Have New York City's Public Health Initiatives Reduced Mortality? Comparing Period-based Variation in NYC & US Mortality Rates, 1990-2009*

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Male and female life expectancy in the United States have steadily increased over the past two decades, from 71.8 and 78.8 in 1990, respectively, to 75.7 and 80.8 in 2010 (US Census 2012 Statistical Abstract). Despite the gains, serious concerns remain about the persistence and extent of mortality disparities by race/ethnicity, geographic region, and socioeconomic class (Olshansky et al. 2012, Woolf and Aron 2013), as well as the United States' overall poor standing among economically advanced countries in terms of health and longevity (Woolf and Aron 2013). For example, mortality inequalities are growing across education groups (Masters et al. 2012; Miech et al. 2011; Montez et al. 2011; Olshansky et al. 2012) and evidence suggests life expectancy has declined for some segments of the US population (Montez and Zajacova 2013; Murray et al. 2006; Olshansky et al. 2012). The Institute of Medicine's recent report, "Shorter Lives, Poorer Health," exemplifies the growing calls among health professionals and policy-makers for innovative approaches to addressing early-death in the United States – especially from accidents, homicides, and drug and alcohol abuse – as well as more effectively addressing later-life morbidity and mortality risk from chronic diseases such as heart disease, stroke, diabetes, and cancers (Ho 2012; Woolf and Aron 2013).

New York City is on the forefront of implementing both preventative measures and curative techniques to address a wide array of public health concerns. For example, The Fund for Public Health in New York started in 2002 as a public-private partnership to enact pro-active public health measures. The fund has raised more than $250 million and has implemented a number of sweeping structural changes to the cityscape (e.g., Pedestrian Safety Program) as well as encourage lifestyle-based changes in the city's population (e.g., posting calorie counts in chain restaurants). Many of the city's public health measures have been emulated by other municipal, state, and national governmental agencies. For instance, the Smoke Free Air Act in 2002 was the first comprehensive smoking ban in the United States. Highly controversial at the time, the act has since sparked an anti-tobacco trend across the country with many large cities and states enacting similar anti-smoking measures. Adult smoking rates in NYC have decreased 27% since 2002 and rates of youth and young adult smoking are down 52%. New York City has also been a leader in the Big City Health Coalition, which has helped to develop ideas, recruit staff, and provide the technical assistance needed to pioneer new public health measures for urban populations. Subsequent public health and lifestyle measures have been enacted in NYC including a trans-fat ban in 2006, aggressive HIV-prevention measures, a National Salt Reduction Initiative in 2008, increases in police presence, and electronic medical records and diabetes registry to improve patient services in hospitals and clinics.

The 2009 NYC life expectancy at birth was reported to be 80.6 years, contrasted against the 78.8 years for the entire United States. And not only is NYC's life expectancy higher than the rest of the country's, but the city's gains in life expectancy between 2000 and 2010 outpaced the corresponding rise in overall U.S. life expectancy by nearly twofold (~3 years in NYC vs. 1.5 years for the entire US population). New York City Mayor Michael Bloomberg and the NYC Department of Health were quick to cite such differences as evidence of the effectiveness of the city's public health measures and its overall attentiveness to healthy living. Further, a 2013 report by the New York City Department of Health and Mental Hygiene attributed 70% of the increase in NYC life expectancy to "decreases in deaths due to heart disease, cancer and HIV infection" (Li, Maduro, and Begler 2013: 11). Doubts remain, however, as to whether the recent increases in NYC longevity reflect the specific public health investments made by the city during this time period. New York City is the largest, most diverse, and richest city in the United States. And across the 2000s it experienced profound demographic changes that might have fundamentally altered the composition of the population and, consequently, the underlying mortality risks in that population. Accordingly, while life expectancy might have tracked well with the temporal sequence of NYC's implementing its health measures, the association might simply reflect age-based and/or cohort-based compositional changes in the city's population across a recent period of time. In this paper we fit age-period-cohort models on official death records to investigate period-based changes in

age-specific mortality rates from multiple causes of death in New York City and the US population between 1990 and 2010. While we do not directly test the effectiveness of specific public health measures during this time, our aim is to simply examine whether period-based changes in mortality risk – beyond age- and cohort-based variation – were greater in NYC than in the rest of the United States. That is, we document whether period-based mortality reductions over the past two decades are descriptively consistent with the suggestion that such reductions might have stemmed from NYC's public health initiatives.

Analytic Strategy

Data

Yearly counts of death for both the NYC population and the entire US population were obtained from the National Vital Statistics (NVSS), 1990-2004 for NYC and 1990-2009 for the United States. Because NVSS data stopped reporting geographic location of US deaths in 2005, we obtained counts of deaths in NYC for years 2005-2009 from the NYC Department of Health and Mental Hygiene Death Master File. Population counts for both NYC and the entire US were obtained from the 1990-2009 Bridged-Race Population Estimates from the National Center for Health Statistics CDC Wonder (http://wonder.cdc.gov/bridged-race-population.html).

Data were arranged in one four-year age grouping (ages 1-4) and 16 five-year age groupings (*A*) ranging from 5-9 to 80-84 and mortality rates were estimated across four five-year periods (*P*) spanning 1990-1994 to 2005-2009. Twenty ten-year birth cohorts (*C*) were computed as direct linear combinations of the five-year time periods and five-year age groups, and range from birth cohort 1906-1915 to 2001-2009. Five-year age-specific mortality rates for the US population were stratified by sex and by race/ethnicity. Mortality rates for the NYC population were stratified by sex, race/ethnicity, and in some analyses by county (i.e., city borough).

Methods

To account for compositional changes in the US and NYC populations, differential mortality risk across birth cohorts, and residual confounders we employ recently developed age-period-cohort (APC) models on NYC and US adult mortality rates. That is, in order to attempt to isolate the temporal changes in NYC's mortality rates after the implementation of certain health initiatives, we simultaneously estimate age-, period-, and cohort-based variation in US and NYC adult mortality rates between 1990 and 2009, using the intrinsic estimator (IE) APC modeling technique (Yang, Fu, and Land 2004; Yang 2008; Yang et al. 2008; Powers 2013). Logged counts of deaths within each APC cell are assumed to follow a Poisson distribution and offsetting the aggregated exposure time lived across each cell estimates a rate model, specified as:

$$\log\mathrm{E}(r_{ij}) = \log\mathrm{E}\left(\frac{d_{ij}}{n_{ij}}\right) = \beta_0 + \beta_i^A + \beta_j^P + \beta_k^C, \quad (1)$$

where $\log\mathrm{E}(r_{ij})$ is the logarithm of the expected mortality rate based on d_{ij} deaths and n_{ij} population pertaining to cell *ij* of the cross-tabulated generated data structure. Effects associated with age interval *i* (for $i = 1, \ldots, I$ age groups) and with period *j* (for $j = 1, \ldots, J$ periods) are captured by β_i^A and β_j^P,

respectively. β_k^C denotes the kth diagonal of birth cohort effect (for k = 1,…, I+J-1 birth cohorts), where the index $k = I - i+j$.

We use the apc_ie (Yang 2008), ie_rate, and ie_norm (Powers 2013) programs in Stata 12 to model the APC terms as ANOVA, centered, multiplicative effects:

$$\mathrm{E}(r_{ij}) = \boldsymbol{\tau}_0 \boldsymbol{\tau}_i^A \boldsymbol{\tau}_j^P \boldsymbol{\tau}_k^C, \quad (2)$$

where $\prod \boldsymbol{\tau}_i^A = \prod \boldsymbol{\tau}_j^P = \prod \boldsymbol{\tau}_k^C = 1$. The $\boldsymbol{\tau}$ parameters in the APC model are multiplicative effects whose product is 1 over the levels of each factor. Under this normalization, the constant term $\boldsymbol{\tau}_0$ is the scaled grand mean of all five-year age-specific mortality rates. We use the IE with the linear model above to obtain unique estimates of the age, period, and cohort effects on US and NYC men's and women's mortality rates.

To investigate period-based variation in age-specific mortality rates for the US and NYC populations we stratify models in the following ways:

1. All-cause mortality by age groups:

   0-4 through 10-14
   15-19 through 30-34
   35-39 through 60-64
   65-69 through 80-84

2. All-cause mortality (younger [ages 1-4 through 40-44] and older [ages 45-49 through 80-84]) in NYC by Borough compared with all-cause mortality (younger and older) for the entire US population.

   Brooklyn
   Bronx
   Manhattan
   Queens
   Staten Island

3. All-cause mortality (younger [ages 1-4 through 40-44] and older [45-49 through 80-84]) in NYC and the entire US population by Race/Ethnicity Groups:

   Non-Hispanic White
   Non-Hispanic Black
   Non-Hispanic Other
   Hispanic

4. Cause-specific mortality among adults (ages 35-39 through 80-84) in NYC and the entire US population:

   Circulatory Diseases
   Diabetes

Lung Cancer
Breast Cancer (Women)
Non-Lung/Non-Breast Cancer

5. Cause-specific mortality among children, adolescents, and young adults (ages 0-4 through 30-34) in NYC and the entire US population:

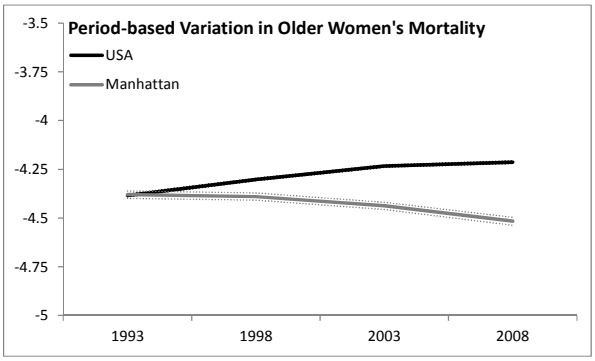
   Accidents
   Homicide
   Infectious Disease

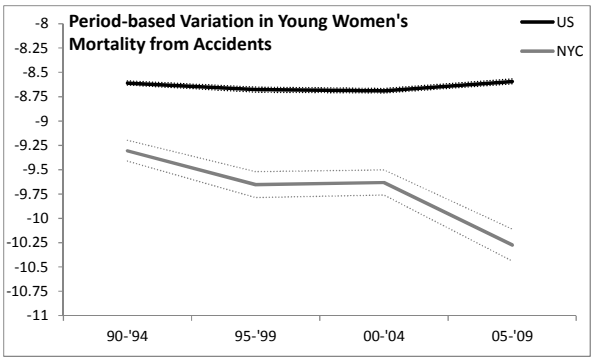
Results

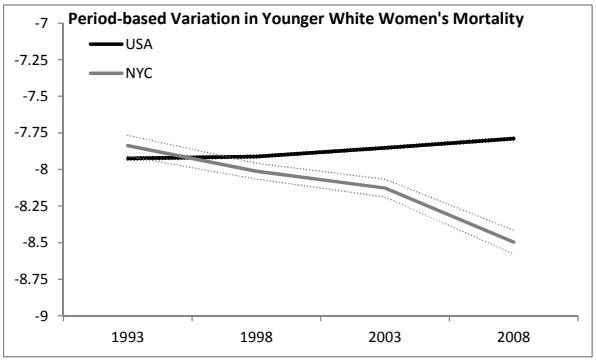
Preliminary results indicate that period-based reductions in mortality rates between 1990 and 2009 were substantively larger in the NYC population than the overall US population. Two points are especially worth noting, one of which is consistent with the suggestion that NYC's public health initiatives across the 2000s affected mortality levels and the other of which is inconsistent with this notion. On the one hand, period-based reductions in NYC mortality are largest among (1) subgroups disproportionately affected by the initiatives and simultaneously least affected by confounding effects of selective immigration (i.e., the non-Hispanic white and non-Hispanic black NYC populations); (2) are largest in some causes of death directly targeted by the initiatives (i.e., heart disease, accidents, homicides, infectious disease); and (3) are also greatest in the boroughs most affected/targeted by the policies (i.e., Bronx and Manhattan). Related to this last point, no significant period-based variation was observed in Staten Island mortality, the Borough least affected by the structural and policy changes.

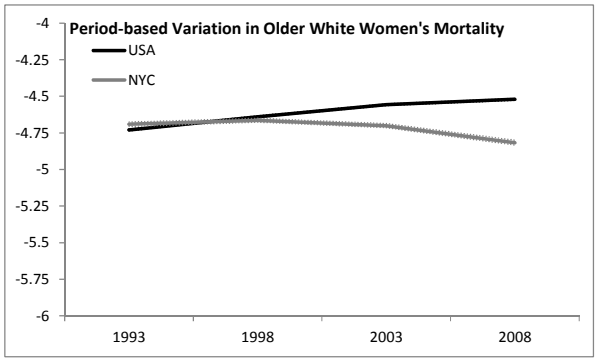
However, inconsistent with the idea that NYC's public health initiatives are driving period-based reductions in mortality rates are the following two points: first, some causes of death directly targeted by the policies increased across periods in the 1990s and 2000s (e.g., diabetes and lung cancer). However, it must be noted that the rate of increase in NYC is less than the rate of increase in these causes of death in the entire US population, and deaths from these causes tend to have a long latency period. Thus, the substantive impact of policies aimed at reducing lung cancer and diabetes likely will not be seen for some time. Second, most of the period-based variation in NYC mortality rates started in the 1990s, well before the implementation of the The Fund for Public Health in New York (2002) and its subsequent policy changes.

Select results showing large period-based reductions in NYC older women's mortality in Manhattan, for accidents among young women, and in the NYC non-Hispanic white population (old & young):

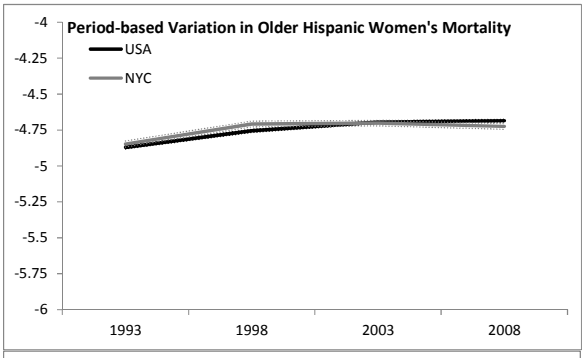


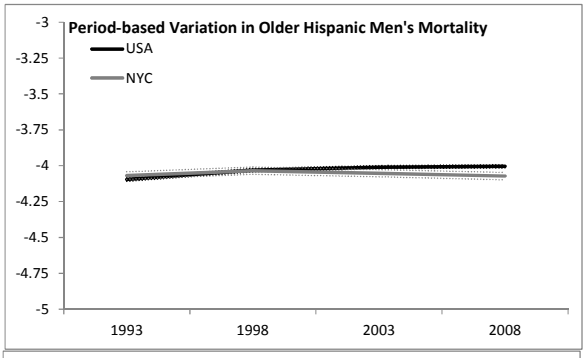


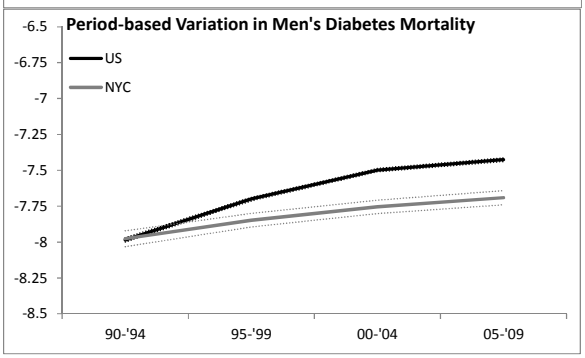


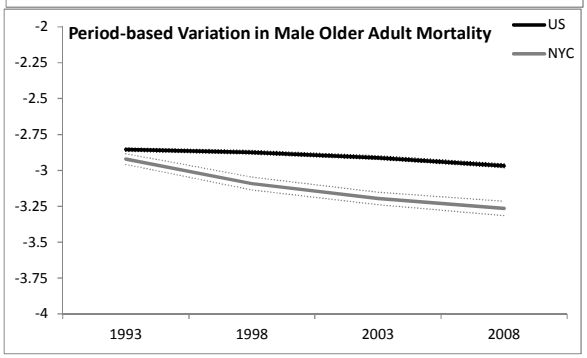


Select results showing minimal period-based reductions in NYC mortality among older Hispanic men and women, period-based increases in NYC diabetes mortality among men (although at relatively slower rates than the overall US period-based increases in diabetes mortality), and evidence of period-based reductions in the 1990s among older NYC men – with no notable acceleration across the 2000s.









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