How Do Smart City Technologies Help to Cope with the Pandemic?

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Abstract—The COVID-19 pandemic has brought significant changes worldwide. A large body of research already exists to identify factors that influence the disease incidence and mortality, both at the scale of individual regions within countries and at the national scale. The consistently high number of cases of virus acquisition and the discovery of new strains show that the relevance of this research is not decreasing. International and domestic experience demonstrates the expansion of the use of digital technologies to combat the pandemic and its consequences. These include technologies that help identify infected individuals, trace contacts, predict the spread of the disease, conduct diagnostics and treatment, raise population awareness, maintain social distancing and self-isolation, and enable the transition to an online format. These technologies are more widespread in smart cities through the availability of the corresponding infrastructure; however, they can be implemented anywhere. This study is aimed at assessing the contribution of smart technology and comfortable urban environment to the fight against coronavirus infection. A hypothesis is proposed about the existence of an inverse dependence between smart urban environment and the number of deaths. The dependence is checked by statistical methods. The results we obtained show that the presence of a developed urban infrastructure in fact reduces excess mortality, which includes deaths not only from the infection itself but also from its consequences. A developed urban infrastructure also contributes to mitigating the issues associated with healthcare system overload and helps to reduce difficulties related to planned medical examinations and planned operations, etc. Nevertheless, the level of digitalization of urban environment has no significant impact on mortality.

Keywords: smart city, COVID-19, excess mortality, Urban Environment Quality Index, “IQ of cities” urban economy digitalization index

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INTRODUCTION

The COVID-19 coronavirus, which emerged in 2019, caused a pandemic and significantly changed the lives of people throughout the world. As of July 15, 2021, the number of officially registered cases exceeded 190 million people; more than 4 million people died. The closure of borders, the introduction of lockdowns or self-isolation regimes, the decrease in consumer demand, and the increased pressure on healthcare system led to negative social and economic consequences throughout the world. As an example, Russia is faced with a 3% decrease in GDP in 2020 compared to 2019, a 3% decrease in real disposable income of the population in 2020 compared to 2019, and an increase in registered unemployment from 4.7% in January 2020 to 5.7% in February 2021.1 The Russian Federal Service for Surveillance on Consumer Rights Protection and Human Wellbeing (Rospotrebnadzor) estimated the damage to the Russian economy from coronavirus in 2020 (excluding the nonproduced GDP) at RUB 997.06 bln, which is greater by a factor of 1.4 than the total damage from the consequences of the other infectious diseases. Of this amount (RUB 997.06 bln), direct costs of hospital care account for 18.4%; testing, 10.8%; support for individuals and companies, 51.7%; and organization and delivery of medical care to patients with coronavirus, 19%.2

The spread and impact of the pandemic vary substantially both across countries and across regions within countries. Natural, climate, economic, social, and other conditions are localized and differentiated, which is especially noticeable in countries with a vast

1From the data of the Federal Service for State Statistics (Rosstat).
2See State Report On the State of Sanitary and Epidemiological Well-Being of Population in the Russian Federation in 2020. https://www.rospotrebnadzor.ru/upload/iblock/5f/a/gd-seb_02_06--s-pod-pisyu_.pdf.
territory. From the perspective of this paper, we paid special attention to studies aimed at analyzing the interactions of the main actors in the fight against the coronavirus pandemic (national and regional governments and healthcare systems, science institutions, high-tech businesses, population, and civil society) (Comparative ..., 2021; Seliverstov et al., 2021). A substantial body of research already exists to identify and assess factors that influence the spread of the disease. Researchers considered both personality factors such as gender, age, ethnicity, presence of comorbidities, and income of those who fell ill and died from COVID-19 (Andrew et al., 2020; Baqui et al., 2020; Fazeli et al., 2020; Wanga et al., 2020; Wilder et al., 2020; Zemtsov and Baburin, 2020) and regional factors such the state of healthcare system in a given region, climate, air pollution, share of urban population, population density, presence of a large center nearby, and even the ruling party in the region (Azzolina et al., 2020; Fazeli et al., 2020; Frontera et al., 2020; Gupta et al., 2020; Wilder et al., 2020; Zyryanov, 2020). However, researchers differ in their assessments of the impact of population density on morbidity. Thus, the well-known researcher Wendell Cox emphasized that it is virtually impossible to maintain social distancing in urban areas. The large number of public spaces, public transport, and even common hallways and elevators do not allow people to avoid personal contacts and, therefore, significantly increase the risk of infection. Other researchers (Zyryanov, 2020) did not find a direct relationship between the population density and infection rates. The absence of such a relationship is attributed to the larger infrastructure capabilities, greater opportunities for transition into online formats to reduce personal contacts, the possibility of ordering goods via the Internet, and a more developed healthcare system. Wabha et al. and Puzanov and Bobrova propose to distinguish between population density and overcrowding. The latter has an adverse impact on coronavirus infection rates. In overcrowded areas, where personal hygiene and social distancing cannot be maintained, such as in ghettos and favelas, it is extremely difficult to avoid the spread of an airborne virus.

Modern digital technologies are making an important contribution to the fight against the COVID-19 pandemic. The introduction of artificial intelligence, machine learning, big data processing, and the Internet of things enable one to predict the spread of the disease; analyze the channels of infection; quickly and efficiently collect data on the disease and analyze these data; track and localize the contacts of infected individuals; raise public awareness. Telemedical healthcare is developing vigorously; modern technologies help diagnose and treat diseases. Digital technologies help people more easily adapt to epidemiological requirements and endure self-isolation or lockdown. The wide range of video conferencing (Zoom, Google Meet, Skype, and Microsoft Teams) and sharing (Jira, Trello) software as well as cloud technologies make remote work and distance education possible. The development of various digital educational platforms and resources has gained much impetus. For these technologies to work successfully, they need a developed digital infrastructure like the one provided, e.g., in smart cities. The existing infrastructure in smart cities can be adapted to the conditions of a pandemic, as several countries have demonstrated recently (Kostina and Kostin, 2021).

In addition to a developed digital component, a large number of sensors and cameras, high-speed information processing, and feedback systems allowing one to quickly analyze the situation in the city and cope with epidemiological pressures, a smart city implies the presence of “smart healthcare” (Batagan, 2011), i.e., a modern, well-developed healthcare system. Another distinctive feature of a smart city is a concern for the health of its residents and availability of well-designed recreational infrastructure, sports facilities, and green areas. The residents of a smart city are “smart people,” who are capable of using digital infrastructure and are socially responsible, which means, in terms of a pandemic, the compliance with the sanitary and epidemiological recommendations of the WHO and Russia’s Ministry of Health.

Since 2018, Russia has been implementing the Smart City Project; in 2019, the Smart City Standard was developed, which contains a set of tools, direc-

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3 See also: Hallas, L., Hatibie, A., Majumdar, S., Pyarali, M., and Hale, Th., Variation in US States’ responses to COVID-19 2.0. https://www.bsg.ox.ac.uk/research/publications/variation-us-states-responses-covid-19. Accessed February 1, 2021; Puzanov, A.S. and Bobrova, K.V., Cities on the front line of the fight against coronavirus—an overview of the international expert agenda and an assessment of its adequacy to Russian realities. http://www.urbanecconomics.ru/research/mind/goroda-na-peredney-linii-borbys-s-koronavirusom-obzor-mezhdunarodnoy-ekspertnoy. Accessed February 20, 2021.

4 Cox, W., Early observations on the pandemic and population density, New Geography, 2020. www.newgeography.com/content/006600-early-observations-pandemic-and-population-density. Accessed February 20, 2021.

5 See also: Puzanov, A.S. and Bobrova, K.V., Cities on the front line of the fight against coronavirus—an overview of the international expert agenda and an assessment of its adequacy to Russian realities. http://www.urbanecconomics.ru/research/mind/goroda-na-peredney-linii-borbys-s-koronavirusom-obzor-mezhdunarodnoy-ekspertnoy. Accessed February 20, 2021.

6 Wabha, S., Mohd Sharif, M., Mizutori, M., and Sorkin, L., Cities are on the front lines of COVID-19, World Bank Blog, 12.05.2020. https://blogs.worldbank.org/sustainablecities/cities-are-front-lines-covid-19. Accessed February 1, 2021.

7 See also: Puzanov, A.S. and Bobrova, K.V., Cities on the front line of the fight against coronavirus—an overview of the international expert agenda and an assessment of its adequacy to Russian realities. http://www.urbanecconomics.ru/research/mind/goroda-na-peredney-linii-borbys-s-koronavirusom-obzor-mezhdunarodnoy-ekspertnoy. Accessed February 20, 2021.
The aim of this study was to assess the impact of a smart city with a comfortable urban environment on mitigating the negative effects of the coronavirus pandemic in Russia. Two indicators were taken as criteria for evaluating the development of smart cities: the urban digitalization index (IQ of Cities) and the urban environment quality index (UEQI). The indices were proposed by Russia’s Ministry of Construction, Housing and Communal Services. The first index estimates the level of urban economy digitalization and efficiency of the smart city technologies. The second one shows the quality of urban space development.

The first part of this paper presents a brief overview of the digital technologies used in Russia to combat the pandemic. The second part describes a methodology for assessing the impact of Russian smart cities on excess mortality, primarily associated with the COVID-19 pandemic, using the UEQI and the IQ of Cities. Due to the lack of statistics at the level of municipalities, in order not to limit the scope of this study, the UEQI and IQ of Cities data were aggregated at the regional level. The third part of the paper presents the results of the calculations and their analysis.

**DIGITAL TECHNOLOGIES TO COMBAT CORONAVIRUS IN RUSSIA**

**Forecasting the Epidemic and Infection Channels.** Russia applies forecasting tools using big data and machine learning. As an example, Sberbank modeled the incidence of coronavirus infection in Russia on the basis of an epidemiological simulator using the SEIR mathematical model. However, the model has not been updated since mid-April 2021. The Institute of Computational Technologies, Siberian Branch, Russian Academy of Sciences developed a simulation model for predicting the number of disease cases.

**Monitoring and Tracking Diseased Individuals and their Contacts.** Russia does not pay as much attention to contact tracing as some other countries, such as China and Republic of Korea. However, there is some progress in this area. Specifically, Russia’s Ministry of Telecommunications and Mass Communications developed a set of rules on contact tracking using data received from satellites and telecom operators, and the Ministry of Digital Development provided a mobile application Stopcoronavirus. My Contacts, which has popular analogues worldwide. The application allows one to track mobile devices nearby and notify if a sick individual approaches within a 10-m radius. However, mobile users install the application on a strictly voluntary basis, and as foreign practice shows, for the application to operate successfully, it needs a large number of users. Therefore, the possibility that this application will operate efficiently in Russia, taking into account the mentality of the population, is doubtful.

**Diagnosis and Treatment.** Modern technology makes it possible to reduce the time spent in a medical institution, e.g., receive test results by e-mail, sign in for a doctor’s appointment or vaccination through a website, or receive remote treatment oversight. In Russia, both private and public healthcare clinics are increasingly using the possibilities of telemedicine. This approach helps to reduce direct contacts, provide consultations, and make diagnoses without exposing medical workers to unnecessary risk. According to the Ingosstrakh insurance company, in 2020 the number of requests for telemedicine consultations increased by a factor of 64 compared to 2019. The Lanit-Integratsiya company introduced a remote consultation system using smart glasses in 39 Russian clinics. The SberZdorov'e service also provided an AI-based application for reading computed tomography images of the lungs. Yandex also runs a similar pilot project.

**Enforcing and Maintaining Social Isolation and Distancing.** In Moscow, this goal was achieved by

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8 See: Basic and additional requirements for smart cities (Smart City Standard). Approved by the Ministry of Construction of Russia on March 4, 2019. 
9 See: The IQ of Cities Index of big cities. https://minstroyrf.gov.ru/docs/57575/?sphrase_id=1029161; the IQ of Cities Index of the biggest cities. https://minstroyrf.gov.ru/docs/57574/?sphrase_id=1029161. Accessed October 5, 2020; the Urban Environment Quality Index as a tool to assess the quality of a city’s material environment and the conditions in which it is created. index-gorodov.rf.

10 See: The disease incidence model for Russia. https://www.sberindex.ru/ru/dashboard/model-zabolevamost/sti-dlya-rossii?partition=8. Accessed May 30, 2021.

11 See: Scientists from the Institute of Computational Technologies predicted the coronavirus situation. http://www.sib-science.info/ru/institutes/virus-04032021. Accessed May 30, 2021.
using cameras and drones and by introducing pass control procedures.

In addition, the quarantine showed that most of the work and educational activities, as well as entertainment, can be done online. The transition to distance learning during the period of isolation and the introduction of remote work formats, where possible, turned out to be relatively successful. The number of online purchases increased substantially, and food delivery services became widely popular.

To stimulate vaccination and reduce the spread of infection, Moscow authorities introduced a system of QR codes for visiting restaurants, cafes, and mass events. The QR code was issued to citizens who had been through the disease within 6 months prior and had a recent negative PCR test or were fully vaccinated with a vaccine recognized in the Russian Federation. The QR code was issued through specialized applications, websites, or directly at outpatient clinics.

Raising Public Awareness. A large number of websites were created to provide reliable information about the disease and its distribution. Representatives of the Russian Ministry of Health and government agencies have been providing information updates on the disease and support measures. The special Internet portal COVID-19 PREPRINTS was created in Russia for publishing scientific papers on coronavirus. A campaign is underway against disinformation in social networks.

Summing up the examples given above, it can be argued that Russia, especially Moscow, makes a profound use of modern technology, albeit not on such a massive scale as some other countries. Thus, the 2021 COVID-19 Innovation Report ranked Moscow third among cities worldwide in terms of innovations in the fight against coronavirus. However, it should be noted that big cities have more opportunities for the use of innovative technologies and more access to them and are better prepared in terms of infrastructure.

RESEARCH METHODS

The impact of urban environment digitalization and quality on excess mortality during the pandemic was estimated by a regression analysis. Official statistics for 2020 on excess mortality by regions of Russia were taken as the variable to be explained.

Varying estimates exist for the COVID-19 mortality, with the majority of researchers considering the official data to be grossly underestimated. As an example, the Institute for Health Metrics and Evaluation at the University of Washington estimated the gap between the official COVID-19 mortality data in Russia and the real rate at a factor of 5.4. Therefore, our study used the excess mortality rate (calculated as the death rate per 10000 people in 2020 by region minus the average mortality per 10000 people in 2018–2019 by region).

Excess mortality includes deaths directly from coronavirus, from complications caused by this disease, and from the increased pressure on the healthcare system (decrease in planned medical examinations, etc.). The growth in the number of deaths in Russia is shown in Fig. 1.

It should be noted that excess mortality varies significantly by region (Fig. 2). The largest increase in excess mortality was recorded in the Central and Volga federal districts, especially in Samara (32.0 per 10000 people), Lipetsk (31.8), Penza (29.7), and Orenburg (29.2) oblasts. The smallest growth was observed in remote regions: republics of Buryatia (9.0), Ingushetia (7.6), Tyva (7.2), and Chukotka Autonomous Okrug (3.9).

To measure the impact of smart city technologies and environment in general on excess mortality, we took the following composite indices as explanatory indicators: the IQ of Cities and the UEQI. Both of these indices were developed by the Russian Ministry of Construction, Housing and Communal Services in cooperation with partners. The IQ of Cities urban digitalization index is designed to assess the digital transformation of cities. It is calculated in ten main areas: city management, smart housing and communal services, urban environment innovations, smart urban transport, smart public safety systems, smart environmental safety systems, tourism and service, smart social service systems, economy and investment climate, and communication network infrastructure. The urban digitalization index includes 47 parameters.

However, as shown in the literature, the smart city concept means more than just the digitalization of urban environment. Therefore, our study also used the UEQI, which targets specifically the quality and sophistication of urban infrastructure, public leisure and entertainment venues, sports and recreational facilities, and business centers. The index involves the assessment of six types of spaces (housing and adjacent spaces, public and business infrastructure, street and road network, social and leisure infrastructure, green spaces, and citywide space) by six criteria, which gives a total of 36 indicators.

It should be noted that these indices have their drawbacks. The information for calculating the indices is provided by the administrations of cities; however,

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18 See: COVID-19 Innovation Report. 2021. https://coronavirus.startupblink.com/COVIDReport2021/.
19 Rosstat data. https://rosstat.gov.ru/storage/mediabank/TwbjciZH/edn12-2020.html.
20 See: IHME Estimation of total mortality due to COVID-19. http://www.healthdata.org/node/8660.
21 Data of the Ministry of Construction for 201 cities of the Russian Federation. https://minstroyrf.gov.ru/.
22 Data for 201 cities of the Russian Federation. indeks-gorodov.rf.
they may have different understanding of the methodology for measuring individual indicators; therefore, there is no certainty that the calculation is correct. Moreover, some indicators are not sufficiently objective. As an example, such indicator as the “attractiveness of green areas” involves mentions in social networks; however, social networks could make those mentions in a negative context. Figure 3 shows the 2018–2020 UEQI in million-plus cities. The highest rates are observed in Moscow and St. Petersburg; the majority of the cities demonstrate an increase in the index over the period under review.

Nevertheless, it makes sense to add these indices as regressors because they provide a large amount of con-

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Fig. 1. Mortality in Russia in 2018–2020, people.
*Source:* compiled by the authors from Rosstat data.

Fig. 2. Excess mortality in Russian regions, 2020 to 2019–2018, per 10000 people.
*Source:* compiled by the authors from Rosstat data.
centrated information about the cities. Since excess mortality and other factors included in the analysis are provided at the regional level, we propose to calculate the UEQI of region \( j \) (UEQI).

\[
\text{UEQI}_j = \frac{\sum_i \text{UEQI}_{i,j} P_{i,j} + h \left( P_j - \sum_i P_{i,j} \right)}{P_j}.
\]

Here, \( \text{UEQI}_{i,j} \) is the UEQI of city \( i \) in region \( j \); \( i \in [1, N_j] \), where \( N_j \) is the number of cities in region \( j \) for which the IQ of Cities and UEQI were calculated; \( P_j \) is the population of region \( j \); \( P_{i,j} \) is the population of city \( i \) in region \( j \); \( h \) is the environment quality indicator for small settlements. The indicator \( h \) was estimated by experts at 100 units on the grounds that the minimum UEQI in small towns (with population of 5000 to 25 000 people) is 98 units and the majority of small settlements have less developed infrastructure and living environment than cities and towns. Meanwhile, the calculations showed that the value of \( h \) has little effect on the significance of the factor; it only leads to small changes in the coefficient at UEQI_{reg}.

The number of cities in the regression is 201, which includes all the 173 cities with a population of over 100 000 people and 28 small towns for which the UEQI and IQ of Cities were calculated. This way we were able to cover 69% of urban population in Russia. Figure 4 shows the proportion of population living in the cities under consideration in relation to the entire urban population of the regions. The dots indicate the cities included in the sample. This coverage allows us to conclude that the sample is representative and that we can move on from the city level to the regional level.

IQ\(_ j \) is calculated in a similar way.

\[
\text{IQ}_j = \frac{\sum_i \text{IQ}_{i,j} P_{i,j} + d \times \left( P_j - \sum_i P_{i,j} \right)}{P_j}.
\]

Here, IQ\(_ {i,j} \) is the IQ of city \( i \) in region \( j \); \( i \in [1, N_j] \), where \( N_j \) is the number of cities in region \( j \); \( d \) is the digitalization index of small settlements. The indicator \( d \) was estimated by experts at 20. Further research showed that the value of \( d \) has almost no effect on the significance of IQ\(_ j \).

We also added factors that characterize the population density: the share of urban population of the region, the presence of million-plus cities, and the presence of cities with a population of 500 000 to 1 million people. Other factors were also taken into account, which added such smart city components as “smart economy” (GRP per capita, average per capita income of population in the region, unemployment rate); “smart healthcare” (number of doctors of all specialties per 10000 people, number of hospital beds per 10000 people, outpatient clinic capacity per 100000 people), “smart transport system” (number of public buses per 100000 people), “smart environment” (total area of residential premises per resident, number of connected subscriber mobile communication devices per 1000 people, number of PCs per 100 employees), “smart education” (number of students enrolled in bachelor, specialist, and master degree programs per 10000 people).\(^23\) In our opinion, this approach allows a more comprehensive study of the urban economy development, i.e., not only its “smart” part but also the traditional one.

After excluding insignificant factors (with at \( p \) value greater than 0.1), the final regression is written as follows:

\[
\text{Em}_j = a_1 \text{UEQI}_{j} + a_2 m_1 + a_3 m_2 + a_4 T_j + a_5 H_j + a_6 S_j + c + e_j,
\]

where \( \text{Em}_j \) is the excess mortality in region \( j \) per 10000 people; \( m_1 \) is the presence of million-plus cities.

\(^{23}\)Data for 2019–2020 from the statistics bulletin Regiony Rossii (Regions of Russia). https://rosstat.gov.ru/folder/210/document/13204/. Accessed May 30, 2021.
in region $j$; $m2_j$ the presence of cities with population from 500 000 to 1 million people in region $j$; $T_j$ the number of doctors of all specialties per 10 000 people in region $j$; $H_j$ is the total area of residential premises per resident; $S_j$ is the number of students enrolled in bachelor, specialist, and master degree programs per 10 000 people; $e$ are the regression residuals; $a_1...a_6$ are the values of the coefficients; and $c$ is a constant. The number of observations is 83; Moscow and St. Petersburg were excluded as outliers. The results of calculating the regression, constructed by the least squares method, are presented in Table 1.

Excess mortality correlates with the presence of big cities in the region. It turns out that the presence of large centers contributes to the spread of the disease and reduces the possibility of self-isolation and contact minimization. This result complements the previous studies on the impact of population density on the pandemic.

The number of students also shows a positive correlation with mortality; universities turn out to be places responsible for spreading the disease. Students come from different regions and actively transmit the virus during classes. Moreover, they often do not com-

### Table 1. Results for the correlation estimates

| Factor                                                                 | Value  | $p$-value |
|------------------------------------------------------------------------|--------|-----------|
| UEQI ($a_1$)                                                           | −0.07  | 0.026     |
| Presence of million-plus cities in region ($a_2$)                      | 6.59   | 0.000     |
| Presence of cities with a population from 500 000 to 1 million people ($a_3$) | 5.85   | 0.000     |
| Number of doctors of all specialties per 10 000 people ($a_4$)         | −0.17  | 0.006     |
| Number of students enrolled in bachelor, specialist, and master degree programs per 10 000 people ($a_5$) | 0.01   | 0.054     |
| Total area of residential premises per resident ($a_6$)                | 0.55   | 0.000     |
| Constant ($c$)                                                         | 17.3   | 0.006     |
| $R^2$                                                                  | 0.49   |           |
ply with epidemiological requirements, such as the requirement to wear medical face masks.

Another significant factor is the number of doctors per 10000 people in the region. The more doctors there are, the greater the chance of receiving adequate and timely treatment and preventing a negative outcome of the disease is.

Initially, we assumed that the total area of residential premises per resident, in the case of a high value, would correlate negatively with mortality since people would have the opportunity to reduce contacts and isolate themselves. However, the factor turned out to be significant with a positive coefficient. A possible explanation is that the regions with a high value of the indicator are the ones with increased population mobility.

The UEQI turned out to be significant with a negative correlation, i.e., the higher the value of this index is in a given region, the lower the mortality rate is. This shows that the presence of comfortable spaces and developed infrastructure, including modern business and leisure centers, as well as recreational facilities, contributes to mitigating the consequences of the pandemic.

The IQ of Cities turned out to be insignificant. This is due to the narrow distribution of the smart technologies and to the government policy because authorities seek to avoid unnecessary lockdowns. If our country used the experience of the Republic of Korea or China with their high-tech methods of tracking sick people’s contacts and observing the self-isolation regime and pass control, then urban economy digitalization would have a much more significant effect. The mentality of the population also plays an important role, since people do not want to install the applications (which are very popular in some countries) for tracking infected people in a close radius or do not even think about installing them.

Such socioeconomic indicators as GRP per capita, average per capita income in the region, and unemployment rate turned out to be insignificant. Wealthy regions are usually characterized by a higher population density, difficulties with social distancing, higher population activity, a higher level of contacts, and a greater migration flow, all of which has adverse effects during a pandemic. However, these issues in wealthy regions are counterbalanced by better healthcare and better opportunities for people to switch to a remote work format. The insignificance of the other two factors shows that financial wellbeing has no significant effect on excess mortality. The absence of the impact of financial wellbeing on mortality may be the reason for the insignificance of such characteristics as the number of connected mobile subscriber devices per 1000 people and the number of PCs per 100 employees. The lack of correlation between the number of public buses per 100000 people and excess mortality can be explained by the high popularity of other modes of transport in a given city.

CONCLUSIONS

The coronavirus pandemic has brought about structural changes throughout the world. Among other impacts, it gave impetus to the rapid development of technology. Digitalization has increased considerably in the field of healthcare, i.e., telemedical healthcare services and the use of various electronic resources, including the growing support for the Russian Gosuslugi public service portal. The use of artificial intelligence and machine learning has become possible, both for predicting the spread of diseases and for making a diagnosis and searching for treatments. Russian scientists were the first to develop a highly effective vaccine, which was put into mass production.

The application has considerably expanded of other modern digital technologies aimed at the transition to an online format. First of all, they cover a substantial part of state and municipal administration, educational services, and remote work in high-tech companies. Furthermore, the implementation of the Smart City Standard involves the digitalization of urban economy and the expansion of digital services provided by municipalities.

A higher quality of urban environment leads to a decrease in excess mortality during a pandemic. A developed business infrastructure creates better opportunities for organizing social distancing; the availability of broadband Internet makes it possible to switch to an online format. Modern housing, as well as landscaped house territory, makes self-isolation easier. Moreover, the orientation of urban spaces towards environmental friendliness, a large number of green areas, and a sports lifestyle improve the health of urban population.

However, our study showed that urban environment digitalization as such has no significant impact on combating pandemics. The reason is that smart city technologies are introduced vigorously mostly in big cities, where the effects of digitalization are offset by the adverse impacts associated with big cities, i.e., the presence of big cities in the region greatly increases excess mortality during a pandemic. Due to overcrowding and a large number of contacts in public transport and public spaces, a disease transmitted by airborne droplets spreads swiftly in metropolises. This is further confirmed by the fact that after removing the factor of the presence of big cities in the region as an instrumental variable in the regression, the IQ of Cities becomes significant yet with a positive sign, due to the high correlation of these factors.

It can be concluded that in order to reduce the negative consequences of future pandemics it is important to focus on the development of smart technologies not only in big cities but also in other cities and towns in
Russian regions. The development of these cities and towns can be facilitated by a breakthrough in remote work opportunities, which will allow a large proportion of the population to choose their habitat, focusing on possibilities of digital access in their place of residence, a comfortable urban environment, advanced healthcare, availability of recreational and leisure facilities, etc. In Russia there are successful examples of creating and replicating small smart cities (e.g., the smart cities of the Rosatom state corporation), which will potentially reduce the costs of their distribution.

Thus, we can answer the question “How do smart city technologies help cope with pandemics?” as follows: as of today, these technologies make a small, yet positive, contribution to the fight against pandemics.

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**CONFLICT OF INTEREST**

The authors declare that they have no conflict of interest.

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