, the 2006–2010 age-adjusted breast cancer incidence rate for non-Hispanic White (White) women in the United States was 127.4 (per 100,000 women per year) compared to 121.4 for non-Hispanic Black (Black) women [1]. This yields a Black:White rate ratio (RR) of 0.95. For the same period, the mortality rates were 22.1 (age-adjusted, per 100,000 women per year) for White women and 30.8 for Black women (RR = 1.39) [1]. Thus, while White women are more likely to be diagnosed with breast cancer, Black women are more likely to die from it.

A recent analysis by Whitman et al. [2] showed that the Black:White mortality disparity observed at the national level is seen in many of the nation's largest cities as well. The authors reported significant RRs in 13 of the 25 biggest U.S. cities in 2005–2007. Another analysis by Whitman et al. [3] examined the mortality rates for Black and White women during the period 1980–2005 for Chicago, New York City, and the U.S. The authors found that the disparity in breast cancer mortality emerged in the 1990s. The findings from each of these analyses sparked interest in an expanded analysis that would include more cities and points in time. To that end, this paper presents race-specific breast cancer mortality rates and the corresponding rate ratios for the 50 largest U.S. cities for each of the 5-year intervals between 1990 and 2009. Our previous analysis is thus expanded from 25 to 50 cites and from a single time period to 20 years. Special attention is paid to how these disparities changed over this time interval as this has practical implications for interventions related to screening, diagnosis, and treatment.

2. Methods

The 50 most populous cities were determined using 2005 U.S. Census data [4]. Deaths where the cause was malignant neoplasm of the breast (ICD-9 = 174 and ICD-10 = C50) for women were included in this analysis. Numerator data for 1990–2009 were abstracted from death files obtained from the National Center for

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Health Statistics [5]. Five-year average annual rates were calculated for 1990–1994 (T1), 1995–1999 (T2), 2000–2004 (T3), and 2005–2009 (T4).

Population-based denominators for the non-Hispanic White (White) and non-Hispanic Black (Black) populations were obtained from the U.S. Census Bureau for 1990, 2000, and 2010. Population-based denominators for years other than 1990, 2000, and 2010 were estimated using linear interpolation. For each of the two data sources – the census and the death files – Black and White classifications were obtained by cross-tabulating two self-report variables: Hispanic ethnicity and racial identity. Age-adjusted rates per 100,000 population were calculated employing the year 2000 standard U.S. population.

Nine cities were excluded from this analysis. Population data were not available at the city-level for two cities (Louisville/Jefferson County, KY and Nashville/Davidson, TN). An additional seven cities (Albuquerque, NM; Arlington, TX; Colorado Springs, CO; El Paso, TX; Mesa and Tucson, AZ; San Jose, CA) were excluded because either all four time points or time points 1 and 4 (1990–1994 and 2005–2009, respectively) had fewer than 20 Black deaths due to small Black population size. This left 41 cities for analysis. These deletions are in accordance with research showing that mortality rates based on less than 20 deaths can be unreliable [6,7]. There were no cities for which there were fewer than 20 White deaths.

2.1. Statistical analysis

The disparity in breast cancer mortality was measured by calculating the Black:White rate ratio (RR) for each city at each time period. An RR of 1.00 indicates no disparity between the Black and White mortality rates. An RR less than 1.00 indicates that the White rate is higher than the Black rate, while an RR greater than 1.00 indicates that the Black rate is higher than the White rate. An RR was considered statistically significant if the 95% confidence interval did not contain 1.00. Confidence intervals for the RRs were calculated using a Taylor series expansion technique [8]. Chi-square tests were employed to examine the differences in the distributions of the disparities over time. All data were analyzed using SAS v 9.2 [9].

Excess deaths due to the racial disparity in breast cancer mortality are calculated by multiplying the age-specific White mortality rates by the corresponding Black populations in each age category. The sum of these products is the number of Black deaths that would be expected if White death rates were applied to this population. We then subtracted the number of expected deaths from the number of observed deaths to obtain the excess number of deaths for each city.

3. Results

Table 1 presents the age-adjusted breast cancer mortality rates for Black and White women in 1990–1994 (T1), 1995–1999 (T2), 2000–2004 (T3), and 2005–2009 (T4), and the corresponding racial rate ratios and confidence intervals. The cities are arranged in descending order by largest to smallest 2005–2009 rate ratio. The RR in the U.S. was 1.17 at T1 and it grew steadily to 1.40 by T4. The smallest city, Raleigh, had an initial RR of 0.82 (not significant) which grew to 1.46 by T4. The largest city, New York City, had a T1 RR of 1.18, which remained virtually the same at T4 (1.19). Memphis had the largest RR (2.11) at T4, up from 1.27 at T1, and New York City had the smallest (while remaining significant) RR at T4 (1.19).

Bold-faced rate ratios indicate statistical significance. At T4, no rate ratios are significantly less than 1 but 23 are significantly greater than 1. Note that 35 of the 41 cities saw an increase in the Black:White RR between T1 and T4. Furthermore, 24 of the cities (59%), as well as the U.S., saw an increase in the Black:White RR of 0.2 or more, an empirically derived cut point indicative of notable change in this analysis. These observations demonstrate that the Black:White breast cancer mortality disparity worsened in the majority of cities over this 20-year period.

Table 2 displays the within race T4:T1 rate ratios for Blacks and Whites. For example, in the U.S., the Black rate was 37.5 at T1 and 32.6 at T4 (Table 1), yielding a T4:T1 RR = 0.87 (Table 2). At the same time, the T4:T1 RR for Whites was 0.73 (23.3/32.0). In other words, the White rate decreased by about 20% more than the Black rate over this period, resulting in an increase in the Black:White RR from 1.17 at T1 to 1.40 at T4 (Table 1). In Los Angeles the Black rate was 45.1 at T1 and 45.6 at T4, yielding a T4:T1 RR = 1.01. At the same time, the T4:T1 RR for Whites was 0.73 (26.7/36.5). Thus, while the Black rate increased by a very small amount, the White rate decreased by 27%, resulting in an increase in the Black:White RR from 1.24 at T1 to 1.71 at T4. In Chicago, the Black rate was 41.7 at T1 and 36.5 at T4, resulting in a T4:T1 RR = 0.87, while the White rate declined from 38.7 to 24.6 (resulting in a within race RR = 0.64). These changes increased the Black:White RR from 1.08 at T1 to 1.48 at T4.

In Memphis, the Black rate declined slightly from 46.3 to 44.3 (T4:T1 RR = 0.93) while the White rate declined from 36.4 to 21.0 (T4:T1 RR = 0.58). These changes resulted in an increase in the Black:White RR from 1.27 at T1 to 2.11 at T4. Overall, of the 41 cities, 16 showed a decrease of less than 10% for the Black breast cancer mortality rate and a decrease of more than 20% for the White rate, resulting in substantially increased disparities over this 20-year time interval.

Table 2 also contains the number of excess Black deaths due to the racial disparity for each city. This excess number is a function of the size of the disparity and the size of the population of each area. Rates are only calculated for those cities for which the disparity is statistically significant. As can be seen, the annual number of Black excess deaths in the United States at T4 was 1710. In Memphis, which had the largest disparity, the number was 43. Chicago had the largest number of annual excess deaths of any of these cities (61) even though New York City (56) is more than twice as populous (but had a much smaller RR).

Table 3 contains the frequency distributions of the Black:White rate ratios for each interval. Whereas at T1 the majority of cities (78%) displayed an RR of 1.2 or less, by T4 only 37% were in this category. Similarly, while only one city displayed an RR greater than 1.41 at T1, this number had risen to 16 (39%) by T4 and two of these cities displayed an RR greater than 1.70 at this point: Los Angeles (RR = 1.71) and Memphis (RR = 2.11). In addition, the proportion of disparities greater than 1.2 rose from 22% at T1, to 60% at T2, to 58% at T3, and to 63% at T4. A chi-square test comparing the T1 and T4 distributions indicates that they are significantly different ($p < 0.0001$). Comparisons between T1 and T2 and T1 and T3 reveal similarly significant differences in the distributions (Yates' $p < 0.005$ for each).

The time trends for the RRs are presented graphically in Fig. 1. New York City, Los Angeles, Chicago, Memphis, and the U.S. have been selected to illustrate various trends. Note that the T1 RRs for all 4 cities and the U.S. are between 1.0 and 1.3. By T4, only one of these (New York City) maintains an RR less than 1.3. Despite the fact that we observe an increase in the RRs between T1 and T4 for all four cities and the U.S., the slopes of the five lines vary substantially. In the U.S., the RR increases steadily from 1.17 at T1 to 1.40 at T4. In New York City, the RR starts at 1.18 at T1, drops slightly at T2, and then increases slightly at T3 and T4, producing an overall increase of only 0.01. In Los Angeles, the RR at T1 is 1.24; this number increases sharply at T2, decreases at T3, and then jumps again at T4 to 1.71 – a large increase from the T1 RR. Chicago's T1 RR of 1.08 increases steadily for T2 and T3, and drops

Table 1
Five-year estimates of the breast cancer mortality rates of and disparities between non-Hispanic Black (Black) and non-Hispanic White (White) Women for 41 of the 50 largest cities in the United States, 1990–2009.

	1990–1994 (T1)				1995–1999 (T2)				2000–2004 (T3)				2005–2009 (T4)			
City, State (largest to smallest 2005-09 RR)	Black rate[a]	White rate[a]	Rate ratio[*]	95% CI	Black rate	White rate	Rate ratio	95% CI	Black rate	White rate	Rate ratio	95% CI	Black rate	White rate	Rate ratio	95% CI
U.S.	37.5	32.0	**1.17**	1.16–1.19	37.4	28.8	**1.30**	1.28–1.32	34.9	25.9	**1.35**	1.33–1.37	32.6	23.3	**1.40**	1.38–1.42
Memphis, TN	46.3	36.4	**1.27**	1.09–1.48	41.4	30.0	**1.38**	1.16–1.63	38.9	24.6	**1.58**	1.32–1.89	44.3	21.0	**2.11**	1.75–2.55
Los Angeles, CA	45.1	36.5	**1.24**	1.12–1.37	47.5	31.9	**1.49**	1.34–1.65	39.1	29.0	**1.35**	1.20–1.51	45.6	26.7	**1.71**	1.53–1.90
Wichita, KS	33.8	35.5	0.95	0.61–1.49	56.4	28.1	**2.01**	1.44–2.80	48.3	31.4	**1.54**	1.09–2.16	38.0	24.3	**1.57**	1.08–2.27
Houston, TX	46.4	40.2	**1.15**	1.02–1.30	42.2	37.9	1.11	0.99–1.25	41.2	33.2	**1.24**	1.10–1.40	44.8	29.7	**1.51**	1.34–1.70
Boston, MA	37.0	39.2	0.94	0.75–1.18	28.2	32.9	0.86	0.67–1.09	34.6	31.7	1.09	0.87–1.36	33.4	22.4	**1.49**	1.18–1.88
Denver, CO	37.9	34.6	1.10	0.81–1.48	42.2	29.7	**1.42**	1.07–1.89	22.7	24.7	0.92	0.64–1.32	29.9	20.1	**1.49**	1.08–2.04
Chicago, IL	41.7	38.7	1.08	0.99–1.17	40.3	33.4	**1.21**	1.11–.131	40.4	27.2	**1.49**	1.35–1.63	36.5	24.6	**1.48**	1.34–1.64
Phoenix, AZ	35.3	34.2	1.03	0.72–1.48	37.8	30.0	1.26	0.91–1.74	41.3	24.5	**1.69**	1.25–2.27	33.3	22.6	**1.48**	1.09–2.00
Dallas, TX	44.5	32.0	**1.39**	1.19–1.63	36.8	27.7	**1.33**	1.13–1.57	40.7	24.6	**1.65**	1.41–1.94	34.3	23.4	**1.47**	1.24–1.74
Indianapolis, IN	38.6	34.5	1.12	0.93–1.35	35.9	32.1	1.12	0.93–1.34	30.7	27.4	1.12	0.92–1.36	37.8	25.8	**1.46**	1.23–1.74
Raleigh, NC	29.4	35.7	0.82	0.55–1.22	39.5	28.4	1.39	0.99–1.95	24.6	22.0	1.12	0.78–1.61	31.5	21.5	**1.46**	1.07–1.99
Fort Worth, TX	40.1	33.2	1.21	0.94–1.55	39.6	31.2	1.27	0.99–1.62	40.1	27.6	**1.45**	1.14–1.84	35.0	24.2	**1.44**	1.14–1.83
Jacksonville, FL	31.7	30.4	1.04	0.84–1.29	37.9	32.1	1.18	0.98–1.42	32.9	29.3	1.12	0.93–1.36	38.8	26.9	**1.44**	1.21–1.71
San Diego, CA	48.9	33.8	**1.45**	1.13–1.86	38.1	31.3	1.22	0.94–1.59	38.4	29.9	1.28	1.00–1.65	36.6	25.4	**1.44**	1.11–1.87
Philadelphia, PA	44.9	41.2	1.09	0.99–1.20	40.5	35.0	**1.16**	1.05–1.28	37.4	32.9	**1.14**	1.02–1.26	36.7	25.6	**1.43**	1.28–1.60
Washington, DC	46.1	33.2	**1.39**	1.15–1.68	45.9	28.9	**1.59**	1.30–1.94	36.7	29.4	**1.25**	1.02–1.53	34.4	24.3	**1.42**	1.14–1.77
Milwaukee, WI	35.5	37.7	0.94	0.75–1.17	31.9	31.6	1.01	0.81–1.26	29.6	26.6	1.11	0.89–1.39	27.7	20.1	**1.38**	1.08–1.75
Oakland, CA	36.3	32.7	1.11	0.86–1.43	36.3	28.6	1.27	0.97–1.65	32.4	29.8	1.09	0.83–1.44	34.5	25.4	**1.36**	1.02–1.80
Austin, TX	42.8	31.5	1.36	0.98–1.89	40.2	28.1	**1.43**	1.04–1.96	33.5	25.2	1.33	0.96–1.84	31.6	23.6	1.34	0.96–1.87
Kansas City, MO	37.3	34.1	1.09	0.88–1.37	38.6	29.0	**1.33**	1.07–1.66	35.6	25.2	**1.42**	1.13–1.78	34.7	25.9	**1.34**	1.07–1.68
Columbus, OH	34.0	34.4	0.99	0.79–1.24	38.5	34.4	1.12	0.91–1.37	35.6	27.2	**1.31**	1.07–1.61	35.9	26.9	**1.34**	1.10–1.62
Oklahoma City, OK	31.7	30.0	1.05	0.77–1.45	32.8	26.1	1.26	0.93–1.70	38.6	26.6	**1.45**	1.11–1.91	29.3	22.9	1.28	0.96–1.71
Cleveland, OH	39.9	40.1	1.00	0.84–1.19	44.0	38.3	1.15	0.96–1.37	37.6	35.0	1.07	0.89–1.30	35.2	27.6	**1.28**	1.03–1.58
Baltimore, MD	37.2	32.1	1.16	1.00–1.35	39.9	38.1	1.05	0.90–1.21	37.5	33.1	1.13	0.96–1.33	32.1	25.5	**1.26**	1.04–1.52
San Antonio, TX	33.0	36.7	0.90	0.67–1.20	40.7	33.6	1.21	0.94–1.56	41.6	31.3	**1.33**	1.04–1.70	34.4	27.6	1.24	0.96–1.61
San Francisco, CA	47.3	35.6	**1.33**	1.05–1.68	41.4	32.6	1.27	0.98–1.64	47.1	29.3	**1.61**	1.25–2.06	29.1	23.9	1.22	0.89–1.66
Seattle, WA	31.0	34.4	0.90	0.63–1.30	45.1	34.7	1.30	0.96–1.76	36.0	24.7	**1.46**	1.04–2.04	30.3	25.4	1.19	0.84–1.71
New York, N.Y.	36.2	30.8	**1.18**	1.11–1.25	37.6	34.4	**1.09**	1.03–1.15	32.7	29.8	**1.10**	1.03–1.16	30.8	26.0	**1.19**	1.12–1.26
Minneapolis, MN	38.0	36.9	1.03	0.67–1.59	31.1	29.8	1.04	0.68–1.60	26.8	25.7	1.04	0.65–1.67	28.2	24.4	1.16	0.78–1.73
Tulsa, OK	31.5	32.9	0.96	0.67–1.38	41.0	31.7	1.29	0.95–1.77	40.8	31.1	1.31	0.96–1.78	31.9	28.0	1.14	0.82–1.59
Charlotte, NC	39.1	35.9	1.09	0.86–1.38	38.8	28.2	**1.37**	1.10–1.72	32.1	26.9	1.19	0.96–1.49	29.1	25.9	1.12	0.91–1.38
Miami, FL	52.1	58.7	0.89	0.65–1.22	61.2	58.6	1.04	0.76–1.43	76.7	65.3	1.17	0.88–1.57	83.0	74.1	1.12	0.85–1.48
Omaha, NE	37.1	32.1	1.16	0.80–1.67	42.1	28.6	**1.47**	1.04–2.08	44.0	27.5	**1.60**	1.17–2.20	27.3	24.5	1.12	0.76–1.63
Fresno, CA	35.6	40.0	0.89	0.56–1.42	–	–	–	–	32.6	35.3	0.92	0.60–1.43	33.0	30.3	1.09	0.71–1.66
Detroit, MI	40.1	30.6	**1.31**	1.12–1.54	40.3	29.0	**1.39**	1.16–1.67	37.5	27.9	**1.34**	1.07–1.67	36.3	33.7	1.08	0.85–1.37
Portland, OR	33.0	32.7	1.01	0.64–1.59	32.1	29.4	1.09	0.71–1.68	–	–	–	–	27.2	25.4	1.07	0.69–1.66
Atlanta, GA	42.9	42.6	1.01	0.82–1.24	45.2	33.3	**1.36**	1.09–1.69	37.8	30.3	1.25	0.98–1.59	33.8	32.4	1.04	0.82–1.32
Long Beach, CA	43.7	38.6	1.13	0.78–1.64	33.8	32.5	1.04	0.70–1.56	34.1	27.4	1.24	0.86–1.80	28.2	27.3	1.03	0.71–1.51
Las Vegas, NV	44.4	44.3	1.00	0.66–1.53	44.0	41.4	1.06	0.74–1.52	45.5	46.4	0.98	0.73–1.32	45.4	44.0	1.03	0.79–1.35
Virginia Beach, VA	28.9	32.0	0.91	0.57–1.44	38.2	29.4	1.30	0.91–1.87	33.1	25.3	1.31	0.93–1.84	26.6	26.8	0.99	0.70–1.40
Sacramento, CA	48.4	66.9	0.72	0.53–0.98	55.1	58.1	0.95	0.73–1.24	62.3	51.9	1.20	0.94–1.54	44.7	47.1	0.95	0.72–1.24
San Jose, CA	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
El Paso, TX	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Louisville, KY	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Nashville, TN	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Tucson, AZ	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Albuquerque, NM	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Mesa, AZ	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Colorado Springs, CO	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Arlington, TX	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

[*] Bolded rate ratio denotes it is significantly different from 1.00.
[a] Age-adjusted rate is expressed per 100,000 females using the US 2000 Standard Population.

Table 2
T4:T1 rate ratios (RR) for Non-Hispanic Black (Black) and Non-Hispanic White (White) Breast Cancer Mortality.

City, State (largest to smallest)	T4:T1[a] RR		T4 annual excess Black deaths[b]
	Black	White	
U.S.	0.87	0.73	1710
New York, NY	0.85	0.84	56
Los Angeles, CA	1.01	0.73	41
Chicago, IL	0.87	0.64	61
Houston, TX	0.96	0.74	39
Philadelphia, PA	0.82	0.62	40
Phoenix, AZ	0.94	0.66	3
San Antonio, TX	1.04	0.75	
San Diego, CA	0.75	0.75	4
Dallas, TX	0.77	0.73	17
San Jose, CA	–	–	
Detroit, MI	0.90	1.10	
Indianapolis, IN	0.98	0.75	12
Jacksonville, FL	1.22	0.89	13
San Francisco, CA	0.62	0.67	
Columbus, OH	1.06	0.78	8
Austin, TX	0.74	0.75	
Memphis, TN	0.96	0.58	43
Baltimore, MD	0.86	0.80	14
Fort Worth, TX	0.87	0.73	6
Charlotte, NC	0.74	0.72	
El Paso, TX	–	–	
Milwaukee, WI	0.78	0.53	8
Seattle, WA	0.98	0.74	
Boston, MA	0.90	0.57	9
Denver, CO	0.79	0.58	3
Louisville, KY	–	–	
Washington, DC	0.75	0.73	18
Nashville, TN	–	–	
Las Vegas, NV	1.02	0.99	
Portland, OR	0.82	0.78	
Oklahoma City, OK	0.93	0.76	
Tucson, AZ	–	–	
Albuquerque, NM	–	–	
Long Beach, CA	0.65	0.71	
Atlanta, GA	0.79	0.76	
Fresno, CA	0.93	0.76	
Sacramento, CA	0.92	0.70	
Cleveland, OH	0.88	0.69	9
Kansas City, MO	0.93	0.76	6
Mesa, AZ	–	–	
Virginia Beach, VA	0.92	0.84	
Omaha, NE	0.74	0.76	
Oakland, CA	0.95	0.78	7
Miami, FL	1.59	1.26	
Tulsa, OK	1.01	0.85	
Minneapolis, MN	0.74	0.66	
Colorado Springs, CO	–	–	
Arlington, TX	–	–	
Wichita, KS	1.12	0.68	2
Raleigh, NC	1.07	0.60	5

[a] T4 is the 2005–2009 interval and T1 is the 1990–1994 interval.
[b] Excess Black deaths are only calculated for rate ratios that are significantly different from 1.00.

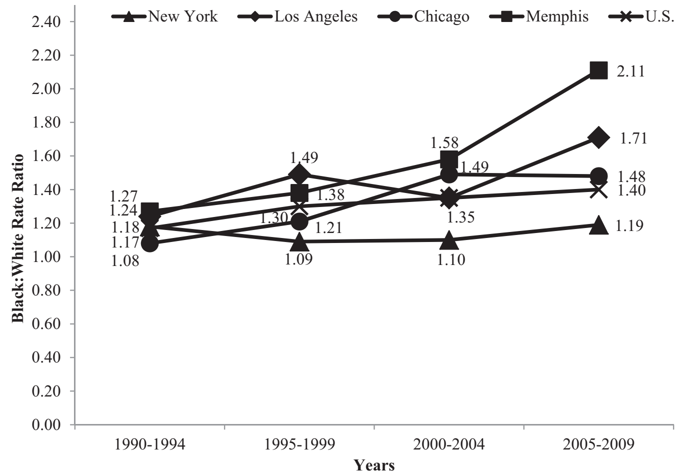

Fig. 1. Black:White breast cancer mortality rate ratios for U.S. and 4 U.S. Cities: 1990–2009.

slightly at T4 to 1.48 – well above the T1 RR. Memphis provides an unfortunate example of a steadily growing RR, starting at 1.27 at T1 and increasing at each time point to reach 2.11 at T4, an RR higher than for any of the other cities at any time interval.

4. Discussion

An analysis of the racial disparities in breast cancer mortality in the 41 largest cities in the U.S. (reduced by data limitations from 50) demonstrates that such disparities are present in almost all these cities. During the latest 5-year time interval for which data are available (2005–2009), the Black:White rate ratio was greater than 1 for 39 of the 41 cities and significantly so for 23; for 17 cities the RR was greater than 1.4. In other words, disparities are prevalent with Black women suffering much higher breast cancer mortality rates than White women in many of these cities.

The growth in these RRs from 1990–1994 (T1) to 2005–2009 (T4) is also notable. In 35 of the 41 cities there was an increase between T1 and T4. Furthermore, 24 of the cities (59%), as well as the U.S., saw an increase in the Black:White RR of 0.2 or more. This means that the Black:White breast cancer mortality disparity worsened substantially in the majority of these cities over this period.

Importantly, it is clear that in most of the cities the RR grew because the Black rate did not change substantially between T1 and T4 while at the same time the White rate declined dramatically. This is true for the U.S. as a whole (where the Black rate decreased by 13% and the White decreased twice as much – by 27%) and for several of the cities.

Table 3
Changes in rate ratios (RR) by time periods: 1990–2009.

Change in RR	T1 (1990–1994)		T2[a] (1995–1999)		T3[b] (2000–2004)		T4[c] (2005–2009)	
	N	%	*N*	%	*N*	%	*N*	%
Less than or equal to 1.0	14	34	2	5	3	8	2	5
1.01–1.20	18	44	14	35	14	35	13	32
1.21–1.40	8	20	18	45	12	30	10	24
Greater than or equal to 1.41	1	2	6	15	11	28	16	39
Total	41	100	40	100	40	100	41	100

[a] The Yates chi-square test comparing the T1 and T2 distributions indicates that they are significantly different (chi-square = 13.24; df = 3; $p < 0.005$).
[b] The Yates chi-square test comparing the T1 and T3 distributions indicates that they are significantly different (chi-square = 13.35; df = 3; $p < 0.005$).
[c] The chi-square test comparing the T1 and T4 distributions indicates that they are significantly different (chi-square = 26.26; df = 3; $p < 0.0001$).

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It is important to note that there was an annual average of 1710 excess deaths in the United States at T4, or almost five a day. That is, on average, for any given day in T4, almost five Black women died due to this racial disparity. We believe this is an extraordinary finding that indicates how far away we are from health equity in this area.

What are the implications of this growing racial disparity in breast cancer mortality and the shapes of the disparity curves? There is no genetic explanation that readily fits these data. Why would these racial disparities have opened up as they did in the 1990s? Despite numerous papers that attribute this disparity to genetics [10–12], our data suggest that this cannot be the case. In fact, in a previous paper [3] we traced the racial disparity in breast cancer mortality back to 1980 for Chicago, New York City, and the U.S. and found smaller disparities at that time than even the small ones that existed in the current analysis for 1990–1994.

4.1. The amenability index and the genetic explanation

A much more logical explanation is that certain technological advances related to screening and treatment became available in the 1990s [13] and that Black women, who are disproportionately poor and un- or under-insured, were less able to obtain access to these advances. The phenomenon that technical advances could actually widen disparities has manifested itself according to what some authors have called the ''amenability index'' [14]. According to this dynamic, which applies to several diseases and several cancers in particular, including breast cancer, as a disease's amenability to treatment increases, better off people (in this case White women) will be able to gain access to these improvements. Conversely, less well off people (Black women) will not. Tehranifar et al. show that this is the case for many cancers. For the types of cancers that are ''non-amenable'' (such as pancreatic cancer) there are virtually no racial disparities; for the cancers that are ''amenable'' (such as breast and prostate cancer) there are large disparities. Based upon an analysis of 580,000 SEER cases diagnosed with 53 cancer sites, the authors note, ''As amenability increased, racial/ethnic differences in cancer survival increased for African Americans, American Indians/Native Alaskans, and Hispanics relative to Whites. Efforts in developing cancer control measures must be coupled with specific strategies for reducing the expected disparities'' [14, p. 2701]. Such results have been replicated in another analysis by Glied and Lleras-Muney [15] and in two others by Levine et al. [16,17].

These findings were presaged in a prior paper by Phelan and Link, in which they advance their notion of ''fundamental causes'' [18]. It is worth quoting them at length:

> ''Any explanation that ignores large improvements in population health and fails to account for the emergence of disparities for specific diseases is an inadequate explanation of current disparities. We argue that genetic explanations and some prominent social causation explanations are incompatible with these facts. We propose that the theory of ''fundamental causes'' can account for both vast improvements in population health and the creation of large socioeconomic and racial disparities in mortality for specific causes of death over time. Specifically, we argue that it is our enormously expanded capacity to control disease and death in combination with existing social and economic inequalities that create health disparities by race and socioeconomic status: When we develop the ability to control disease and death, the benefits of this new-found ability are distributed according to resources of knowledge, money, power, prestige, and beneficial social connections'' [18, p. 27].

In particular, we have hypothesized that these racial disparities in breast cancer mortality have emerged due to four factors: (a) differential access to screening; (b) differential quality in the screening process; (c) differential access to treatment; and (d) differential quality of treatment. There is substantial support in the literature for all four of these hypotheses and we have cited these in numerous references in previous reports [e.g., 3,19,20].

None of this should be taken to suggest that we are asserting that genetics plays no role in breast cancer or that there are not some breast cancers in Black women which are more aggressive. For instance, we recognize that triple negative breast cancer occurs more frequently in women of African descent [21,22] and that the higher prevalence of these basal-type, treatment-resistant tumors among this population, compared with White women, might account for a small proportion of the observed mortality disparity. Nonetheless, it is clear that these dynamics cannot be primarily responsible for the observed disparities in these cities. If they were, why is the disparity in New York City so different from the one in Los Angeles or Memphis? Surely these are a function of social or ecological variables which in turn generate the four factors listed above. When we considered such variables in a previous report we found that median household income and racial segregation were significant predictors of the racial disparity in breast cancer mortality and also that the percent below the poverty level and a measure of financial inequality (the Gini Index) were correlated with the disparity but not significantly [2].

4.2. Methodological observations

The data employed in this report come from the U.S. Census Bureau and national death certificate files. Both of these sources have been found to be comparatively error-free and rather complete [23]. In addition, the diagnosis of breast cancer is likely to be one of the least ambiguously coded causes of death, compared to, for example, various chronic diseases [23]. Additionally, the use of mortality data for the present analysis eliminates concerns regarding overdiagnosis of breast cancer [24] because overdiagnosis among any specific race/ethnic group would have no influence on mortality rates. We would like to acknowledge that the age-adjusted breast cancer mortality rates we calculated for Miami seem unreasonably high, especially when compared to the other major U.S. cities. However, the methodology employed in this calculation was identical for each city and thus we cannot explain the finding nor did we think it warranted exclusion from the analysis.

This analysis has only examined Black:White disparities. It will be important to also examine disparities among Hispanics (and Hispanic subgroups), Asians (and Asian subgroups), and Native Americans as well. In these latter cases, questions of adequate sample sizes will arise but these are important analyses and they should be pursued.

5. Conclusion

This analysis revealed large and growing disparities in Black:White breast cancer mortality in the U.S. and many of its largest cities during the period 1990–2009. This vast assemblage of data from the 41 largest U.S. cities indicates that while there are undoubtedly geographic variations in care across the study area which would influence the disparity at the city-level, there is a unanimity of disparities overall, suggesting a pervasive problem. The task in front of us now is to eliminate these disparities. As Tehranifar et al. have asserted, once we make advances we must take steps to distribute these advances equally [14]. Indeed, our task must be more than just observing and analyzing the world of disparities; it must involve taking actions to eliminate them. Reversing the four differential factors delineated in the paragraph above is one way to begin. Note that this will necessarily require all health care providers in a city to participate; it cannot just be left up to public hospitals and other safety net institutions. The very privilege that has provided access to the advances in breast cancer early diagnosis and treatment now must be shared with those for whom access has been limited.

Attention will continue to be paid to genetic solutions to the disparity in breast cancer mortality. This is inevitable given the disproportionate share of the funding available for such approaches [25]. What we humbly propose, however, is that first we try providing equal access to quality early detection and treatment and determine the progress that we can make there.

Conflict of interest statement

None of the three authors have any financial or personal relationships with other people or organizations that could inappropriately influence (bias) our work.

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