Social Science & Medicine 71 (2010) 2057–2065

Contents lists available at ScienceDirect

Social Science & Medicine

journal homepage: www.elsevier.com/locate/socscimed

Are local health department expenditures related to racial disparities in mortality?

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A R T I C L E I N F O

Article history:
Available online 29 September 2010

Keywords:
Local health departments
Public health expenditures
Mortality disparities
Race and ethnicity
Public health systems research
Health inequalities
USA

A B S T R A C T

This study estimated whether 1990–1997 changes in expenditures per capita of local health departments (LHDs) and percentage share of local public revenue allocated to LHDs were associated inversely with 1990–1997 changes in mortality rates for Black and White racial/ethnic groups in the US. Population was 883 local jurisdictions with 1990 and 1997 mortality rates for Black and White racial populations from the Centers for Disease Control and Prevention Wonder Compressed Mortality File and LHD expenditures from the National Association of County and City Health Officials. Using a time-trend ecologic design, changes in LHD expenditures per capita and percentage share of public revenue were not related to reductions in Black/White disparities in total, all-cause mortality rates. Increased LHD expenditures or percentage share were associated with reduced Black/White disparities for adults aged 15–44 and males. LHD expenditures or percentage share were related to absolute reductions in mortality for infants, Blacks, and White females but did not close Black–White mortality differences for these groups. Therefore, disparities in Black and White mortality rates for subgroups with the greatest mortality gaps may be more likely to be reduced by public investment in local health departments than disparities in Black and White total, all-cause mortality rates.

Introduction

Our study addresses an important policy and comparative effectiveness research question for the 21st century: How much of society's resources should be allocated to local public health departments versus health care or social determinants to reduce health disparities? The question is difficult to answer because we know little about whether and how much local public health funds contribute to local population health and reduce health disparities (Becker, Principe, Adams, & Teutsch, 1998; Mays and Smith in press; Schenck, Miller, & Richards, 1995). Prior to today's bioterrorism and infectious disease threats, about 5% of U.S. health expenditures were for government-funded public health activities and population-based disease prevention, health protection and health promotion programs (Lee & Paxman, 1997). The Institute of Medicine (IOM, 1988) and others (Hemenway, 2010; Kinner & Pellegrini, 2009; Rust, Satcher, Fryer, Levine, & Blumenthal, 2010) recommend allocating more of society's resources to public health, but it is unclear how much additional resources should be allocated, and little is known empirically about whether more public funds would translate into better population health and reduced health disparities.

On one hand, public health interventions have improved population health. In the 20th century average life expectancy in the U.S. increased from 47 years in 1900 to 76 years in 1996 (Fielding, 1999), and about 25 years of the 29-year gain are due to public health interventions (Baker et al., 1994; Centers for Disease Control, 1999). The Public Health Service (1993) reports that population-based public health programs in the 1970s contributed greatly to recent improvements in reduced tobacco use, blood pressure control, diet, use of seat belts, and injury control, which in turn have contributed to declines of more than 50% in deaths due to stroke, 40% in deaths due to heart disease, and 25% in overall death rates for children.

Several studies indicate that generosity is good for *population health*. Applying instrumental variables and longitudinal data to address this issue, Mays and Smith (in press) report that a 10% increase in U.S. local health department (LHD) expenditures per capita is associated with a 1–7% decline in mortality rates, depending on cause of death. Erwin, Greene, Mays, Ricketts, and Davis (2010) report similar relationships in state-level data. Drawing from historical U.S. data from 1907–1910 in the era of infectious diseases, Costa and Kahn (2006) found that a one standard deviation increase in city health expenditures was associated with a decline in infant

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doi:10.1016/j.socscimed.2010.09.004

mortality from 14.9 to 11.5 deaths per 100 children under age one. Other U.S. and international studies also report that greater public spending is related to lower infant and child mortality rates (Conley & Springer, 2001; Harknett et al., 2005; Lundberg et al., 2008). Chesson, Harrison, Scotton, and Varghese (2005), Chesson and Owusu-Edusei, (2008) report greater state-level funding is related to lower gonorrhea and syphilis rates. Hadley (1982) found that a 10% increase in medical expenditures per capita was associated with a 1–2% reduction in mortality rates.

On the other hand, these returns on investment coexist with persistent and growing *health disparities* across racial/ethnic, socioeconomic and other groups in the U.S. and other developed countries (Graham, 2004a; Link & Phelan, 2005; White, Adams, & Heywood, 2009). Because LHD expenditures are devoted to population-based activities that often target vulnerable groups with higher rates of disease and disability, greater expenditures of local health departments *may* reduce health disparities. Evidence indicates that population-based interventions that influence everyone, such as water fluoridation and highway safety, have the potential to reduce health disparities (Mechanic, 2002). However, many public health interventions do not reach everyone. Preventive and other effective interventions that depend on voluntary participation may actually *increase* disparities because people with more resources and less need are more likely to take advantage of them (Link & Phelan, 2005).

WHO Commission on the Social Determinants of Health (2008), Graham (2004a), Krieger (2008) and others present conceptual models of the determinants of health disparities, but none explicitly include public health systems. The models indicate generally that health disparities result mainly from disparities in social and physical environments (Graham, 2004a, 2004b; Evans & Stoddart, 1990), and public health spending may not be powerful enough to offset their effects. Alternatively, if greater public health spending does reduce health disparities, the effects of social disparities on health disparities in the literature may be overstated because spending is not controlled usually in analyses, or the effects may be moderated by spending. Public health spending may respond to health disparities, as well as influence them, suggesting that 2-way causation may exist between spending and health disparities (Bloom & Canning, 2000; Boeke, Zahner, Booske, & Remington, 2008). It is unclear whether spending more on public health and less on personal medical care would reduce health disparities (Evans & Stoddart, 1990; Hemenway, 2010; Rust et al., 2010).

Few studies have examined the relationships between public health spending and health disparities. In The Patient Protection and Affordable Care Act (Sections 4301 and 4302) of 2010, the U.S. Congress authorized studies examining the effectiveness and costs of state and local health departments, and to collect data on health disparities for research.

Our aim is to estimate whether 1990–1997 changes in local department expenditures per capita are related inversely with 1990–1997 changes in all-cause mortality and infant mortality rates for Black and White racial/ethnic groups. We also examine whether an increased percentage share of local public revenue allocated to local health departments is related to reduced Black–White disparities in mortality. To our knowledge, no published U.S. study has examined the relationship between LHD expenditures per capita and disparities in mortality among Black and White racial groups in the United States.

Methods

Study design

A time-trend ecologic study design was chosen to estimate the association between 1990 and 1997 changes in local health department (LHD) expenditures and 1990–1997 changes in Black-White disparities in all-cause mortality and infant mortality rates for U.S. counties, controlling for other factors (Morgenstern, 2008). Estimation and interpretation of ecologic effects in county populations are stronger in longitudinal than cross-sectional study designs because alternative explanations for an observed relationship between change in per capita spending and change in mortality rates are reduced but not eliminated in time-trend designs (Gordon & Heinrich, 2004; Morgenstern, 2008).

We chose 1990–1997 longitudinal data for the following reasons. First, in 1990, the study's baseline year, the U.S. Department of Health and Human Services released *Healthy People 2000*, which defined increasing life expectancy and reducing health disparities among racial/ethnic groups as national policy, and established 116 racial/ethnic performance objectives (U.S. D.H.H.S., 1995). *Healthy People 2000* may have focused LHD services and spending on the twin goals of improving life expectancy and reducing disparities.

Second, 1990–1997 represents historical, 'steady-state' LHD spending patterns before local health departments received additional bioterrorism and emergency preparedness funds following the 2001 terrorist attacks, which may have influenced the relationship between LHD spending and disparities in Black–White mortality rates in unknown ways. LHD expenditure data existed for 1997 and 2005 but not 2001, and therefore, we cannot examine 1990–2001 changes in LHD expenditure and mortality.

The study was approved by the University of Washington's Institutional Review Board (Application No. 06-4827-X/G).

Data sources and measures

Secondary data files, most available to the public, were linked to create the following measures based on the determinants of population health and health disparities (US DHHS 2000).

Mortality rates

We collected all-cause county mortality rates for Black populations in 1990 and 1997 (rates were age-adjusted per 100,000 population using the 2000 standard population) from the Centers for Disease Control and Prevention/National Center for Health Statistics (CDC Wonder Compressed Mortality File). Annual Black mortality rates did not exist for counties with ≤20 Black deaths due to measurement unreliability. CDC Wonder also suppressed annual mortality rates for counties with less than 100,000 population and ≤5 deaths. We measured only all-cause mortality because the Black populations in counties were too small to construct cause-specific Black mortality rates. Second, we also collected the same mortality rates for the White population in counties with at least one Black mortality rate.

Changes in 1983–1993 Black and White life expectancy were greater generally for males than females, with ages 15–44 accounting for 39% of the Black–White gap for males in 1993 and 25% for females (Harper, Lynch, Burris, & Smith, 2007). Consequently, we also collected Black and White mortality rates for males, females, and ages 15–44. Infant mortality rates in children less than 1 year old per 1000 live births were constructed for 3-year periods, 1989–1991 and 1996–1998, to increase county sample size.

For each mortality rate we measured the disparity in Black and White mortality by computing Black/White mortality rate ratios for 1990 and 1997, and for infant mortality we computed the ratios for 1989–1991 and 1996–1998. For each period we also computed the difference between the Black and White mortality rates in each county.

We also measured the 1997–1990 change in Black and White mortality in three ways. First, the 1997–1990 change in the Black/White rate ratio in a county was measured as shown in Equation (1), where (i) indicated the county. Because our focus was disparities in Black mortality, we excluded counties where Black mortality was lower than White mortality in both 1990 and 1997. In Equation (1) positive 1997–1990 change scores indicated an increase in Black/White mortality disparities.

$$\begin{aligned}&1997-1990\,\text{change in Black/White rate ratio}_i\\&=(1997\,\text{Black mortality rate}_i/1997\,\text{White mortality rate}_i)\\&\quad-(1990\,\text{Black mortality rate}_i/1990\,\text{White mortality rate}_i)\qquad(1)\end{aligned}$$

Second, the 1997–1990 absolute change in mortality rates in each racial group was calculated as follows, where (i) was the county and (j) was either the Black population or White population (negative change scores indicated reductions in mortality).

$$\begin{aligned}&1997-1990\ \text{absolute change in mortality rate}_{ij}\\&=(1997\ \text{mortality rate}_{ij})-(1990\ \text{mortality rate}_{ij})\qquad(2)\end{aligned}$$

Third, from Equation (2) the difference between the 1997–1990 Black absolute change in mortality and the 1997–1990 White absolute change in mortality was measured in the ith county as in Equation (3), where BMR97 and WMR97 indicate the county's Black mortality rate and White mortality rate in 1997, respectively, with similar notation for 1990 rates.

$$\begin{aligned}&\text{Black–White difference in absolute change scores}_i\\&=(\text{BMR97}_i-\text{BMR90}_i)-(\text{WMR97}_i-\text{WMR90}_i)\qquad(3)\end{aligned}$$

Re-arranging items on the right side of Equation (3) yielded Equation (4), or the difference between the 1997 difference in Black–White mortality rates and the 1990 difference in Black–White mortality rates, or simply the "difference in annual differences (DAD)" in Black–White morality rates.

$$\begin{aligned}&\text{Difference in annual Black–White differences}_i\\&=(\text{BMR97}_i-\text{WMR97}_i)-(\text{BMR90}_i-\text{WMR90}_i)\qquad(4)\end{aligned}$$

Excluding counties where Black mortality was lower than White mortality in both 1990 and 1997, positive scores in Equations (3) and (4) indicated that the 1997–1990 difference in the annual Black-White differences had increased (greater disparity), while negative scores indicated the 1997–1990 difference had decreased (less disparity) in 1997–1990.

Local health department expenditures and percentage share of local public revenue for LHD

Local health department total expenditures per capita were measured by the *1989–1990* and *1996–1997 National Profile of Local Health Departments* from the National Association of County and City Health Officials (NACCHO, 1990, 1998). Response rates for the mail surveys were 77% in 1990 and 88% in 1997. The 1990 LHD expenditures were adjusted to 1997 dollars using the Consumer Price Index for urban areas, and we computed the 1997–1990 change in expenditures per capita (Gerzoff, Gordon, & Richards, 1996; Gordon, Gerzoff, & Richards, 1997).

The annual percentage share of total public revenue in a county allocated to the LHD was measured as follows. We collected the total public revenue for all U.S. counties from the 1988, 1992 and 1997 U.S. Census of Government Organizations, defined as the sum of all revenue from county government, all cities, towns and school districts in the county, plus independent special districts (e.g., fire districts, water supply, flood control). Total revenue in 1990 was calculated by interpolating total revenue between the 1988 and 1992 total revenues. After converting 1990 revenue into 1997 dollars, the 1990 percentage share was computed as (1990 LHD expenditures/1990 total public revenue × 100), and we computed the 1997–1990 change in percentage of public revenue allocated to LHDs.

Local health department characteristics

We measured whether the local health department had a board of health, whether the department was administered independently or by an external organization such as state government, whether the LHD had a part-time or full-time health officer, and the number of full-time-equivalent staff from the 1990 NACCHO Profile Survey.

Local area social characteristics

Based on Kilmarx et al., we measured county social characteristics using the 1990 U.S. Census Summary Tape File 1C and Summary Tape File 3A data files and the Bureau of the Health Professions' *2005 Area Resource File* (ARF; Kilmarx et al., 1997; Lynch et al., 1998; Mansfield, Wilson, Kobrinski, & Mitchell, 1999). The following measures were collected for each racial group: percentage female, percent households headed by a single female with children, percentage adults with no high school diploma, income per capita, and percentage unemployed. We computed the Black/White ratio for each measure.

Local medicare expenditures and health system

Because per capita medical expenditures were not available for the entire populations of U.S. counties, we used 1990 and 1997 adjusted Part A and Part B Medicare expenditures per capita from the Centers for Medicare and Medicaid Services and computed 1997–1990 change scores (CMS: see website: http://www.cms.hhs.gov/MedicareAdvtgSpecRateStats/RSD/list.asp#TopOfPage). The 1990 Medicare expenditures were adjusted to 1997 dollars. The ARF was used to construct 1997–1990 change scores for hospital beds and the number of general and medical specialty physicians per 100,000 population, defined as general practice, family medicine, internal medicine, pediatrics, pulmonary disease, allergy and immunology, cardiovascular disease, dermatology and gastroenterology.

Rural–urban county

Rural and urban counties were distinguished using the 1995 U.S. Department of Agriculture Rural–Urban Commuting (RUCA) Codes, which classify counties into 10 mutually-exclusive categories based on population density and population work commuting patterns (http://www.ers.usda.gov/Data/RuralUrbanCommutingAreaCodes/). We collapsed the categories into three binary (0,1) variables indicating whether the county was metropolitan, micropolitan (a non-metropolitan area with an urban cluster of at least 10,000 persons), or small town.

Geographic areas

For each county we constructed binary variables identifying the state and federal region that each county was located in.

Data base construction and spatial unit of analysis

We created 'common local areas' to link records across data sources. LHDs that had county jurisdictions were linked with other county-level data. For LHDs that consisted of multiple counties, we aggregated county-level measures up to the multi-county level. For city/town LHDs, we aggregated the city/town Profile data up to the county level. LHDs with overlapping jurisdictions were combined to form regional areas.

Data analysis

Descriptive statistics were computed for all variables. ANOVA was performed to determine whether Black and White mortality rates and social characteristics were significantly different across areas. We also tested whether mortality rates were significantly different for areas with LHD expenditures in 1990 and 1997 compared to areas without LHD expenditures due to Profile survey nonresponse.

Drawing from Auster, Levison, and Saracheck (1972), Filmer and Pritchett (1999), Hadley (1982, 1988), Mays and Smith (in press), Newhouse and Friedlander (1980), and Stewart (1982), for each mortality rate we computed the first-difference estimator of the association between the 1997 and 1990 change in LHD expenditures per capita and 1997–1990 change in mortality rate (Gordon & Heinrich, 2004; Wooldridge, 2002). Equation (5) presents the general form of the first-differenced equation:

$$(\mathrm{MR}_{i,97} - \mathrm{MR}_{i,90}) = \beta_1(\mathrm{LHD\$}_{i,97} - \mathrm{LHD\$}_{i,90}) + \beta_2\mathrm{LHD\$}_{i,90} + \beta_3(\mathrm{x}_{i,97} - \mathrm{x}_{i,90}) + \beta_4 s + \Delta e_i \quad (5)$$

where β_1 was the first-difference estimator, (i) was the local area, 97 and 90 were years of observation, MR was a mortality rate defined earlier, LHD$ were annual local health department expenditures per capita, and x was a vector of time-varying covariates for medical care and health system. Baseline 1990 LHD expenditures were in the model to control for underlying differences in local governments' propensity to invest in public health. To adjust for potential state government and other state influences on LHDs, we added a vector (s) of 40 binary (0,1) fixed effects indicating the area's state. Observed time-invariant characteristics, such as Census measures that existed only for 1990, and unobserved time-invariant covariates potentially affecting mortality were differenced away in Equation (5).

Multivariate analyses were conducted in two steps. First, Equation (5) was estimated using general estimating equations (GEE) to adjust for clustering of local areas within federal regions. Because the variance in mortality rates was generally larger for areas with smaller populations, weighted analyses were conducted using the inverse of the variance of the county mortality rate (Baum, 2006; Lynch et al., 1998; McLaughlin & Stokes, 2002).

Second, reverse causation may exist between 1997 and 1990 changes in LHD spending, physician supply, Medicare expenditures and hospital beds and 1997–1990 changes in mortality rates, and estimates of LHD spending effects may be correlated with the error term in Equation (5) and therefore may be inconsistent. To address this issue, Equation (5) was re-estimated using instrumental variables (IV) and unweighted two-stage least squares (2SLS) to obtain unbiased estimates, testing for endogeneity using Wooldridge's (1995) robust score test which assumes unweighted estimation (Newhouse & McClellan, 1998). Equations with significant endogeneity tests were re-estimated with weighted 2SLS.

We identified two instrumental variables based on RUCA codes: whether the area was a large (micropolitan) town, and whether the area was a small town (metropolitan area omitted category). Regression models indicated the two instruments were associated strongly with 1997–1990 changes in LHD spending, changes in percentage share of public revenue, and changes in physician supply (with a minimum F-value of 24 in models estimated separately for areas with mortality rates for all Blacks, Black males, Black females), and *not* associated with changes in mortality rates (F-values were inconsistent and smaller for Medicare expenditures and hospital beds). For local areas with all-cause, all-ages Black mortality rates and 1990 and 1997 Profile Surveys, 1997–1990 changes in LHD spending per capita averaged $13 in metropolitan areas, $23 in large towns, and $15 in small towns. Similarly, 1997–1990 changes in percent share of public revenue for LHDs averaged .5% in metropolitan areas, 1.4% in large towns, and .5% in small towns; 1997–1990 changes in physician supply per 100,000 population averaged 12 in metropolitan areas, 4 in large towns and .8 in small towns. LHD differences may exist because in small and medium-sized populations a relatively small change in LHD spending may result in a relatively large change in per capita spending, while in large, metropolitan populations the same absolute dollar change in spending may have little impact. Rural–urban was associated with physician supply because rural areas have much greater difficulty in recruiting and retaining physicians than urban areas (Ricketts & Randolph, 2007). RUCA codes also reflect local commuting patterns and therefore, may also be adjusting for the functional relationships, or spatial correlation, among adjacent local areas (Cliff & Ord, 1981; Goodchild, 1987).

For areas with age 15–44 and infant mortality rates, IV regressions were not estimated because little variation existed in the areas' RUCA codes. Of the 110–130 areas with these rates, almost all had metropolitan RUCA codes 1–3, which were not associated strongly with 1990–1997 changes in LHD spending, percentage share of public revenue and physician supply.

We re-estimated the models, replacing changes in LHD spending with changes in the percentage share of public revenue allocated to LHDs.

A model assumption was that mortality rates changed over a 7-year period in direct response to changes in local expenditure over the 7-year period. However, a lag model would be more appropriate if annual LHD activity acted as an investment, with delayed effects on health and health disparities over a long-run time horizon. For all mortality measures we estimated lag models to determine whether baseline 1990 LHD expenditures or percentage share were related to 1997–1990 changes in mortality.

All regression models were estimated with *Stata version 10.1* 2008 statistical software™.

Results

We identified 855 local areas with at least one Black mortality rate in 1990 or 1997, and 85% of the areas were counties with a county LHD, 5% were multi-counties with one LHD, 8% were cities/towns (each with an LHD) aggregated up to the county-level, and 2% were LHDs combined to form regions within states. About 68% of the areas were in Federal Regions 4 and 6 between New Mexico and North Carolina. About 61% of local areas were urban, 27% were micropolitan, and 12% were small town/rural.

Table 1 presents descriptive statistics of 1990, 1997 and 1997–1990 changes in mortality rates across local areas, which generally have normal distributions. On average, the absolute change in mortality rates from 1990 to 1997 decreased for both Black and White populations, and Black mortality rates decreased more than White mortality rates. Cross-sectional Black/White rate ratios for total, female, male mortality consistently averaged 1.3 in 1990 and 1997. Black/White rate ratios for ages15–44 mortality and infant mortality ranged between 2.0 and 2.5. On average, Black/White rate ratios changed little between 1990 and 1997, but the infant mortality ratio increased by .13 (about 5%).

About 66% of the local areas ($n = 562$) had a NACCHO Profile Survey in 1990 and 1997. Black/White rate ratios for total mortality

Table 1
Descriptive statistics of 1990, 1997 and 1997–1990 change in all-cause mortality rates for local areas.

Mortality rate	Number of areas	1990 Average (St dev)	1997 Average (St dev)	1997–1990 average change (St dev)
Black/White rate ratios (RR)				
All ages and genders	733	1.3(.22)	1.3(.23)	−.01(.25)[b]
Females	543	1.3(.23)	1.3(.27)	−.01(.28)[b]
Males	602	1.3(.29)	1.3(.25)	−.02(.31)[b]
Ages 15–44	174	2.1(.59)	2.0(.56)	−.05(.51)
Infant mortality	161	2.4(.55)	2.5(.63)	.13(.60)
Absolute differences				
All ages and genders	733			
Black		1236(192)	1170(200)	−65(223)
White		963(106)	922(115)	−41(99)
Difference		273(197)	249(194)	−24(231)[a,b]
Females	543			
Black		973(153)	941(149)	−32(174)
White		757(85)	742(91)	−15(97)
Difference		216(161)	199(160)	−17(191)[a,b]
Males	602			
Black		1643(306)	1504(269)	−140(322)
White		1249(164)	1156(165)	−94(155)
Difference		394(322)	348(248)	−48(354)[a,b]
Ages 15–44	174			
Black		289(94)	251(77)	−38(67)
White		140(39)	125(34)	−15(34)
Difference		149(79)	126(65)	−24(61)[a]
Infant mortality	161			
Black		18(3.3)	15(3.4)	−3(3.7)
White		8(1.3)	6(1.3)	−2(1.2)
Difference		10(3.1)	9(3.2)	−1(3.5)[a]

[a] The cell contains the 1997–1990 difference in the annual Black–White differences as defined by Equation (4).
[b] In 1997–1990 average changes, we excluded the following number of areas where the Black mortality rate was lower than the White mortality rate in1990 and 1997: total mortality: 17 areas; female mortality: 12 areas; male mortality: 8 areas.

declined on average (−.03) in areas with Profile surveys for both years but increased (+.02) in areas without surveys ($p = .006$). The average difference in the annual differences of Black-White mortality rates (DAD Equation (4)) decreased (−41) in areas with Profile surveys but increased (+8) in areas without surveys ($p = .007$). These patterns suggest that our findings for areas with Profile surveys may not be generalizable to areas without Profile surveys.

For local areas with Profile surveys, LHD spending per capita increased $16 (st dev $46) from 1990 (avg, $28; st dev $27) to 1997 (avg, $44; st dev $53). Similarly, the percentage share of public revenue for LHDs increased by .5% (st dev 2.7) from 1.3% (st dev 1.02) in 1990 to 1.8% (st dev 2.8) in 1997. In 1990 about 65% of the LHDs had a board of health, 84% had a full-time health officer, full-time equivalent staff averaged 184 (st dev 1114), and 63% were either independent LHDs or shared some operations with state health agencies.

For time-varying covariates in Table 2, Medicare expenditures per capita and the number of general and medical specialty physicians per 100,000 population increased in 1990–1997, while hospital beds decreased in local areas.

Table 3 compares the social characteristics of the Black and White populations across local areas in 1990. On average, about 19% of the population was Black. The Black populations in local areas had greater social disadvantages than the White populations. The average percentage of female-headed households with children was almost 5 times higher in Black populations than White populations. Similarly, the percentage of adults with no high school diploma averaged almost two times higher in Black populations than White populations. Black income per capita was about half of White income per capita, and on average Black unemployment rates were over two times higher than the White rates across areas.

Table 2
Descriptive statistics of health system characteristics for local areas with 1990 and 1997 Profile Surveys ($n = 562$).

Characteristics	1990 Average (St dev)	1997 Average (St dev)	1997–1990 Average change (St dev)
Medicare expenditures per capita (parts A and B)	$265(49)	$434(73)	$170(43)
Hospital beds per 100,000 population	492(459)	415(304)	−77(347)
General and medical specialty physicians per 100,000 population[#]	53(28)	62(37)	9(18)

[#]General and medical specialty physicians include general practice, family medicine, internal medicine, pediatrics, pulmonary disease, allergy and immunology, cardiovascular disease, dermatology, and gastroenterology.

Endogeneity tests

In six models with Black/White mortality ratios, two of the endogeneity tests were statistically significant ($p < .10$). In eighteen models for absolute changes in mortality rates, thirteen models had significant tests. This pattern of test results implies that taking potential endogeneity into account is important for obtaining unbiased estimates.

Fixed effect and IV models

In Table 4 fixed effect and IV models for all ages, females, males and infants, 1997–1990 changes in LHD expenditures and percentage share generally had no association with 1997–1990 changes in Black/White mortality rate ratios. Ratios for adults aged 15–44 were marginally significant in the expected direction for changes in LHD spending (−.0006; $p = .14$) and LHD percentage share (−.02; $p = .09$), which may be due to small sample size.

In the absolute difference models, none of the fixed effect and IV estimates indicated that changes in LHD spending or percentage share were related to the DAD Black-White mortality rates. Otherwise, 1997–1990 increases in LHD spending and percentage share were related to 1997–1990 decreases in infant mortality rates in the Black and White populations (the −.09 estimate approaches significance ($p = .13$)). IV models indicate a greater increase in LHD spending or LHD percentage share were associated with reductions in mortality for White females but unexpectedly with increased mortality for all Whites.

Lag models

Table 5 indicates whether baseline 1990 LHD expenditures and percentage share were related to 1997–1990 changes in total mortality. Greater 1990 LHD spending and percentage share were related to small reductions in Black/White rate ratios for adults aged

Table 3
Descriptive statistics of social characteristics in 1990 for local areas with 1990 and 1997 Profile Surveys ($n = 562$).

Characteristics	Black population average (St Dev)	White population average (St Dev)	Black/White population average (St Dev)
Female (percent)	52%(4.9)	51%(2.5)	1.00(.1)
Single female-headed households with children	34%(6.6)	7.4%(1.7)	4.8(1.5)
Adults with no high school diploma	43%(13)	27%(9)	1.7(.5)
Income per capita	$7607(2535)	$13,896(3551)	.55(.1)
Unemployed (percent)	7%(2.2)	3%(.8)	2.5(.9)

Table 4
First difference equation estimates of the effect of 1997–1990 changes in Local Health Department (LHD) expenditures and changes in percent LHD share of public revenue on 1997–1990 changes in mortality rates for Black and White populations in local areas with 1990 and 1997 Profile Surveys.

1997–1990 Change in mortality rates	1997–1990 Change in LHD expenditures[a]		1997–1990 change in percent share[a]	
	Fixed effects regression coefficients	Instrumental variables regression coefficients[c]	Fixed effects regression coefficients	Instrumental variables regression coefficients[c]
Black/White rate ratios				
All ages and genders	−.00003	NE	−.001	NE
Females	−.00003	NE	−.004	NE
Males	.00004	.0002	.001	.0002
Ages 15–44	−.00062	–	−.018*	–
Infant mortality	−.00244	–	−.082	–
Absolute differences				
All-ages & genders				
Black	.013	−2.34	−.56	NE
White	.029	.02***	.28	.59***
Difference in annual differences[b]	.001	NE	−.10	NE
Females				
Black	.052	.05	2.11	1.51
White	−.026*	−.22***	−.86	−6.27***
Difference in annual differences[b]	−.046	NE	−3.52	NE
Males				
Black	−.08	−.14	−3.41	.27
White	−.04	−1.61	-.41	−107.20
Difference in annual differences[b]	.16	.01	2.44	22.78
Ages 15–44				
Black	.06	–	1.58	–
White	−.03	–	−1.21	–
Difference in annual differences[b]	.003	–	.41	–
Infant mortality				
Black	−.014***	–	−.38***	–
White	−.005**	–	−.09	–
Difference in annual differences[b]	.003	–	.13	–

*$p < .10$.
**$p < .05$.
***$p < .01$.
[a] A coefficient with a (−) sign indicates an inverse association between the independent variable (1997–1990 change in LHD expenditures or LHD percentage share of public revenue) and the 1997–1990 change in a mortality rate. For example, a 1997–1990 increase in LHD expenditures is associated with a 1997–1990 decrease in a measure of Black-White disparity.
[b] The difference in the annual differences (DAD) in Black–White mortality rates is defined by Equation (4).
[c] NE indicates the endogeneity test was not significant and, therefore, the IV regression model was not estimated. No instrumental variables were detected for 1997–1990 changes in infant mortality rates and age 15–44 mortality rates, and no instrumental variable results are presented (–) in those rows.

15–44; 1990 LHD percentage share also was related weakly to the Black/White rate ratio for males (−.0023, $p = .095$). In the DAD models for males, both greater 1990 LHD spending and percentage share were related to 1997–1990 reductions in annual Black–White mortality differences. Similar negative associations were found for 1997–1990 absolute changes in Black mortality, and the relationship for Black males (−.38) was of marginal significance ($p = .08$).

Discussion

These findings provide little consistent and compelling evidence that increases in LHD expenditures or percentage share of public revenue are related negatively to reductions in Black-White disparities in all-cause total mortality rates. However, reductions in disparities were found in regression models for some groups.

We estimated two types of regression models: 1) a simultaneous change model examining whether changes in LHD spending or percentage share of public revenue were related to changes in Black-White mortality rates; and 2) a lag model examining whether 1990 (baseline) LHD expenditures or percentage share were related to 1997–1990 changes in Black–White mortality rates. Coefficients were consistently negative in both models only for adults aged 15–44 for Black/White mortality rate ratios.

Otherwise, ecological relationships depend on the specification of the regression model and subgroup. Lag models for males indicate greater 1990 LHD spending and percentage share were related to 1997–1990 reductions in annual Black-White mortality differences. A greater 1990 percentage share also was related weakly to a 1997–1990 decrease in the Black/White rate ratio for males.

We also found that greater LHD funding sometimes was related to reduced mortality in one racial group, but the 1997–1990 difference in mortality between the two racial groups did not shrink. Lag models show greater LHD spending and percentage share in 1990 are related to reductions in Black mortality. In general, 1997–1990 increases in LHD spending and percentage share are related to 1997–1990 decreases in infant mortality for Blacks and Whites, but the difference in mortality between the groups does not change. IV models indicate similar associations for White females but increased mortality for all Whites.

These patterns suggest that in Black and White populations, subgroups with the greatest differences in mortality may be most likely to benefit from investments in local health departments. Harper et al. (2007) report that from 1983 to 1993 Black–White gaps in life expectancy were increasing, mainly from higher mortality among Blacks for human immunodeficiency virus (HIV), homicide and heart disease, particularly among males aged 15–49. From 1993 to 2003 mortality declined greatly among Black males aged 15–49 and, to a lesser extent, females, mainly because of rapid declines in HIV following the widespread adoption of highly active antiretroviral therapy (HAART) as well as reductions in homicide and unintentional injuries. Our findings suggest that LHDs that spend more or have a greater percentage share may be the same LHDs providing more primary care prevention, communicable

Table 5
Effects of 1990 Local Health Department (LHD) expenditures and 1990 percent LHD share of public revenue on 1997–1990 changes in mortality rates for Black and White populations in local areas with 1990 and 1997 Profile Surveys.

1997–1990 Change in mortality rates	1990 LHD expenditures[a]	1990 LHD Percent share[a]
Black/White rate ratios		
All ages and genders	.00003	.0012
Females	.00005	.0005
Males	−.00005	−.0023*
Ages 15–44	−.0005*	−.0178**
Infant mortality	.0001	.0175
Absolute differences		
All-ages & genders		
Black	−.25***	−2.79**
White	.01	.53
Difference in annual differences[b]	−.02	.72
Females		
Black	.04	.90
White	−.01	.54
Difference in annual differences[b]	−.17	−1.79
Males		
Black	−.38*	−3.53
White	−.12	−1.90
Difference in annual differences[b]	−.36***	−12.40***
Ages 15–44		
Black	−.03	−2.45
White	−.02	−1.11
Difference in annual differences[b]	−.03	−.62
Infant mortality		
Black	−.003	−.066
White	.001	−.018
Difference in annual differences[b]	.001	.027

*$p < .10$ **$p < .05$ ***$p < .01$.
[a] A coefficient with a (−) sign indicates an inverse association between the independent variable (LHD expenditures or LHD percentage share of public revenue in 1990) and the 1997–1990 change in mortality rates. For example, an increase in 1990 LHD expenditures is associated with a 1997–1990 decrease in a measure of Black-White disparity.
[b] The difference in the annual differences (DAD) in Black–White mortality rates is defined by Equation (4).

disease (HIV) screening and treatment, and injury control services, which may have contributed to reductions in Black–White mortality disparities among adults aged 15–44, particularly males.

History also may explain why we found small rather than large associations. In 1990 the U.S. Department of Health and Human Services released *Healthy People 2000*, and by 1993 about 70 percent of local health departments were using *Healthy People 2000* objectives (US DHHS, 1995). A 1995 midcourse review indicated that of 48 performance targets for Blacks, 35% of the targets were moving in the wrong direction, which was the highest percentage among minority groups (US DHHS, 1995).

We hypothesized that when LHDs spend more resources on population-based interventions, everyone benefits, which has the potential to reduce racial/ethnic disparities in mortality. Our results are inconsistent with the hypothesis because Black/White mortality disparities did not decline in the total population. One potential explanation is that LHDs placed more resources into improving overall population health rather than reducing health disparities. Mays and Smith (in press) report that increases in LHD spending were associated with reductions in mortality rates, and if the relationship is causal, LHDs are indeed capable of improving population health. We lacked data about whether local health departments had formal goals to reduce racial/ethnic disparities, or whether local health departments were allocating resources and services to reduce specifically disparities in Black-White morbidity and mortality. We might expect disparities in Black-White mortality to decline more in LHDs with formal goals to reduce disparities and allocations of resources to achieve those goals. Further studies are recommended to discover whether LHDs increase spending in response to Black–White mortality disparities, and to examine whether LHD activities, a more precise measure of LHD interventions than spending, are related to population health and disparities.

Individual-level and community-level socioeconomic characteristics shape population health, and Black/White mortality disparities arise from differences in the social positions of Black and White populations in society (Graham, 2004b). Murray et al. (2006) recently identified ‘eight Americas’ in the U.S., where the 7th and 8th Americas with the worst health were rural and urban Black populations with low average income per capita ($10,463 and $14,800, respectively) and low percentages of completing high school (61% and 72%, respectively). For Black populations in this study, the average income per capita and percentage completing high school were worse than in the ‘worst Americas’ (see Table 3). In our study the effects of public health spending on racial disparities in mortality may be small because the amount of public health funding was too small to offset the more powerful effects of racial disparities in social position in LHD areas (Graham, 2004a, 2004b).

Another hypothesis was that public health interventions often do not reach everyone, and that preventive and other effective interventions that depend on voluntary participation may increase racial/ethnic disparities because people with more resources and less need are more likely to take advantage of them. We find no compelling evidence, however, that greater public health funding increased Black–White mortality gaps.

Our findings in lag regression models suggest that today’s public investments in LHDs may not reduce racial/ethnic disparities in mortality for Black and White subgroups until some time in the future, but little is known about the timing of those benefits or if the benefits are linked with the adoption of new technologies such as HAART. Studies are needed that estimate the covariation in LHD funding and racial/ethnic disparities in mortality over a minimum of one or two decades, and that include spells when the mortality gap is increasing and decreasing to gain an understanding of how secular trends in mortality affect LHD funding–mortality relationships.

Limitations & conclusions

Our findings are limited to local health departments that completed 1990 and 1997 NACCHO Profile Surveys and who have county mortality rates for Black and White populations in those years. The Profile surveys lack information about how local health departments allocated expenditures across services, and therefore, we cannot examine whether the quantity or quality of services is related to mortality. County mortality data do not exist for other social disparities, such as income, and therefore, we cannot examine whether LHD funding is related to other disparities in mortality. Other community agencies may also perform local public health functions (Barry, Centra, Pratt, Brown, & Giordano, 1998), but no data on public health spending by all community agencies exist for counties in 1990 and 1997. Although individual health behaviors contribute to population health and health disparities, population-level data of health behaviors do not exist for counties, but this is less of a problem if behaviors are time-invariant. LHD funding may be related to disparities in cause-specific Black–White mortality rates, but Black populations in most U.S. counties are too small to obtain cause-specific Black mortality rates from the CDS Wonder database. Overall, these omitted variables create a conservative bias toward zero in estimating the contribution of LHD spending toward health disparities.

In conclusion, on a population-level LHD spending and percentage share of public revenue are not related to reductions in Black–White disparities in all-cause, total mortality. However, subgroups with the greatest mortality differences appear to be more likely to benefit from public investment in local health departments. LHD funding or percentage share of public revenue appears to reduce Black–White disparities for adults aged 15–44 and for males. Investment in LHDs may reduce mortality in a racial group without closing Black–White mortality gaps, particularly for infants, Blacks, and White females.

Acknowledgments

We thank gratefully the anonymous reviewers for their comments. We also thank Carolyn Leep and the National Association of County and City Health Officials for their support and assistance in providing the National Profile of Local Health Departments Surveys for this study, along with the Centers for Disease Control and Prevention for its financial and technical support of the Profile Survey initiatives. We also thank Tina Tian in the Center for Social Science Computation and Research at the University of Washington for her assistance in obtaining public data files from the U.S. Census Bureau. We thank Eric Darst for his assistance in building the study's data base. Funding support from the Robert Wood Johnson's Changes in Health Care Financing and Organization Initiative Grant No. 59949.

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