Infant Mortality and Income in 4 World Cities: New York, London, Paris, and Tokyo

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Objectives. We investigated the association between average income or deprivation and infant mortality rate across neighborhoods of 4 world cities.

Methods. Using a maximum likelihood negative binomial regression model that controls for births, we analyzed data for 1988–1992 and 1993–1997.

Results. In Manhattan, for both periods, we found an association (.05% significance level) between income and infant mortality. In Tokyo, for both periods, and in Paris and London for period 1, we found none (5% significance level). For period 2, the association just missed statistical significance for Paris, whereas for London it was significant (5% level).

Conclusions. In stark contrast to Tokyo, Paris, and London, the association of income and infant mortality rate was strongly evident in Manhattan. (*Am J Public Health.* 2005;95:86–90. doi: 10.2105/AJPH.2004.040287.)

The nationwide infant mortality rate in the United States is notoriously high in comparison with the national rates of other wealthy nations belonging to the Organization for Economic Cooperation and Development (OECD).[1,2] This problem is often attributed to bias in reporting differences among nations.[3,4] However, no one would argue that reporting bias constitutes a complete explanation. The higher US infant mortality rate may also be attributable to our more heterogeneous population and our lack of universal health care coverage (leading to inadequate access to services, including prenatal care for pregnant mothers). More generally, the higher US rate may result from socioeconomic conditions (e.g., the relatively high level of poverty and the extent of income inequality in the United States compared with other OECD nations).[5]

We departed from more conventional comparative analyses of national health statistics. We took as our units of analysis large administrative neighborhoods in New York, London, Paris, and Tokyo. These world cities have heterogeneous populations (albeit much less so in Tokyo) and increasing income disparities between rich and poor. Within each city, we investigated the relationship between infant mortality rate and an income-related variable across its neighborhoods.

METHODS

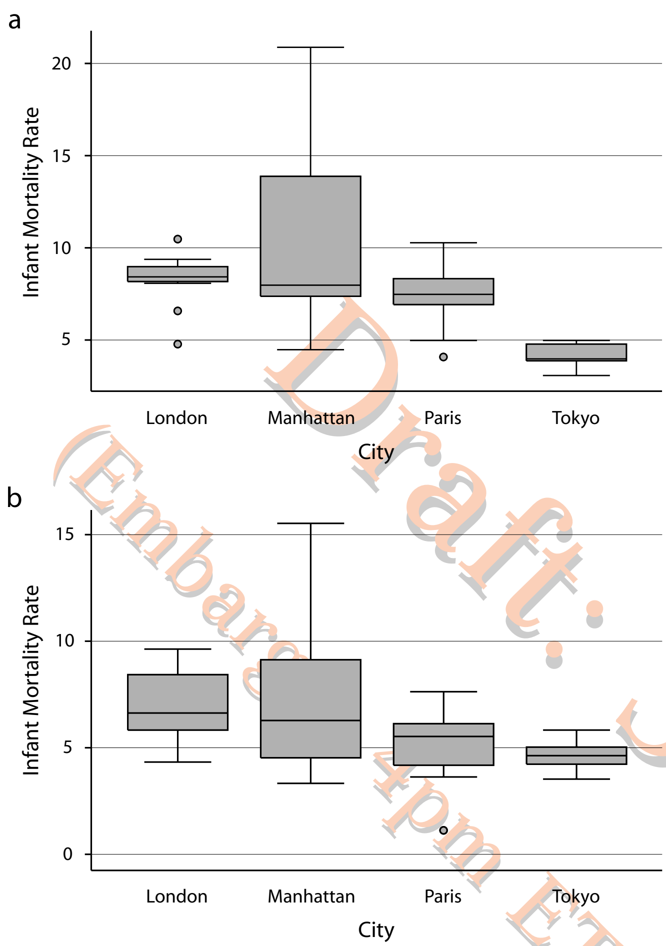
City Definition, Neighborhood Selection, and Period Choice

New York City (population, 8 million), greater London (population, 7.3 million), Paris and its surrounding first ring (population, 6.2 million), which includes the Seine-Saint Denis, Hauts-de-Seine, and Val-de-Marne départements, and central Tokyo (population, 8.1 million) are the largest cities among the higher income nations of the OECD. They also have the highest number of births in their respective nations. These world cities function as hubs in the global economy of transnational corporations, financial services, and information exchange.[6,7] One can define them, spatially, as enormous "city-regions."[8] In this article, however, as in previous ones growing out of the World Cities Project,[9,10] we study their "urban cores"[11]: Manhattan (1.5 million population), inner London (2.7 million population), Paris (2.1 million population), and inner Tokyo (2.1 million population). For simplicity, we refer to these units as Manhattan, London, Paris, and Tokyo in the remainder of the article.

These urban cores share a number of convergent characteristics. They are medical capitals with a disproportionate share of hospitals and specialist physicians. They are destinations for large immigrant communities from around the world (with the exception of Tokyo). The foreign-born population of Paris (1999), London (2001), and Manhattan (2000) is 22.7%, 33.7%, and 29.4%, respectively.[12] In Paris, of the foreign-born from outside the European Union, most are from northern Africa (40.3%), Asia (21.1%), and sub-Saharan Africa (16.9%). In London, those from outside the European Union are mostly from Africa (30.8%), the Caribbean (25.6%), and Bangladesh (17.3%). In Manhattan, recent immigrants are predominantly from Latin America (including the Caribbean [48%], Asia [27%], and Europe [18%]). However, despite these differences, in all 3 cities, recent immigrants have exacerbated social and spatial inequalities.[13–15]

To some extent, defining neighborhoods is arbitrary. We relied on 2 criteria: existing designations or administrative boundaries and data availability. We obtained data on live births, infant deaths, and an income-related measure that is as similar as possible across cities (our data set is posted at http://www.ilcusa.org/_lib/pdf/ajph.dataappendix.pdf). For Manhattan, we used the 10 subborough units for which the New York City Housing and Vacancy Survey provides mean household income estimates during periods between the decennial census. For London, we used the 14 boroughs of inner London; for Paris, the 20 *arrondissements*; and for Tokyo, 11 *ku*.

Infant mortality—deaths in the first year of life—is an important indicator of social well-being, which reflects multiple social determinants of health. The infant mortality rate is defined as the number of infant deaths for a period divided by the number of live births for that period. Neighborhoods with relatively small numbers of births have less stable neighborhood rates. Because some neighborhoods in the 4 cities we examined have a relatively small number of annual live births, to increase the stability of the rates for these neighborhoods, we chose (as we did in a previous study) to study 5-year rather than 1-year periods.[10] By studying 2 such periods (1988–1992 and 1993–1997), we can learn whether the relation between infant mortality rate and an income-related measure changes from 1 period to the next. Data for births and infant deaths are as comparable as one can find in making international comparisons of infant mortality rates.[2–4]



Note. The common vertical axis is the neighborhood infant mortality rate. The thick middle horizontal line across the full rectangle is at the median neighborhood rate on the vertical axis. The upper and lower horizontal lines of the full rectangle are at the 75th and 25th percentile rates, respectively. The remaining 2 horizontal lines, the whiskers, are at the largest and smallest rates 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. For inner London, we included each of the 14 boroughs (Camden, City of London, Hackney, Hammersmith and Fulham, Haringey, Islington, Kensington and Chelsey, Lambeth, Lewisham, Newham, Southwark, Tower Hamlets, Wandsworth, and Westminster); for Manhattan, each of the 10 subborough units used by the Housing and Vacancy Survey (Greenwich Village/Financial District, Lower East Side, Chinatown, Stuyvesant Town/Turtle Bay, Upper West Side, Upper East Side, Morningside Heights/Hamilton Heights, Central Harlem, East Harlem, and Washington Heights/Inwood; for Paris, each of the well-known 20 *arrondissements* (1–20); and for inner Tokyo each of the 11 *ku*: Chiyoda, Chuo, Minato, Shinjuku, Bunkyo, Taito, Sumida, Koto, Shibuya, Toshima, and Arakawa.
Source. The birth and death data on which these rates were based are available from the authors. London: Office of National Statistics, birth registration and linked mortality files, number of live births (1990–1997), population < 1 year of age and number of infant deaths (1988–1997). Manhattan: Data were extracted from birth and death files, Division of Vital Statistics, Department of Health and Mental Hygiene. Paris: 1988–1992 number of live births and infant deaths are from "La santé de la mère et de l'Enfant à Paris," Département des Affaires Sanitaires et Sociales, Ville de Paris, July 2000. For the period 1993–1997, data were provided by Eric Jougla, Institut Nationale Scientifique d'Etudes et de Recherches Médicales (INSERM). Tokyo: 1988–1992 data are from Tokyo Eiseikyoku (1993), Annual Report on Health in Tokyo. Data on 1993–1997 are from Fiscal Year 2000 Report of the Bureau of Public Health, Tokyo Metropolitan Government, 2000.

FIGURE 1—Box plots of neighborhood infant mortality rate distributions for London, Manhattan, Paris, and Tokyo for (a) 1988–1992 and (b) 1993–1997, showing differences in spread and symmetry in the distribution of neighborhood infant mortality rates for the 4 cities.

Research Questions

Figure 1 shows the infant mortality rate distributions in the 4 cities for both periods. Except for Tokyo, median neighborhood rates fell between the 2 periods. For both periods, the Manhattan distribution exhibits greater spread than those of the other cities and is also more skewed in the direction of high rates. However, the figure reveals nothing about the relationship of income and infant mortality rate in the cities. Do lower income neighborhoods of a city tend to have higher rates than neighborhoods in the rest of the city? If so, does the magnitude of the difference change from 1 period to the next?

If 1 neighborhood has 1000 births and 10 deaths and another has 10 000 births and 100 deaths, they would both have infant mortality rates of 10 per 1000 and would be indistinguishable in a model that did not control for births. However, intuitively, variation in births is likely to influence variation in deaths or variation in infant mortality rate. Thus, we sought a model that controls for births.

Because deaths is a nonnegative count variable, a Poisson regression model was a possibility. However, to account for greater variation than in a true Poisson process, we used instead a maximum likelihood negative binomial regression model that constrains the predicted number of deaths to a nonnegative number. Number of deaths is the response, number of births is the exposure, and an income-related variable is the explanatory variable.

For income, a similar measure of pretax, average household income, by neighborhood, is available for Manhattan, Paris, and Tokyo, so we began with this variable for these 3 cities. Since household income data are not available in the United Kingdom, for London, following British custom, we began with "deprivation" indices in place of direct income measures. Income figures for Manhattan, Paris, and Tokyo are in dollars, francs, and yen, respectively. For London, we began with the Carstairs Deprivation Index (http://census.ac.uk/cdu/Datasets/1991Census_ datasets/Area_Stats/

Derived_data/Deprivation_scores/Carstairs_index.htm) for period 1 and the Department of the Environment, Transport and the Regions Deprivation Index (http://www.detr.gov.uk) for period 2.

Using income and 2 different deprivation indices as explanatory variables in the models would make London and the other 3 cities hard to compare. Therefore, we used income and the deprivation indices to define an indicator variable that we used as the explanatory variable in the models. For Manhattan, Paris, and Tokyo, we let income (I)=0 for a neighborhood if it was in the lower income quartile of neighborhoods. These are the 2 lowest income neighborhoods in Manhattan, the 5 lowest in Paris, and the 3 lowest in Tokyo. For the other neighborhoods in these cities, we let I=1. For London, we let I=0 for each of the 4 neighborhoods in the highest deprivation index quartile. For the other neighborhoods of London, we let I=1. If both deprivation indices in London included the 4 lowest income neighborhoods in their upper deprivation quartile, our combination of income and deprivation indicators selected the lower income quartile of neighborhoods for all 4 cities.

We reported not the estimate of the underlying coefficient of I but the exponential of the estimate (i.e., the estimated incident rate ratio). The incident rate ratio here is the ratio of the value of the infant mortality rate in the rest of the city to its value in the low-income (or high-deprivation) neighborhoods. Our null hypothesis in each city and period was that the true value of the incident rate ratio for I is 1, that is, that there was no difference in infant mortality rates between the low-income (or high-deprivation) neighborhoods and those of the rest of the city. Our alternative hypothesis was that the incident rate is less than 1, that is, the low-income (or high-deprivation) neighborhoods have higher infant mortality rates than those in the rest of the city.

RESULTS

Except for Tokyo in the second period (Table 1), all of the incident rate ratios were less than 1, as expected. That is, with births fixed, shifting a neighborhood out of the lower income (or higher deprivation) quartile lowered its number of deaths or infant mortality rate. More income for the neighborhood was associated with a lower infant mortality rate.

The findings were most dramatic for Manhattan, where we found strong support for the alternative hypothesis since the downward shift in infant mortality rate from low-income to high-income neighborhoods was significant at the .05% level in both periods. The first period estimate was that the rate in the high-income neighborhoods was 44% of the rate in the low-income neighborhoods; for the second period estimate, it was 39%.

In London, we estimated that the low-deprivation neighborhoods had a rate 94% of the rate in the high-deprivation neighborhoods in the first period and 82% in the second period. However, only the second period estimate was statistically significant at the 5% level.

In Paris, we found no difference in the low- and high-income neighborhood rates in the first period. We estimated that the high-income neighborhood rate was 87% of the low-income neighborhood rate in the second period, a figure that just missed statistical significance at the 5% level.

Finally, in Tokyo we found no significant difference (at the 5% level) between low- and high-income neighborhood rates in either period.

TABLE 1—Results of Maximum-Likelihood Negative Binomial Regression That Controls for Births

	1988–1992				1993–1997			
City	IRR	SE	*Z* Stat	*P* Value	IRR	SE	*Z* Stat	*P* Value
London	.941	.046	−1.24	.107	.814	.082	−2.03	.021
Manhattan	.441	.101	−3.59	< .0005	.391	.082	−4.50	< .0005
Paris	.999	.058	−0.01	.496	.871	.074	−1.52	.065
Tokyo	.922	.098	−0.77	.221	1.002	.121	.01	.506

Note. IRR = incident rate ratio; SE = standard error; *Z* Stat = *Z* statistic. The model controls for births and regresses deaths on an indicator variable for the lower quartile of income (or the upper quartile of deprivation). With births fixed, IRR is the ratio of the infant mortality rate of those in the upper (lower) three quartiles of income (deprivation) to those in the lower (upper) quartile of income (deprivation). Estimations use a maximum-likelihood negative binomial regression. *P* values are for 1-sided tests and are asymptotic. The number of neighborhoods or observations for each period for London, Manhattan, Paris, and Tokyo, respectively, are 14, 10, 20, and 11.

DISCUSSION

In summary, after controlling for births, we found that between the two 5-year periods, each city, except for Tokyo, experienced a widening of the infant mortality rate gap between its low-income (or high-deprivation) neighborhoods and the rest of the city. Despite this apparent “manhattanization” of London and Paris, Manhattan still stood out conspicuously in comparison with London, Paris, and Tokyo in 2 respects. First, after controlling for births, Manhattan was the only city with a statistically significant association (at the 5% level) between infant mortality rate and income (or deprivation) indicator in both periods. Second, the magnitude of the infant mortality rate gap was dramatically greater in Manhattan than in any of the other cities. In Manhattan, we estimated that the low-income neighborhoods had an infant mortality rate approximately 2.5 times that of the rest of the city. In the other 3 cities, in contrast, we estimated that the infant mortality rate of the low-income (or high-deprivation) neighborhoods was never greater than approximately 1.25 times that of the rest of the city in either period.

We found that the evidence of higher infant mortality rates in low-income neighborhoods, when births are fixed, was especially strong in Manhattan. Central and East Harlem were the Manhattan neighborhoods in the lower income quartile, and they were also the neighborhoods with the highest infant mortality rates. A causal reading of this finding suggests a clear policy strategy. To lower infant mortality rates in Central and East Harlem, New York City should promote economic development in these neighborhoods and thereby raise their average income levels.

The problem, of course, is that even after controlling for births, an association between income level and infant mortality rate does not establish that the former causes the latter. Even if our Manhattan model was perfectly specified, no conclusion that low income causes more infant deaths is warranted because our data were ecological. The infants who died in the low-income Manhattan neighborhoods could have been children of the higher income residents of those neighborhoods. Only if our data were at the individual level and experimental—not observational—would our findings support a causal argument. Nonetheless, our regression results and broader comparative analysis raise at least 3 important questions for debates about the direction of policy in Manhattan:

First, what characteristics of high-infant-mortality, low-income neighborhoods, other than insufficient income, contribute to raising infant mortality? Are such neighborhoods characterized by inadequate provision of family planning, prenatal care, and other health care services leading to low levels of maternal health?

The New York Department of Health and Mental Hygiene (DHMH) recently introduced several new initiatives all of which suggest an affirmative answer to this question. For example, after an internal study that reported an 80% rate of unintended pregnancies in neighborhoods with high infant mortality rates,[16] the DHMH established a citywide family planning initiative. In addition, the DHMH established an infant mortality case review committee to examine the causes of each infant death and now is attempting to coordinate citywide and regional perinatal forums to improve access to care for high-risk mothers and newborns. Perhaps most important of all, the DHMH established district public health offices in high-infant-mortality neighborhoods, including 1 for East and Central Harlem, whose responsibilities include leveraging resources and improving coordination of DHMH programs. For example in Central Harlem a strategic action committee designed a range of interventions that address health care as well as social factors related to mothers at risk.

Second, do high-infant-mortality, low-income neighborhoods reflect patterns of racial segregation and other forms of discrimination that might affect both the incomes and access to health care of minority women in Manhattan?

There is abundant evidence that race is an important determinant of infant mortality in the United States.[17,18] Ellen's evidence on this issue has the strength of analyzing individual rather than ecological data, but because the Internal Revenue Service does not disclose household income data at the individual level, the relative role of race and income level as sources of health outcomes cannot be explored.[19] Had we included percentage of African Americans in our Manhattan model, the incident rate ratio for our income indicator might well have been 1.

Third, why do inequalities among high- and low-infant-mortality Manhattan neighborhoods remain so flagrant in spite of the well-known decrease in the overall citywide rate?

Based on our findings, one might suspect that Manhattan provides inadequate levels of health care access to mothers in poorer neighborhoods. New York State's Prenatal Care Assistance Program (PCAP) became part of the Medicaid program after expansion in income eligibility thresholds in 1990. Nevertheless, Joyce's evaluation of the PCAP's impact on birth outcomes of Medicaid recipients in New York City suggests that expansion of prenatal care for women at risk is an inadequate strategy with which to achieve significant birth outcomes.[20] A broader range of services, including family planning, comprehensive health care coverage, and targeted outreach efforts would probably be more effective than the PCAP. In this sense, the absence of universal health insurance in the United States exacerbates the problem of access in comparison to what Joseph White has called the "international standard."[21] For example, Great Britain ensures health care coverage under its National Health Service; France and Japan ensure universal coverage under their national health insurance programs. Perhaps the extent to which a country lacks a commitment to universal coverage strengthens the connections between infant mortality and income.

Most research on the determinants of infant mortality highlights the importance of 3 types of variables in explaining variation in infant mortality rates across geographic units: material conditions (income and deprivation indicators, including race), income inequalities, and levels of available health services for mothers.[22–33] The research is less clear on the relative importance of these variables. Moreover, the range of relevant health services is wide. It includes health education, contraception services, pregnancy counseling and abortion services, prenatal care (particularly for high-risk mothers), routine primary health care, and neonatal medical care and follow-up of high-risk mothers after birth.

Because we have neither a measure of income inequality nor a measure of health service use for each of our neighborhoods, our analysis does not shed light on the relative importance of neighborhood average income, health service use, and income inequality on infant mortality. Just as the absence of race in our Manhattan model could account for the importance of income there, the absence of income inequality and health service use in our models could account for the significant effect of income in Manhattan in contrast to Paris and Tokyo.

We know that local governments in Paris, Tokyo, and London operate nationally funded programs to identify high-risk mothers and offer them special services.[34–36] In Paris, Tokyo, and London (albeit less so), there are aggressive efforts, at the neighborhood level, to follow all mothers in the course of their pregnancies and after birth. Moreover, in Paris, there are even financial incentives from the central government—the *Protection Maternelle et Infantile*—for mothers to seek out these services.[37,38]

Unfortunately, comparable data across all 4 cities on the extent and effectiveness of these services and on the spatial distribution of primary health care and public health professionals, by neighborhood units, are difficult to obtain. Could differences in the distribution of services and personnel responsible for them explain the differences we found for the role of income or deprivation among these cities? Only models that include all 3 variables at once—income level, income inequality, and a measure of accessible services—can begin to answer this question. In the meantime, there is increasing recognition at the New York City DHMH, and within the new Strategic Health Authorities responsible for London, that reducing disparities among neighborhood infant mortality rates will require intense targeting of high-rate neighborhoods and disproportionate resources directed to them. ■

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Contributors

V.R. Rodwin conceived the study and obtained the data. L.G. Neuberg performed the statistical modeling. Both authors worked closely together in writing and interpreting the findings.

Human Participant Protection

Local institutional review board approval was not sought, because this study was a secondary analysis of publicly available data that contained no individual identifying information.

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