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Infant Mortality in Moscow: the Perils of Progress in Russia's World City

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Abstract This paper examines changes in infant mortality (IM) in Moscow, Russia's largest and most affluent city. Along with some remarkable improvements in Moscow's health system over the period between 2000 and 2014, the overall IM rate for Moscow's residents decreased substantially between 2000 and 2014. There remains, however, substantial intra-city variation across Moscow's 125 neighborhoods. Our regression models suggest that in higher-income neighborhoods measured by percent of population with rental income as a primary source, the IM rate is significantly lower than in lower-income neighborhoods measured by percent of population with transfer income as primary source (housing and utility subsidies and payments to working and low-income mothers, single mothers and foster parents). We also find that the density of physicians in a neighborhood is negatively correlated with the IM rate, but the effect is small. The density of nurses and hospital beds has no effect. We conclude that overall progress on health outcomes and measures of access does not, in itself, solve the challenge of intra-urban inequalities.

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Introduction

The most striking aspect of the Russian health care system today is the extent to which it has returned to many of its inherited legacies, namely the principle of universal health coverage (UHC)—at least for a so-called "guaranteed minimum" while at the same time allowing for parallel systems for the most privileged, and massive inequalities across regions, urban/rural areas, and by income. In principle, Russians have a constitutional right to free health care provided by state and municipal organizations [1] and citizens are assigned to a polyclinic based on their place of residence. In practice, however, hospital care in private institutions and pharmaceuticals prescribed to outpatients are excluded for most of the population and the problem of chronic underfinancing leads to informal payments that have the effect of limiting, and sometimes excluding, citizens from access to health care [2–5]. The paradoxical result is that in spite of the fact that the Soviet Union was the world's first constitution to guarantee the right to UHC, geographic residence, occupational status, and income continue to account for inequalities in access to health care in Russia.

We examine, in this paper, the extent to which such inequalities prevail in Russia's capital and increasingly global world city—Moscow. Our empirical analysis focuses on infant mortality (IM) for three reasons: first, because it is an important indicator of social welfare, population

health, and health system performance; second, because we obtained reliable data on the evolution of infant deaths over the first decade of this century—a period following rapid privatization during which the Russian Federation recognized the importance of government in the health sector and made important investments in public health and health system improvements; and the third reason we focus on IM in Moscow is that there are no studies, so far as we know, of intra-urban health inequalities among Russian cities. Moscow, like other world cities, is unique in comparison to other cities in its nation, but given its dominance as a political capital and its mix of strong government, private sector development, and relative affluence, it is an important case in which to examine the factors accounting for inequalities in health.

Most research on intra-urban IM focuses on high-income countries [6] with relatively less attention being paid to middle-income countries, such as Russia [7]. This is an important gap in the literature because studies suggest that the determinants of infant health may be different in high-income, low-income, and middle-income countries [8, 9]. Understanding intra-urban health inequities in middle-income countries is an important step in achieving health equity and lowering IM in line with Millennium health goals [10]. A previous study of urban health among global cities of BRIC nations—Brazil (São Paulo), the Russian Federation (Moscow), India (Delhi), and China (Shanghai)—noted significant progress in amenable mortality between 2000 and 2010, in all of these cities with the notable exception of Delhi [11]. Amenable mortality, like IM, reflects important dimensions of population health as well as health system performance [12]. There are no studies, however, that compare inequalities in IM within cities of BRIC nations. Although several studies [13, 14] examine variations in IM rates within Russia, by large administrative regions (*oblasts*), and some studies have focused on health disparities within Moscow based on survey data, we have only one study that examines variations in IM rates within Moscow, Russia's largest and most affluent city [15–17].

Between 2000 and 2012, the average IM rate in Russia fell from 15.3 (per thousand live births) in 2000 to 8.6 in 2012. However, this improvement was uneven. IM rates vary seven-fold across *oblasts* of the Russian Federation—from 2.9 in Nenets Autonomous Okrug to 21.9 in Chechen Republic [18]. Despite its wealth and recent investments in the city's health care system, Moscow's IM rate is only slightly below the national average [15]. Declines in poverty, higher disposable income, improvements in the public health care system, and growth of the private health system in Russia, as well as in Moscow, are correlated with improved population health [11, 19]. Still, substantial socioeconomic inequalities persist within Moscow [15]. We therefore investigate socio-economic and health system factors affecting IM with special attention to neighborhood effects.

Methods

Sources of Data

We obtained data on infant births and deaths by Moscow's *rayons* directly from the Moscow Statistics Agency (MosGorStat) and verified that they correspond exactly to those in the Russian Fertility and Mortality Database (RusFMD), maintained by the Center of Demographic Research of the New Economic School in Moscow. Public and private health system variables are derived from the 2010 Pokazateli Municipal'nyh Obrazovanij database [20]. All other socio-economic data are from the 2010 Russian Census [21].

Units of Analysis

This study focuses on 125 districts (*rayons*) corresponding to the ten boroughs (*okrugs*) that comprised the city of Moscow in 2010. To our knowledge, this is the first study of intra-Moscow IM variation across *rayon*s. A prior study focused on *okrugs* as the unit of analysis [15]. In 2012, Moscow's administrative boundaries were expanded. The expansion added about 250,000 mostly rural residents to Moscow's 11.5 million population. Since these mostly rural residents were still excluded from Moscow's safety network and public health system, in 2010, they are also excluded from this analysis.

Outcome Measure

IM is monitored across countries as a part of the United Nations Millennium Development Goals [22] and Healthy People 2020 objectives [23]. Between 1990 and 2015, IM rates fell from 43 to 15 in upper-middle income countries and from 83 to 40 in lower-middle-income countries [24]. IM is measured as the number of infant deaths per 1000 live births. In April of 2012, Russia adopted a new definition of live and stillbirths

[25]. We calculate the IM rate using the number of infant deaths and live births of mothers who reside officially in the 125 *rayons* of Moscow included in our study. We exclude from our analysis all infants whose mothers are not Moscow residents. This includes mothers who travel to Moscow due to high-risk pregnancies and some non-resident mothers. The Moscow government is well aware of this distinction as it notes explicitly that the IM rate, in 2010, was 6.3 counting non-resident births and 2.7 if they are excluded [26]. Our data on births and deaths are for 4 years: 2000, 2005, 2010, and 2014.

Independent Variables

Since data on average family or household income, by *rayon*, are not available for Moscow, we rely on an educational attainment measure (the share of population age 15 years old and over with a college degree), and on two measures of neighborhood-level economic circumstances that reflect dimensions of economic advantage and disadvantage. This approach is consistent with previous literature suggesting that neighborhood affluence is not simply the absence of disadvantage [27, 28]. Moreover, neighborhood economic advantage and disadvantage are associated with infant and child health outcomes [29, 30].

The two variables on which we rely as indicators of economic circumstances are the percent of respondents who indicate that transfer and rental income are their primary source of income. Primary source of income is used routinely to approximate socio-economic status [31–33]. Rental income includes income from rental of real estate, leasing of other property, patent income, honoraria, and copyright income. A higher share of population with rental income as a main source of income indicates higher level of *rayon* affluence. Beneficiaries with transfer income are a heterogeneous group that includes parents of children under 1.5 years old; working mothers of children under 3 years old; foster parents; children from low-income families; children who have parent(s) that are avoiding paying child support, single mothers, and spouses of military; students on academic leave; and recipients of housing and utility subsidies. Thus, respondents with transfer income as their main source of income tend to be individuals with high levels of economic disadvantage. A higher share of these respondents reflects a higher *rayon*-level economic disadvantage.

We use three additional health system variables: the number of physicians, nurses and hospital beds per 1000 population, both in the public and private sectors. These are standard measures of medical care availability for inpatient and ambulatory care services in each *rayon*.

Statistical Analysis

To predict intra-urban variation in IM rates, among *rayons*, we estimate a series of multivariate OLS regression models with each specification including additional variables. The pattern of the coefficients and its change as other covariates are added to the model to aid with our interpretation of the results. For example, if estimates are relatively unaffected by the addition of several variables that are strongly correlated with IM, it is reasonable to conclude that relatively little variation of intra-city IM is explained by these variables. The baseline specification includes nine *okrug*-level dummy variables. This specification describes differences in IM rates among boroughs of Moscow. Next, we add the *rayon*-level socio-economic variables described above to the regression analysis. We examine the statistical and substantive significance of these variables, as well as their role in explaining variation in IM rates across *rayons*. Finally, we add our health system variables (density of physicians, nurses, and hospital beds) to the regression. Since they are likely to be highly correlated, we add them interchangeably, one at a time.

Results

The overall IM rate for all Moscow residents fell from 7.53 in 2000 to 5.95 in 2005 and 3.05 in 2010 before increasing slightly in 2014 to 4.4 (Fig. 1). The recent increase in this rate does not call into question the significant progress achieved over this period. It merely reflects Russia's new measure of IM. Until April 2012, infants with birth weight 500–999 g were not included in IM statistics unless they lived for at least 168 h (7 days). The only infants included under 1000 g were multiple births. The inclusion of all infants with birthweight 500 g and over is what accounts for the increase in the IM rate.

Despite the substantial decrease in the overall IM rate within Moscow, there remains substantial intra-city variation across *rayons* (Figs. 2 and 3). In 2010, the rate varied from 0 in affluent *rayons*, e.g., Arbat to 12.3 in

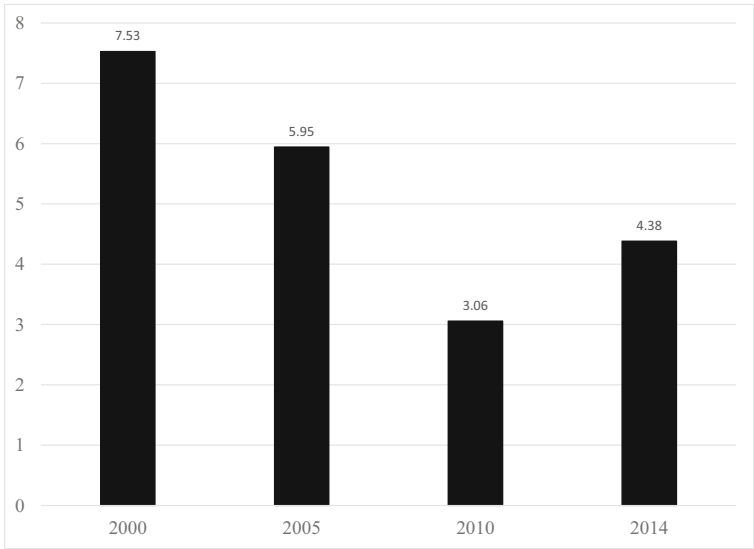

Fig. 1 Infant mortality rates in Moscow: 2000–2014. Notes: (a) IM measured as the number of infant deaths per 1000 live births. Note that in April of 2012, the Russian Federation revised its definition of live births and still-births. The increase in the IM rate between 2010 and 2014 is related to a transition to the new definition [25]. (b) These data are based on the 125 rayons of Moscow covered in this study. We did not include infant births and deaths of Moscow's non-resident mothers

the Zamoskvorechye *rayon*. Overall, *rayons* in the northern and southwestern parts of the city tend to have higher IM rates compared to those in the eastern part of the city (Fig. 2). As far as variation in our explanatory variables, Table 1 indicates the substantial variation among *rayons*.

The first model includes dummy variables for each *okrug*. The second model incorporates our socioeconomic variables, and models 3–5 incorporate the health system variables. In models 2–5, we find that *rayons* in which a higher percentage of the population relies on transfer payments as a primary source of income, the IM rate is significantly higher (Table 2). These models also suggest that *rayons* in which a higher percentage of the population relies on rental income as a primary source of income, the IM rate is significantly lower (Table 2). Models 3 and 4 suggest that the density of physicians and nurses in a public *rayon* health care facilities are negatively correlated with the IM rate, but the effects are small. The density of hospital beds has no statistically significant relationship with IM at the *rayon* level. Models 3–5 also indicate no statistically significant relationship between the density of physicians and nurses in the private health system, and IM.

Discussion

Our findings on the decline in Moscow's aggregate IM rate are consistent with previous studies of the Russian and Moscow health systems [11]. Between 2000 and 2012, the Russian economy experienced rapid economic growth that subsequently led to a decline in poverty [34], and an increase in disposable income, making health care more affordable [35]. Moscow is one of three cities in Russia (Moscow, St. Petersburg and

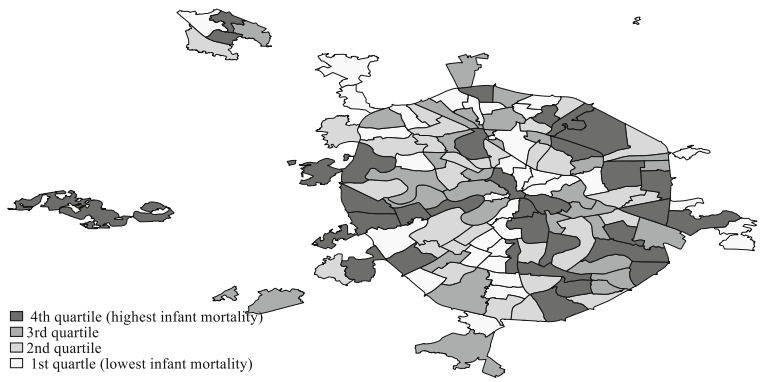

Fig. 2 Variation in Moscow's Infant Mortality Rates by *Rayon*, 2010

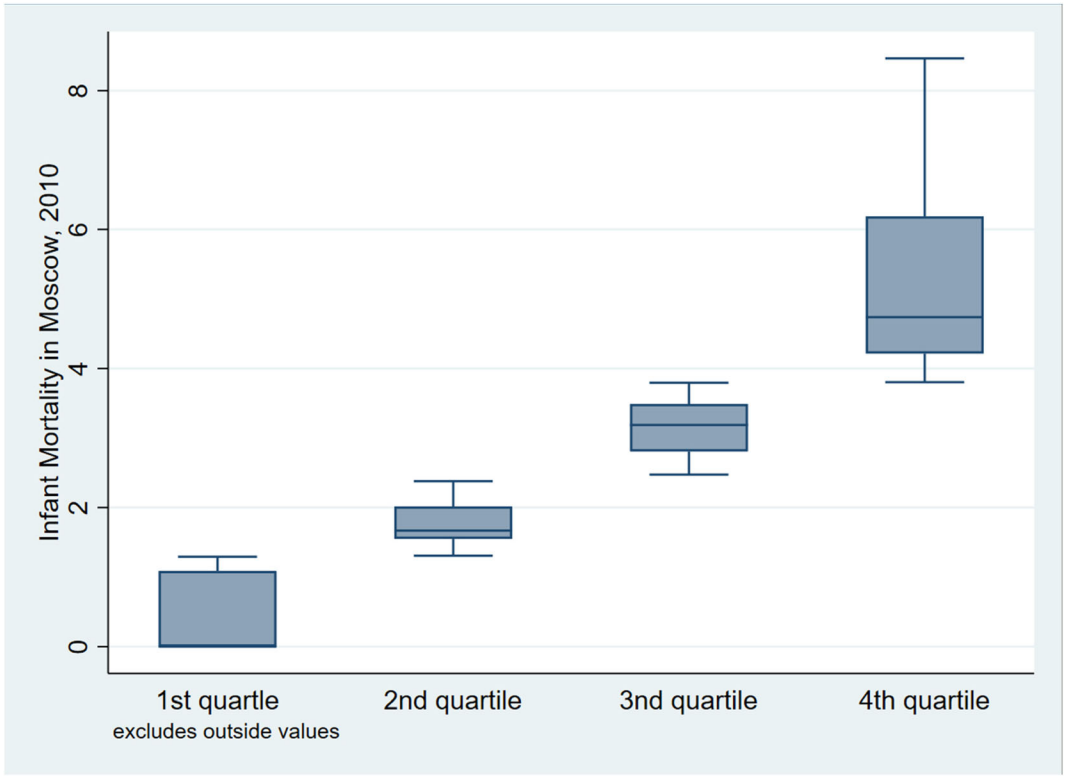

Fig. 3 Boxplots of infant mortality rates in Moscow by Quartile, 2010. Note: The common vertical axis is the neighborhood quartile infant mortality rate. The thick middle horizontal line across the full rectangle is at the median neighborhood rate on the vertical axis. The upper and lower horizontal 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

Sevastopol) with the status of a constituent federal subject. Rather than receiving a share of federal funding from the federal region in which the city is located, these cities operate as separate regions and receive direct federal funding. This provides them with additional funds for social services, public services, and health care. As the wealthiest region in Russia, Moscow's average monthly per capita income in 2010 (44,051 rubles) was more than twice that of the national average (18,958 rubles) [18].

The wide geographic variation in IM rates within Moscow is also consistent with what we know about income inequality in the city. Despite its higher than average national per capita income, the share of Moscow's population living under the official poverty line is only slightly lower than the national average. In 2010, 10.0% of Moscovites lived under the official poverty line compared to 12.5% nationally. This reflects high levels of income inequality [36]. Moscow also has the highest concentration of health-care resources in the nation. For example, in 2010, there were an average of 50 physicians per 10,000 population nationally, compared to 78 in Moscow [37]. Similarly, per capita public health care spending in Moscow is more than double the national average [38].

Recent Health System Changes

Following the collapse of the Soviet Union, in 1991, Russia suffered greatly. The decline in public spending on health care, which had already begun in the 1980s, accelerated during the 1990s. Along with declines in population health reflecting unprecedented levels of unemployment, hyperinflation, vagrancy, and alcoholism, there is evidence that the health system also deteriorated as there were increases in mortality amenable to medical care [39]. By the late 1990s, male life expectancy at birth in Russia fell to 58 years.

During the first decade of the twenty-first Century, as Russia's economy entered a period of strong growth, the government drew on budgetary surpluses to address population decline by improving care for pregnant

Table 1 Descriptive Statistics for Moscow's *Rayons*, 2010

Variable	Mean	Standard deviation
Population size, total of 125 *rayons*	11,503,501	
Infant mortality		
Infant mortality, mean rayon-level	2.70	2.14
Socio-economic status		
College degree education, population 15 years and over (%)	41.75	9.08
Main source of income		
transfer income, population per 1000	4.57	2.37
rental property, population per 1000	1.50	1.60
Utility/housing subsidy (%)	27.47	6.91
Unemployment rate among population 15–72 years old (%)	4.34	1.23
Married or cohabiting (%)	49.77	4.42
Public health care system		
Physicians per 10,000 population	49.12	64.74
Nurses per 10,000 population	82.83	114.26
Hospital beds per 1000 population	10.49	16.58
Private health care system		
Physicians per 10,000 population	7.89	20.00
Nurses per 10,000 population	10.95	34.12
Hospital beds per 1,000 population	0.69	3.57
Number of *rayons* (districts)	125	

(a) All data are at the rayon level. IM data are from the Russian Fertility and Mortality Database (RusFMD), maintained by the Center of Demographic Research of the New Economic School in Moscow. Health system variables are derived from 2010 Pokazateli Municipal'nyh Obrazovanij database; remaining variables are from the 2010 Russian Census. (b) Transfer income beneficiaries include parents of children under 1.5 years old; working mothers of children under 3 years old; foster parents; children from low income families; children who have parent(s) that are avoiding paying child support, single mothers, spouses of military; students on academic leave; and recipients of housing and utility subsidies. (c) Rental property income includes income from rental of real estate property or leasing of other property, income from patents and copyrights, and honoraria

women and newborns and developing programs to improve access and quality of care for TB, cancer, and heart disease, which accounted for a large share of the high mortality rates. In 2005, Putin announced a $4 billion program of national health-care investments to improve the delivery system [40]. By 2006, health spending finally rose to pre-transition levels [41], and continued to grow throughout the rest of the decade.

During this period, the national government implemented the "Children of Russia" program aimed to improve maternal and child health and reduce IM. Russia's private health care services sector is small but growing. The share of individuals covered by private insurance grew from 1.9 to 4.5% during 2000–2009 time period. There are substantial income disparities between those who use private and public health care providers. About 43% of patients using private health care services belong to the highest income quintile group. Less than 4% of individuals in the lowest income quintile group use private health care services compared to about 20% in the highest income quintile group [42]. The penetration of private health care providers in Moscow is far higher than the national average.

In 2008, Moscow's Department of Health developed its "Metropolitan Healthcare" program with the goal of strengthening its public health care infrastructure for pediatric patients constructing a Regional Perinatal Center and reducing IM rates. Moscow's Rogachev National Research Center for pediatric hematology, oncology, and immunology was also established and the federal government made several attempts to improve quality of care by introducing new standards, e.g. for neonatal and infant screening [43]. Even though these standards were criticized on methodological grounds, they represent a notable effort to improve the quality of maternal and child care [44]. These

Table 2 Moscow intra-city infant mortality inequality: regression analysis results

Variables	Okrug-level indicators only	Add socio-economic covariates	Add health care system covariates on…		
			…MDs	…nurses	…hospital beds
Southern okrug	− 0.3391	− 0.1803	− 0.257	− 0.2543	− 0.1661
	(0.7502)	(0.7264)	− 0.7232	− 0.7213	− 0.7272
Southwestern okrug	*− 1.8946*	*− 1.9283*	*− 2.0093*	*− 2.0487*	*− 1.9864*
	*(0.8103)***	*(0.7708)***	*(0.7671)***	*(0.7656)****	*(0.7769)***
Southeastern okrug	− 0.1605	− 0.4031	− 0.4044	− 0.4245	− 0.3979
	(0.8103)	(0.7806)	− 0.7767	− 0.7719	− 0.7813
Central okrug	− 0.3037	0.0001	0.4868	0.3671	0.1425
	(0.8553)	(0.9059)	− 0.9371	− 0.9226	− 0.9133
Northwestern okrug	− 1.2414	*− 1.5061*	*− 1.6794*	*− 1.8642*	*− 1.7193*
	(0.9188)	*(0.8775)**	*(0.9035)**	*(0.8944)***	*(0.8963)**
Northeastern okrug	− 1.1368	− 1.1400	*− 1.2409*	*− 1.2859*	*− 1.2387*
	(0.7391)	(0.6984)	*(0.6972)**	*(0.6947)**	*(0.7048)**
Northern okrug	*− 1.3878**	*− 1.5770*	*− 1.6524*	*− 1.6439*	*− 1.5872*
	(0.7502)	*(0.7151)***	*(0.7115)***	*(0.7082)***	*(0.7203)***
Zelenograd	− 0.4896	− 1.1057	− 1.091	− 1.2232	− 1.0819
	(1.0871)	(1.0452)	− 1.0404	− 1.0352	− 1.0465
Western okrug	− 0.1127	− 0.3370	− 0.3644	− 0.4028	− 0.3928
	(0.7923)	(0.7474)	− 0.7428	− 0.7408	− 0.7539
Eastern okrug(reference category)					
Share of those with at least		3.6033	3.7701	3.6895	3.8842
A college degree among 15+		(2.6294)	(2.6367)	(2.6023)	(2.6750)
Main source of income is:					
Transfer income		*0.2043*	*0.1849*	*0.1914*	*0.1976*
Persons per 1000		*(0.0828)***	*(0.0830)***	*(0.0825)***	*(0.0836)***
Rental property		*− 0.4095*	*− 0.4312*	*− 0.4219*	*− 0.4041*
Persons per 1000		*(0.1245)****	*(0.1284)****	*(0.1235)****	*(0.1284)****
Health system variables					
Public MDs per 10k population			*− 0.0060*		
			*(0.0032)**		
Private MDs per10k population			0.0060		
			(0.0102)		
Public nurses per 10 k population				*− 0.0032*	
				*(0.0017)**	
Private nurses per 10 k population				0.0076	
				(0.0056)	
Public hospital beds per1000 population					− 0.0123
					(0.0122)
Private hospital beds per1000 population					0.0577
					(0.0541)
Intercept	3.4134	1.6600	1.9741	1.9414	1.6792
	(0.5305)	(1.3227)	(1.3354)	(1.3187)	(1.3304)
N	125	125	125	125	125

(a) All regressions are estimated as ordinary least squares based on rayon-level data. (b) Standard errors in parentheses

*Significant at 10% level

**Significant at 5% level

***Significant at 1% level

investments were associated with a decline in amenable mortality [11] and, as we have demonstrated here, with a decline in IM.

It should be noted that Moscow's health system has also achieved notoriety for its progress in applying smart city IT technology with the objective of implementing a unified health management system across all of its medical facilities [45]. Moscow's Integrated Medical Information and Analytical System (IMIAS), launched, in 2011 [46], by the City's Departments of Healthcare and of Information Technology, combines patients' protected health information, past prescriptions, and other relevant information. As of 2013 [47], patients can find a nearby clinic, schedule an office visit, reschedule it as needed, and obtain prescriptions [46]. Physicians in Moscow are now able to order e-prescriptions based on real-time information of where drugs may be purchased [46]. As of 2016, 23,600 doctors and 8.9 million patients were using the system and over 22 million prescriptions have been issued [46]. Moreover, patients can schedule appointments online with a primary physician, and if specialists are required, the primary care physician can use IMIAS to request a referral.

Limitations

We acknowledge important limitations in this analysis. Although individual-level data for residents of Moscow would be preferable to relying on ecological-level data, there are no available data that include relevant variables at the individual level. Previous published research on differences in IM rates within and among global cities have relied on similar ecological level data [48, 49].

Another limitation is that the analysis is likely to exclude a substantial share of migrant women births. About 7% of all births in Moscow are to non-citizen mothers [50]. Whether births to migrant women are included or excluded from the analysis is likely to depend on a mother's legal status. Migrant women typically have either a *residence* permit (that could be temporary or permanent), or they have a temporary-stay permit. Births to the former category of women are more likely to be included in the data than births to the latter category. Mothers with temporary *stay* permits are particularly disadvantaged. Since mid-2010, they are effectively barred from access to government-funded obligatory medical insurance other than for emergencies [51]. This implies that women with temporary stay permits can access urgent delivery in a public hospital free of charge but are excluded from the free prenatal care system. Our data are likely to exclude a substantial share of births to migrant women, particularly to women with temporary-stay permits.

Conclusions

In the only comparative analysis we have identified on mortality in Moscow and five other cities (St. Petersburg, Berlin, Los Angeles, New York, and Singapore), the decline in standardized mortality rates for perinatal deaths, over the 1990–2014 period, was highest in St. Petersburg, followed by Moscow [19]. The higher declines in the Russian cities are clearly due to the higher initial mortality rates there following the collapse of the Soviet Union. According to Andreev and colleagues, standardized mortality rates for perinatal deaths are an "indirect indicator of maternal and child health, as well as the availability and quality of health services" for mothers and infants. Although they remain significantly higher in Moscow than in Berlin, Hong Kong, Los Angeles Singapore, and New York, the progress achieved to date is impressive even though the case of St. Petersburg suggests how much more could still be achieved by Moscow [8].

Overall progress on health outcomes and measures of access does not, in itself, solve the challenge of intra-urban inequalities [52]. Despite Moscow's impressive progress in reducing standardized mortality rates for perinatal deaths over the 1990–2014 period, and the reduction of overall IM rates we have documented between 2000 and 2012, the intra-urban inequalities in Moscow's IM rates are comparable to those that exist in such world cities as New York and London [48]. Moscow Mayor Sergey Sobyanin highlighted the challenge of reducing spatial inequalities in his pre-election program [53]. New measures were announced in July 2018 with respect to the reconstruction of the entire Moscow polyclinic network, including the city's social service centers [53]. We can therefore conclude that the problem of health inequalities in Moscow is on the political agenda. But, as in all world cities, it is easier to identify urban problems than to solve them.

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