Neighborhood Matters

Infant Mortality Rates in Four Cities: London, Manhattan, Paris, and Tokyo

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A comparison of citywide infant mortality rates for Manhattan, Inner London, Paris, and Inner Tokyo during 1988–97 shows the Manhattan rate nearly always higher than those of the other cities. Differences in the neighborhood rate distributions of the four cities explain the citywide pattern. In contrast to the other cities, Manhattan has neighborhoods with rates substantially above its median neighborhood rate and these neighborhoods drag its citywide rate above those of the other cities.

T HE INFANT MORTALITY RATE IN NEW YORK CITY—like the infant mortality rate in the rest of the United States and most nations in the world—has decreased over the past decades. But New York

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City and, more generally, the United States still stand out on the high side in comparison to other world cities and industrialized nations. A common response to this health gap is to note that aggregate rates mask large disparities by race, ethnicity, socioeconomic status, immigrant status, and location. Indeed, an important policy objective announced by the U.S. Department of Health and Human Services is to narrow disparities in infant mortality rates and a range of other health indicators.[1]

Two recent studies maintain that the decline in New York City's infant mortality rate between 1989 and 1992 was due largely to reduced birth-weight-specific mortality rates rather than increased birth weights.[2] This suggests that the source of the declines was a range of perinatal and postnatal factors such as improved medical technologies and practices, improved access to medical care, and widespread use of preventive practices. Although the studies noted these improvements across race, they did not examine the declines in infant mortality rates by neighborhood.

Rationale for Selection of World Cities and Neighborhoods Within Them

In the United States, New York City has the highest concentration of births (over 120,000 in 1999). Along with New York City (population of 8 million), Greater London (7 million), Paris and its first ring (6 million), and Central Tokyo (8 million) are the largest cities among the higher-income nations belonging to the Organization for Economic Cooperation and Development. Like New York City, the other cities also have the highest concentration of births in their respective nations.

Beyond considerations of scale, New York, London, Paris, and Tokyo share world city status due to their high concentration of high-level functions in government, business, media, and the arts.[3] They function as hubs in the global economy of transnational corporations, financial services, and information exchange.[4] One can define these cities, spatially, as enormous metropolitan regions. In thispaper, however, we study their "urban cores":[5] Manhattan (1.5 million popu-

lation), the fifteen boroughs known as "Inner London" (2.7 million), the twenty *arrondissements* of Paris (2.1 million), and eleven inner *ku* (wards) of Tokyo (2 million) located within the area circumscribed by the Yamanote subway line (Figure 1).[6] For simplicity, we will refer to these four entities as Manhattan, London, Paris, and Tokyo in tables and figures.

These urban cores share a number of convergent characteristics. Each has a higher population density than its surrounding region. Their economies, based on services and information, serve as employment centers that attract large numbers of commuters from their outer rings—between 32 percent and 38 percent of their working populations.[7] They are medical capitals with a disproportionate share of hospitals and specialist physicians. In addition, they are destinations for large immigrant communities from around the world (with the exception of Tokyo).[8] Finally, and perhaps most important to our study, Manhattan, Paris, Inner London, and Inner Tokyo are characterized by increasing social and spatial polarization.[9]

With respect to polarization, there are important differences among the cities. Manhattan and Inner London are characterized by the largest socioeconomic disparities across neighborhoods.[10] Paris is known as a "soft" global city, in contrast to Inner London and Manhattan, because it provides more income support, family services, and health services to the poor.[11] Likewise, Tokyo is characterized by less social and spatial polarization, not only because there is less ethnic diversity than in the other cities but also because income distribution is more equal.[12]

Neighborhood Identification and Infant Mortality

Designating neighborhoods is, to some extent, arbitrary. We rely on two criteria: existing designations of neighborhoods or administrative boundaries, and availability of live birth and infant death data for these neighborhoods. Their fifteen boroughs and twenty *arrondissements* define Inner London and Paris, respectively. For Manhattan we relied on the twelve community districts established by the City Charter mandate in 1969, and for Inner Tokyo we relied on the eleven *ku*.
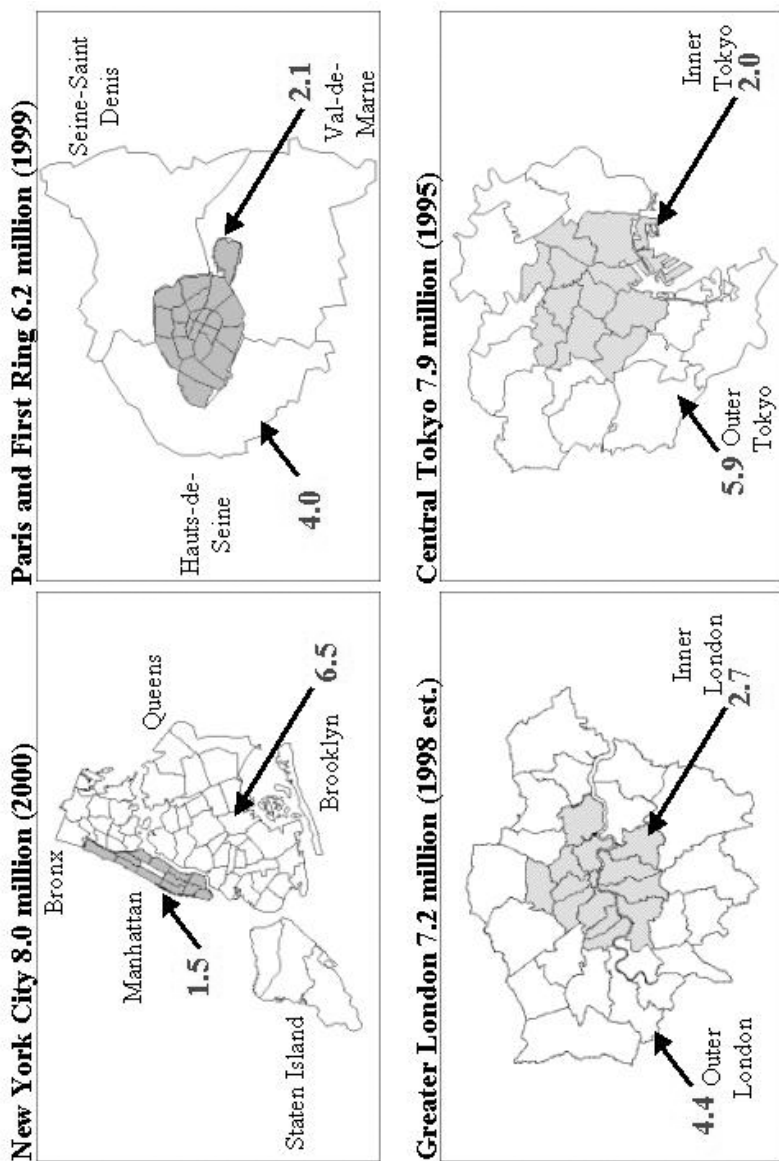
Figure 1. Four World Cities

Table 1

Citywide Infant Mortality Rates (1988–1997)

London	Manhattan	Paris	Tokyo
8.0	9.3	6.5	4.5

For any given geographic entity, the definition of an annual infant mortality rate is the total number of infant deaths in a year divided by the total number of births in that year.[13] The annual number of infant deaths in the neighborhoods defined earlier ranges from zero to sixty-six. The annual number of births ranges from 400 to 5,000.[14] Given the small number of annual births and deaths in some neighborhoods, year-to-year changes in infant mortality rates may sometimes result from chance alone. That is why we focus our analysis on periods of five or ten years where chance plays a lesser role.[15]

Citywide Infant Mortality Rates

Over the 1988–97 decade, the Manhattan citywide infant mortality rate was higher than the rate in London and Paris and more than twice that of Tokyo (Table 1). There has been some discussion in the literature about the extent to which differences in birth registration practices and reporting among France, Japan, the United Kingdom, and the United States affect international comparisons of infant mortality. Although it is recognized that such differences would affect rankings, there is general consensus on the fact that the United States does far less well than do many industrialized nations.[16] Since the citywide rates in Table 1 are calculated over a ten-year period, the numbers of births and deaths are sufficiently large so that the difference among rates of any two adjacent-ranked cities is statistically significant.[17] Had Manhattan's rate been the same as Tokyo's over the 1988–97 period, there would have been 980 infant deaths averted.

Ten years is a long period over which to define a rate. One might reasonably ask how citywide rates evolved on an annual basis (Table

Table 2

Annual Citywide Infant Mortality Rates (1988–1997)

	London	Manhattan	Paris	Tokyo
1988	9.9	13.4	7.3	4.4
1989	9.5	12.4	7.4	4.7
1990	8.7	10.5	7.4	4.5
1991	8.1	9.9	8.0	4.5
1992	7.8	8.6	7.6	4.0
1993	7.5	10.9	6.6	5.2
1994	7.5	7.2	6.1	4.2
1995	7.2	7.2	4.0	5.1
1996	6.9	7.0	4.5	4.2
1997	6.8	4.9	5.6	3.9

Table 3

Citywide Infant Mortality Rates by Five-Year Periods

	London	Manhattan	Paris	Tokyo
1988–92	8.8	10.9	7.5	4.4
1993–97	7.2	7.5	5.4	4.5

2). Several patterns are evident. The Tokyo rates are lowest for every year except the eighth and do not change much over the decade. The rates in the other three cities decline over the decade. Manhattan and London begin the decade with infant mortality rates well above those of the other two cities, and those in Manhattan are above those in London. By the end of the decade, Manhattan and London have similar rates. With the exception of Manhattan in the tenth year, for the whole period, the Manhattan and London rates remain above the Paris rate.

To analyze trends across the cities we compare two five-year periods (Table 3). The citywide infant mortality rates in London, Manhattan, and Paris decline, while in Tokyo there is no significant change. Ranked in order of their percentage increase rather than absolute changes between the two periods, Manhattan has performed relatively well (Table 4). In summary, Manhattan's infant mortality rate was the highest over

Table 4

Change in Citywide Infant Mortality Rates Between Five-Year Periods (1988–1992 and 1993–1997)**, in percent**

London	Manhattan	Paris	Tokyo
−18	−31	−28	+2

Table 5

Neighborhood Infant Mortality Rate Distribution: Five-Number Summary (1988–1997)

	London	Manhattan	Paris	Tokyo
Largest	9.5	18.3	8.4	4.8
75th percentile	8.4	12.1	7.1	4.7
Median	7.6	7.1	6.6	4.6
25th percentile	6.9	5.7	6.1	4.0
Smallest	5.1	3.9	2.5	3.4

the 1988–97 period, but it improved the most. We propose to explain this phenomenon at the neighborhood level.

Neighborhood Infant Mortality Rates

The distribution of neighborhood infant mortality rates across the cities may be analyzed with a traditional five-number summary (Table 5).[18] The median is the best measure of the center of a distribution of rates across neighborhoods. In order of median neighborhood rate (lowest median first), the cities are: Tokyo, Paris, Manhattan, and London. That ranking reverses the positions of Manhattan and London in comparison to the citywide rate ranking (Table 1), a puzzle that we return to below.

Table 5 also reveals other features of the neighborhood rate distributions. For example, the lower quartile Manhattan neighborhood rate is lower than the lower quartile neighborhood rates of both London and Paris (but not Tokyo). Also, the highest Manhattan neighborhood rate is nearly double the highest rate in London, which is the city with the
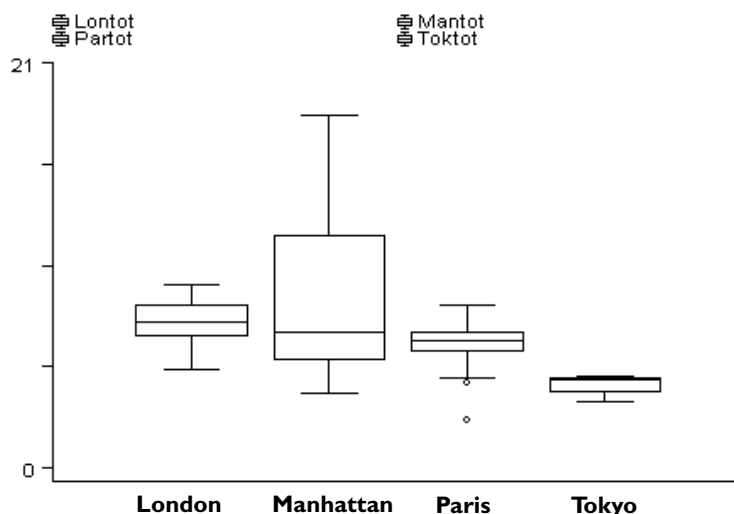
Figure 2. Boxplots of 1988–1997 Neighborhood Infant Mortality Rate Distributions

second highest neighborhood rate. The upper quartile Manhattan rate is more than twice that of the upper quartile Tokyo rate.

Finally, Table 5 provides measures of the spread and asymmetry of the distributions. For example, the highest minus the lowest rate gives the range of a distribution, a good measure of spread. Or the seventy-fifth percentile minus the twenty-fifth percentile gives the inter-quartile range, another good measure of spread. Comparing the highest minus the median rate to the median minus the lowest rate gives a sense of any asymmetry in the distribution.

Box plots graph five number summaries, and box plot comparisons give a graphic sense of differences in spread and asymmetry of distributions.[19] In Figure 2, the box plots show the distributions of infant mortality rates by neighborhood. Manhattan has the largest and Tokyo has the smallest spread, with London and Paris falling in between. In addition, the distributions of neighborhood infant mortality rates in London, Paris, and Tokyo tilt slightly toward rates below the median. In contrast, the distribution of neighborhood infant mortality rates in Manhattan tilts sharply toward rates above the median.

So far we have merely compared the distributions of infant mortality rates across neighborhoods in the four cities. What remains to ex-

amine is how these rate distributions explain the differences among citywide rates in Table 1.

Neighborhood and Citywide Infant Mortality Rates

Another measure of the center of a neighborhood rate distribution is the mean neighborhood rate.[20] It is well understood that when a neighborhood rate distribution is asymmetric, the rates on the side of the median to which the distribution is skewed get greater weight in calculating the mean than do those to the other side.[21] Hence, the asymmetry drags the mean to the skewed side of the median.

Less well understood is how the mean neighborhood and citywide rates are related and what effect a skewed neighborhood rate distribution has on the relation of the citywide and median neighborhood rates. Suppose that there are n neighborhoods. Let m_i be the neighborhood infant mortality rate and b_i be the number of live births, respectively, for neighborhood i. Let B be the number of live births citywide, m be the mean of the neighborhood rates, M be the citywide rate, and V be the covariance of the (b_i / B)s and the m_is. Then it is not hard to prove that:

$$M = m + (n - 1)V \qquad (1)$$

Two things follow from (1). First, as long as V is positive (as is the case for the four cities that we study), the citywide rate will be greater than the mean neighborhood rate. Second, and more important, a skewed neighborhood rate distribution will drag the citywide rate, as it drags the mean neighborhood rate, away from the median neighborhood rate, in the direction toward which the distribution is skewed.

Table 6 shows the citywide and mean and median neighborhood rates for each of the four cities. As (1) suggests, the citywide rate is slightly above the mean neighborhood rates in each city.[22] Furthermore, since the London, Paris, and Tokyo distributions are skewed slightly toward rates below the median (Table 5 and Figure 2), the mean neighborhood and citywide rates are slightly below the median neighborhood rates in these three cities. In contrast, the Manhattan distribution is heavily skewed toward rates above the median.

Table 6

Citywide Infant Mortality Rates and Measures of Center for the Distribution of Neighborhood Infant Mortality Rates (1988–1997)

	London	**Manhattan**	**Paris**	**Tokyo**
Median	7.6	7.1	6.6	4.6
Mean	7.7	8.9	6.4	4.3
Citywide	8.0	9.3	6.5	4.5

Table 7

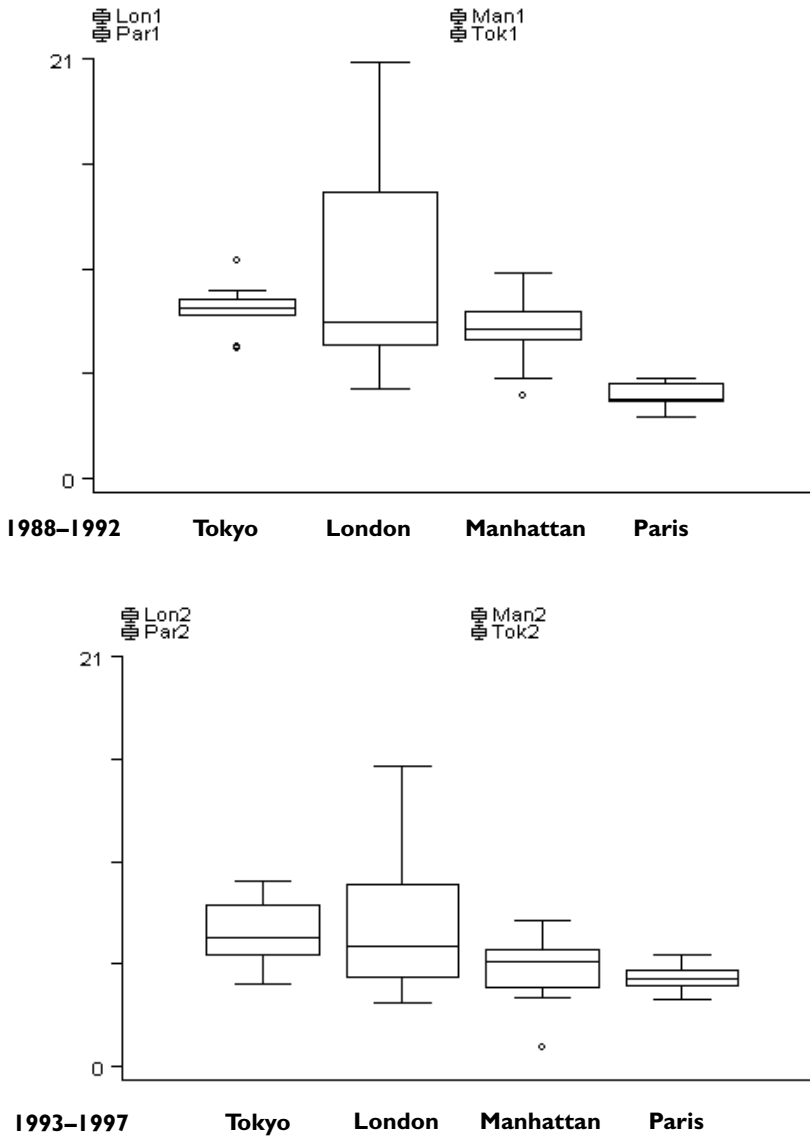**Distribution of Infant Mortality Rates by Neighborhood: Five-Number Summary by Five-Year Periods**

	London	**Manhattan**	**Paris**	**Tokyo**
1988–1992				
Highest	10.9	20.8	10.3	5.0
75th percentile	9	14.3	8.4	4.8
Median	8.5	7.8	7.5	4.0
25th percentile	8.2	6.7	7.0	3.9
Lowest	6.5	4.5	4.1	3.1
1993-1997				
Highest	9.5	15.4	7.5	5.7
75th percentile	8.3	9.3	6	4.9
Median	6.6	6.2	5.4	4.5
25th percentile	5.7	4.6	4.1	4.1
Lowest	4.2	3.3	1.0	3.4

Therefore, the Manhattan mean neighborhood and citywide rates are well above its median neighborhood rate.

How did the neighborhood rate distribution in each city change between the two five-year periods of 1988–97?

Changes in Neighborhood Infant Mortality Rates

Table 7 gives a five-number summary for the neighborhood rate distribution of each city for each of the two five-year periods (1988–92 and 1993–97). The medians show that the centers of the Paris and To-

Figure 3. Boxplots of Neighborhood Infant Mortality Rate Distributions

kyo distributions grew closer together as did the centers of the London and Manhattan distributions. However, the centers of the neighborhood distributions in Paris and Tokyo, the "softer" global cities, drew away from those of Manhattan and London.

Box plots for each of the four cities (Figure 3) for both 1988–92 and

1993–97 indicate some increase in spread between the two periods in London, Paris, and Tokyo and some reduction in spread in Manhattan. In addition, between the two periods, the skewed nature of the London, Paris, and Tokyo distributions changed only slightly while the Manhattan distribution, starting sharply skewed toward rates above the median, grew considerably less skewed toward rates above the median.

How do the changes in the distribution of infant mortality rates across neighborhoods explain changes in the citywide rates between 1988–92 and 1993–97?

Changes in Neighborhood and Citywide Infant Mortality Rates

For both 1988–92 and 1993–97, Table 8 shows the citywide and median and mean neighborhood infant mortality rates for each of the cities.

Little change in closeness of the citywide and mean and median neighborhood rates between the two periods in London, Paris, and Tokyo reflect the small changes in the skewed nature of these three neighborhood rate distributions between the two periods (Table 7 and Figure 3). In Manhattan, in contrast, the citywide rate in the first period is 40 percent greater than the median neighborhood rate, while in the second period it is only 21 percent greater. The growing closer together of the citywide and mean and median neighborhood rates between the two periods in Manhattan reflects the sharp reduction in skewed nature of the Manhattan neighborhood rate distribution between the two periods.

Geography of Neighborhood Disparities

Table 9 and Figure 4 compare the three neighborhoods with highest and lowest infant mortality rates in each city for the overall period. Changes in neighborhoods with highest and lowest infant mortality rates between five-year periods appear in Table 10, which reveals

Table 8

Citywide Infant Mortality Rates and Measures of Center for the Distribution of Neighborhood Rates by Five-Year Periods

	London	**Manhattan**	**Paris**	**Tokyo**
1988–1992				
Median	8.5	7.8	7.5	4.0
Mean	8.6	10.2	7.6	4.2
Citywide	8.8	10.9	7.5	4.4
1993–1997				
Median	6.6	6.2	5.4	4.5
Mean	6.8	7.5	5.1	4.5
Citywide	7.2	7.5	5.4	4.5

greater rigidity of neighborhood rankings in Manhattan than in the other three cities. In Manhattan, Central Harlem, East Harlem, and Midtown, in that order, remain the areas with the highest infant mortality rates in both five-year periods. Even as citywide rates decline significantly, the neighborhoods with the highest neighborhood rates remain the same, not a likely chance occurrence.[23]

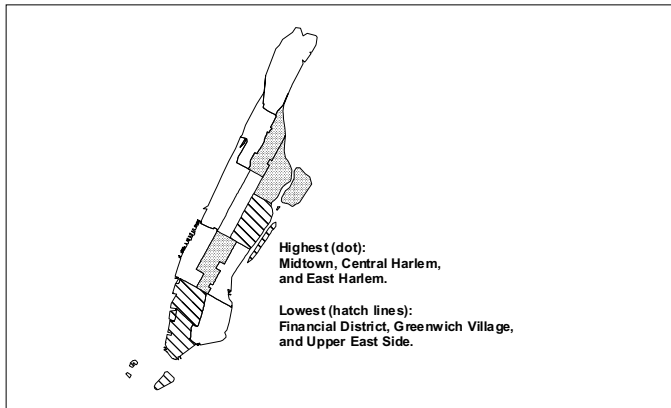## Summary and Implications for Public Health and Social Policy

London, Paris, and Tokyo share world city status with Manhattan. Along with the glamour, they also share increasing levels of social and spatial polarization and (with the exception of Tokyo) high and increasing numbers of immigrants. Although Manhattan succeeded in lowering its citywide infant mortality rate more than the other cities over the decade between 1988 and 1997, its citywide rate remained higher than that of London, Paris, and Tokyo at the end of the period. Moreover, of the four cities, Manhattan stands out by far as the city with the greatest spread and asymmetry in the distribution of neighborhood infant mortality rates for the full ten years and for each of the five-year periods. Finally, Manhattan has a problem that none of
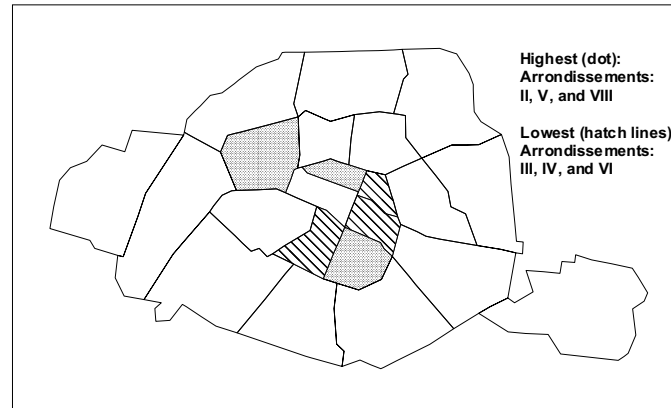
Table 9

Neighborhoods with Highest and Lowest Infant Mortality Rates (1988–1997)

	London	**Rate**	**Manhattan**	**Rate**	**Paris**	**Rate**	**Tokyo**	**Rate**
Highest	Southwark	9.5	Central Harlem	18.3	II	8.4	Shibuya	4.8
	Hackney	9.3	East Harlem	15.4	V	7.8	Kohtou	4.7
	Lambeth	8.8	Midtown	12.9	I	7.6	Sumida	4.7
Lowest	Wandsworth	6.9	Financial District	5.5	VI	4.7	Toshima	4.0
	Kensington-Chelsea	6.6	Greenwich Village	4.8	III	4.4	Taito	3.7
	City of London	5.1	Upper West Side	3.9	IV	2.5	Chiyoda	3.4

Manhattan

Highest (dot):
**Midtown, Central Harlem,
and East Harlem.**

Lowest (hatch lines):
**Financial District, Greenwich Village,
and Upper East Side.**

Paris

Highest (dot):
**Arrondissements:
II, V, and VIII**

Lowest (hatch lines):
**Arrondissements:
III, IV, and VI**

Inner London

Highest (dot):
**Hackney, Lambeth,
and Southwark**

Lowest (hatch lines):
**City of London, Islington,
and Kensington-Chelsea**

Inner Tokyo

Highest (dot):
**Sumida, Kohtoh,
and Shibuya**

Lowest (hatch lines):
**Chiyoda, Taito,
and Toshima**

Figure 4. Three Highest and Lowest Infant Mortality Rate Neighborhoods, 1988–1997

Neighborhood Matters

Table 10

Changes in Neighborhoods with Highest and Lowest Infant Mortality Rates Between Five-Year Periods

	London	Rate	Manhattan	Rate	Paris	Rate	Tokyo	Rate
1988–1992								
Highest	Southwark	10.9	Central Harlem	20.8	V	10.3	Kohtou	4.9
	Haringey	9.4	East Harlem	16.9	I	9.9	Sumida	4.8
	Brent	9.1	Midtown	14.8	VIII	9.9	Shinjuku	4.6
Lowest	Wandsworth,						Minato,	
	City of Westminster	8.2	Financial District	5.9	VI	5.7	Arakawa	3.9
	Kensington-Chelsea	6.6	Greenwich Village	5.5	III	5.0	Chuo	3.6
	City of London	6.5	Upper East Side	4.5	IV	4.1	Chiyoda	3.1
1993–1997								
Highest	Hackney	9.5	Central Harlem	15.4	II	7.5	Chuo	5.7
	Southwark	8.6	East Harlem	13.8	VII	6.6	Shibuya	5.3
	Lambeth	8.5	Midtown	10.2	XX	6.6	Arakawa	4.9
Lowest	Islington	5.1	Upper West Side	4.0	VI	3.7	Toshima	4.1
	Camden	4.9	Greenwich Village	4.0	IX	3.5	Chiyoda	3.9
	City of London	4.2	Upper East Side	3.3	IV	1.0	Taito	3.4

Note: A comma between two neighborhoods indicates a tie for that rank between the neighborhoods.

the other cities share: the neighborhoods with the highest infant mortality rates remain the same for both five-year subperiods.

Infant mortality—deaths in the first year of life—certainly reflects multiple social determinants of health. At least the following are candidates for social determinants of infant mortality rate: race, income class, maternal age and health, and immigrant status. However, statistical modeling of infant mortality as a function of these and other variables is plagued with difficulties. Our data, for example, are ecological or aggregated, and drawing causal conclusions from such data is very difficult. Even those who employ individual level observational, nonexperimental data continue to debate causality because of problems of multicollinearity, excluded variables, model choice, and selection bias.

In this paper, we postponed the difficult question of what causes neighborhood infant mortality rates to vary. We concentrated instead on the simpler question of how the citywide infant mortality rate depends on the distribution of neighborhood infant mortality rates. We demonstrated that a skewed neighborhood rate distribution drags the citywide rate away from the median neighborhood rate. We showed that in Manhattan, in contrast to the other three cities, a distribution of neighborhood rates heavily skewed toward high-rate neighborhoods raises the citywide rate far above the median. Hence, neighborhoods matter for citywide rates and one sensible way to bring down the citywide rate in Manhattan is to focus attention on the neighborhoods with extremely high rates.

The New York City Department of Health (NYCDOH) recognizes this conclusion. Its "Turning Point" initiative launched a public health planning process that convened forums in each of the boroughs to share data and set priorities.[24] Its Infant Mortality Task Force emphasized the importance of responding to "persistent disparities among New York City's communities" by targeting interventions in community districts with the highest infant mortality rates.[25]

NYCDOH's Infant and Reproductive Health Program is also currently trying to understand the causes of infant mortality in some of New York City's community districts with the highest infant mortal-

ity rates. Its staff shares the concern of the Infant Mortality Task Force about many risk factors for high infant mortality rates: the persistence of segregated African-American neighborhoods,[26] high numbers of Caribbean immigrants, and high numbers of single mothers and teen births. We hope in future research to contribute to this effort to the extent that the methodological difficulties in identifying causes will allow us.

It is worth reiterating the conventional wisdom that infant mortality reflects multiple social determinants of health. The infant mortality rate is an aggregate indicator that subsumes a number of other indicators, each of which may point to different problems with different policy implications. For example, high numbers of fetal deaths usually reflect problems of maternal health whereas late infant deaths tend to reflect problems of infant health. For this reason, in reporting infant mortality, the World Health Organization (WHO) distinguishes four categories according to age of death: fetal (less than 28 weeks in utero), early neonatal (less than 7 days), late neonatal (7–27 days), and post-neonatal (28–365 days).[27]

To the extent that neighborhood disparities more reflect the social determinants of infant mortality, for example, a mother's socioeconomic status, than do the perinatal and postnatal factors, it is particularly important to focus interventions at the neighborhood level. The national systems of health insurance (in France and Japan) and the National Health Service in the United Kingdom regularly monitor the health of all women. Beyond these national programs, in London (somewhat less than in the other two cities), Paris, and Tokyo there are aggressive efforts at the neighborhood level to follow all women in the course of their pregnancies and following delivery.[28] In addition, in England, France, and Japan there are nationally funded programs to identify high-risk mothers and offer them special services. In France, there are even financial incentives for women to seek out these services.[29] This is all in stark contrast to the organization and financing of maternal and child health in the United States, including New York City.[30]

Reducing the citywide infant mortality rate further in Manhattan

will require disproportionate declines in the neighborhoods with the highest rates, for example, central and eastern Harlem. Achieving this objective will require, in turn, more searching, case-by-case examination of the reasons for high infant mortality in these neighborhoods followed by more aggressive targeted interventions to improve maternal health and decrease infant deaths.

Notes

1. U.S. Department of Health and Human Services, *Healthy People 2010: Understanding and Improving Health*, 2d ed. (Washington, DC: Government Printing Office, 2000).

2. H. Kalter, Y. Na, and P O'Campo, "Decrease in Infant Mortality in New York City After 1989," *AJPH* 88, no. 5 (May 1998): 816–20; and A. Racine, T. Joyce, W. Li, and M. Chiasson, "Recent Declines in New York City Infant Mortality Rates," *Pediatrics* 101, no. 4 (April 1998): 682–88.

3. This was the sense in which the British city planner, Patrick Geddes, originally used the term "world cities." See his book, *Cities in Evolution (*London: Williams and Norgate, 1951).

4. P. Hall, *The World Cities*, 3d ed. (London: Weidenfeld and Nicholson, 1984); S. Sassen, *The Global City: New York, London, Tokyo*, 2d ed. (Princeton: Princeton University Press, 2001).

5. H.V. Savitch, *Post-Industrial Cities: Politics and Planning in New York, Paris and London* (Princeton: Princeton University Press, 1988).

6. We defined the eleven inner wards of Tokyo to correspond to Manhattan, Paris, and Inner London in terms of population, commuting patterns, and density of hospital beds and physicians.

7. Data on commuting patterns are from the 1990 Census for each of the cities. For more precise references, see the WCP section of the ILC-USA Web site: ilcusa.org.

8. The foreign-born populations of Paris (1990), Inner London (1991), and Manhattan (2000) are 25.1 percent, 27.8 percent, and 28.4 percent, respectively.

9. For recent data on New York, London, and Tokyo, see S. Sassen, "Economic Restructuring as Class and Spatial Polarization," ch. 9 in Sassen, *The Global City*; for data on Paris see E. Preteceille, *La ségregation sociale dans les grandes villes* (Paris: Documentation Française, Problèmes Politiques et Sociaux, no. 684 (July 17, 1992).

10. C. Hamnett, "Social Polarization in Global Cities: Theory and Evidence," *International Journal for Research in Urban and Regional Studies* 31, no. 3 (April 1994): 401–24.

11. Sophie Body-Gendrot, "Paris: A 'Soft' Global City?" *New Community* 22, no. 4 (October 1996): 595–605.

12. See the WCP section of the ILC-USA Web site: ilcusa.org. See also S. Kurasawa et al., *Social Atlas of Tokyo* (Tokyo: University of Tokyo Press, 1986).

13. In calculating infant mortality rates, a problem arises from the fact that to follow a cohort of infants born in a given neighborhood from birth to one year is not

usually practical. Following convention, we define a practical infant mortality rate for a neighborhood as 1,000 times the number of infants below the age of one year who die in the neighborhood in a given period divided by the number of live births in the neighborhood during that period. (In the case of London for 1988 and 1989, data availability forces us to employ the population below the age of one year instead of the number of live births.) What makes this definition differ from the ideal one is the imperfect nature of the cohort involved. During a given period, some infants not born in a region may die there and some born there may move out of the region and die elsewhere. Hence, a problem of infant in- and out-migration makes the practical definition of infant mortality deviate from the ideal one. Researchers generally suppose that in- and out-migration balance to make the deviation of the practical from the ideal infant mortality rate negligible, and we follow suit. The full database for the article is found in the appendixes of V.G. Rodwin and L.G. Neuberg, "Infant Mortality Rates in Four World Cities: London, Manhattan, Paris, and Tokyo," ILC-USA Working Paper, no date.

14. Two cities have one neighborhood with fewer than 400 births, and two cities have two neighborhoods with fewer than 400 births. When these were merged with contiguous neighborhoods, there was no appreciable effect on our results. Thus, we report only our analysis of nonmerged neighborhoods.

15. This allows for tests of significance at the citywide level. In the only table (Table 2) where we consider annual rates, we do not conduct significance tests. At the neighborhood level we do significance tests in only one table (Table 10).

16. S. Sepkowitz, "International Rankings of Infant Mortality and the United States' Vital Statistics Natality Data Collecting System—Failure and Success," *International Journal of Epidemiology* 24, no. 3 (1995): 583–88; E. Howell and B. Blondel, "International Infant Mortality Rates: Bias from Reporting Differences," *AJPH* 84, no. 5 (May 1994): 850–52; K. Liu, M. Moon, M. Sulvetta, and J. Chawla, "International Infant Mortality Rankings: A Look Behind the Numbers," *Health Care Financing Review* 13, no. 4 (summer 1992): 105–17.

17. Statistical significance is always at the .05 level in this article.

18. A five-number summary includes the largest and smallest neighborhood rate, the median or middle neighborhood rate when the rates are ranked in order (the average of the two middle rates when there are an even number of neighborhoods), and the seventy-fifth- and twenty-fifth-percentile neighborhood rates. The seventy-fifth-percentile rate of a distribution is the rate with 25 percent of the neighborhood rates above it, while the twenty-fifth-percentile rate is the one with 75 percent of the neighborhood rates above it.

19. The common vertical axis of all box plots is the infant mortality rate. The thick middle horizontal line across the full rectangle of a box plot is at the median neighborhood rate on the vertical axis. The upper and lower horizontal lines of the full rectangle are at the seventy-fifth- and twenty-fifth-percentile rates, respectively. The remaining two horizontal lines of the box plot, the whiskers, are at the largest and smallest rate of the distribution on the vertical axis, unless there are rates a substantial distance from the others. Such rates are outliers, and a box plot represents them as dots.

20. For a city, the mean neighborhood rate is the sum of all the neighborhood rates divided by the number of neighborhoods.

21. When the distribution is asymmetric, the mean is dragged from the median

in the direction in which the distribution is skewed. This dislocates the mean from the center of the rates and is why statisticians favor the median over the mean as a measure of center for an asymmetric distribution.

22. The algebra of why this is so is discussed in the Appendix.

23. Table 10 indicates that three of three high-rate, and two of three low-rate neighborhoods persist from the first to the second period in Manhattan. The probability that three of three high-rate neighborhoods would persist between the two periods, if all Manhattan neighborhoods were equally likely to form the high-three group, is .0045. The probability that two of three low-rate neighborhoods would persist between the two periods, if all neighborhoods were equally likely to form the low-three group, is .1227. Similar calculations for the other three cities always yield probabilities higher than .1227. Hence, only the persistence of the three high-rate neighborhoods in Manhattan is statistically significant.

24. T. Hubinsky, E. Cagan, A. Goodman, D. Deitcher, and N. Cohen, "Partnering with Communities to Improve Health: The New York City Turning Point Experience," *Journal of Urban Health* 78, no. 1 (March 2001): 176–80.

25. New York City Department of Health Proposal for Infant Mortality Reduction Phase III Report. Blueprint for Action (New York: NYC Department of Health, December 2000).

26. I. Ellen, "Is Segregation Bad for Your Health? The Case of Low Birth Weight," in *Brookings-Wharton Papers on Urban Affairs* (Washington, DC: Brookings Institution Press, 2000), pp. 203–38.

27. This World Health Organization (WHO) "perinatal periods of risk approach" is used by the National Group on Urban Maternal and Child Health Assessment (GUMCHA)—an initiative sponsored by Citymatch and the Centers for Disease Control in the United States. See GUMCHA Periods of Risk Work Group, *WHO Perinatal Periods of Risk Approach: The US Urban Experience*, National Group on Urban Maternal and Child Health Assessment (GUMCHA), no date, p. 24.

28. G. Richardson, *A Welcome for Every Child: How France Protects Maternal and Child Health—A New Frame of Reference for the United States* (Arlington, VA: National Center for Education in Maternal and Child Health, 1994).

29. B. Bergman, *Saving Our Children from Poverty: What the United States Can Learn from France* (New York: Russell Sage, 1996).

30. For a comparison of France, England and Wales, and the United States, see *Child Health in 1990: The United States Compared to Canada, England and Wales, France, the Netherlands and Norway.* Supplement to *Pediatrics* 86, no. 6, part 2 (December 1990).

31. For the standard computational formula for a sample covariance see, for example, B. Rosner, *Fundamentals of Biostatistics*, 3d ed. (Boston: PWS-KENT, 1990), p. 20.

Appendix: Relation of Citywide and Mean Neighborhood Infant Mortality Rates

Suppose that there are n neighborhoods in a city and that m_i is the neighborhood infant mortality rate for neighborhood i. Then the

average of the neighborhood infant mortality rates is $m \equiv \sum (m_i/n)$, where the sum is from 1 to n, that is, over the neighborhoods. One can write m as

$$m = (1/n)m_1 + (1/n)m_2 + \ldots + (1/n)m_n \tag{2}$$

because an average of a set of numbers is the weighted sum of the numbers where each weight is 1 over the number of numbers averaged. Let b_i be the number of live births in neighborhood i, B be the number of live births citywide, and M be the citywide infant mortality rate. If each neighborhood in the city had the same number of live births then M would equal m. However, each neighborhood in the city does not have the same number of live births. When such is the case, to get M from the neighborhood rates, instead of weighting each neighborhood rate by $(1/n)$ and adding them up, one weights each neighborhood infant mortality rate by the proportion of live births citywide that occur in the neighborhood and adds them up. That is

$$M \equiv (b_1/B)m_1 + (b_2/B)m_2 + \ldots + (b_n/B)m_n \tag{3}$$

So in contrast to the case of the average of the neighborhood rates where each neighborhood contributes equally, in the case of the citywide rate, each neighborhood contributes proportionately to the number of live births that occur in it.

Let V be the covariance of the (b_i/B)s and the m_is. Then

$$M \equiv m + (n - 1)V \tag{4}$$

That is, the citywide rate is equal to the sum of the average of the neighborhood rates and the product of 1 less than the number of neighborhoods and the covariance of the (b_i/B)s and the m_is. Recall also that V is the product of the correlation of the (b_i/B)s and the m_is, the standard deviation of the (b_i/B)s, and the standard deviation of the m_is. That is, the difference between the citywide rate and the average of the neighborhood rates is proportional to the spread of the neighborhood rates, the spread of the neighborhood proportions of live births, and the association of the neighborhood rates and proportions of live births.

To summarize, if for a given city the citywide and mean neighborhood rates differ much for a period—1988–97, 1988–92, or 1993–97, the primary reason is a large covariance between the neighborhood infant mortality rates and proportions of live births. That covariance could, in turn, be large because of a large spread of either infant mortality rate (certainly true in Manhattan) or proportion of live births, or a high correlation between these variables.

To prove (3) and (4) above we introduce some simple notation. Let

n = the number of neighborhoods in the city,

b_i = the number of live births in neighborhood i, and

d_i = the number of infant deaths in neighborhood i.

Let $\sum$ always be over the neighborhoods of the city.

Then

the number of live births in the city, B, $\equiv \sum b_i$,

the number of infant deaths in the city, D, $\equiv \sum d_i$,

the citywide infant mortality rate, M, $\equiv D/B \equiv (\sum d_i)/(\sum b_i)$,

the infant mortality rate for neighborhood i, $m_i \equiv d_i/b_i$, and

the average neighborhood infant mortality rate, m, $\equiv \sum m_i/n$.

So $d_i \equiv m_i \times b_i$ and hence $M \equiv D/B = (\sum d_i)/(\sum b_i) = (\sum d_i)/B = (\sum m_i \times b_i)/B = \sum (b_i/B) \, m_i$ Q.E.D. (3).

Also let

$b = \sum (b_i/B)/n$ and

the covariance of the (b_i/B)s and the m_is, V, $\equiv \sum[(b_i/B) - b)(m_i - m)]/(n - 1)$.

Then by the usual computational formula for V we have $V = \sum [(b_i/B)m_i]/(n - 1)] - [m/(n - 1)] = [M/(n - 1)] - [m/(n - 1)]$ so that $M = m + (n - 1)V$ (Q.E.D. (4)).[31]

Acknowledgments and Data Sources

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London: Justine Fitzpatrick, London Regional Office of the National Health Service (1988–89) supplied the number of live births (1990–97), population below one year of age and number of infant deaths (1988–97) for each year for each borough of London.

New York: Birgit Bogler, research assistant at ILC-USA and NYU, extracted data for us from the birth and death files provided to us by the NYCDOH, Office of Vital Statistics. Fabienne Laraque, Melanie Besculides, Kai-Lih Liu, and Tamara Dubanovsky, NYCDOH, Office of Family Health, provided support and assistance as needed.

Paris: The 1988–97 number of live births and 1988–92 number of infant deaths for each *arrondissement* of Paris are from "La Santé de la Mère et de l'Enfant à Paris," Département des Affaires Sanitaires et Sociales, Ville de Paris, July 2000. We thank Dr. Marie-Claude Bonnefoi for her help in reviewing these data. Diane Slama Lequet of the Research Office of the French Ministry of Health obtained data from Institut National Scientifique d'Etudes et de Recherches Médicales (INSERM) on infant births and deaths, by *arrondissement*, for the period, 1993–97.

Tokyo: The 1988–92 Tokyo figures are from Tokyo Eiseikyoku (1993), Annual Report on Health in Tokyo. The 1993–97 Tokyo figures are from the Fiscal Year 2000 Report of the Tokyo Metropolitan Government Bureau of Public Health. Professor Yukiko Kudo of the International Longevity Center-Japan provided vital assistance in obtaining these data. We thank Keiko Honda, research associate at ILC-USA for her assistance with translation.