Sociological Modeling of Smart City with the implementation of UN Sustainable Development Goals

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Abstract

The COVID-19 pandemic before mass vaccination can be restrained only by the limitation of contacts between people, which makes the digital economy a key condition for survival. More than half of the world's population lives in urban areas, and many cities have already transformed into "smart" digital / virtual habs. Digital services make city life safe without an economy lockout and unemployment. Urban society strives to be safe, sustainable, well-being, and healthy. We set the task to construct a hybrid sociological and technological concept of a smart city with matched solutions, complementary to each other. Our modeling with the elaborated digital architectures and with the bionic solution for ensuring sufficient data governance clearly showed that smart city in comparison with the traditional city is tightly interconnected inside like social "organism". We have entered a decisive decade during which the world will change by moving closer towards SDGs targets 2030 as well as by the transformation of cities and their digital infrastructures. It is important to recognize the large vector of sociological transformation as smart cities are just a transition phase to human-centered personal space or smart home. The "atomization" of the world urban population raises the gap problem in achieving SDGs because of different approaches to constructing digital architectures for smart cities or smart homes in countries. The strategy of creating smart cities should bring each citizen closer to SDGs at the individual level, laying in the personal space the principles of sustainable development and wellness of personality.

Introduction

The era of smart cities

The ongoing COVID-19 pandemic, as well as any new lethal pandemic, before mass vaccination can be restrained only by the limitation of contacts between people, which makes the digital economy with online services a key condition for survival. Many cities have already transformed into "smart" digital / virtual habs in which the most of services are provided online with limitations of citizen contacts. Data governance and digital services make city life safe without an economy lockout and unemployment. Around 55% of the world's population lives in urban areas, and according to the United Nations urban population will rise up to 68% by 2050 (United Nations Department of Economic and Social Affairs 2018). Thus more than half of the world population will be cover by "smart" cybernetics online governance of their daily life. The "father" of cybernetics Norbert Wiener in 1948 was the first who emphasized that future society governance in the technology world must be based on humanistic values (2000). Such a new phenomenon in the life of society as smart cities poses new challenges to sociology and must give new opportunities to solve modern problems, boost humanistic values, and withstand a wide range of threats.

The future of urban sociology was comprehensively discussed at the joint session of the British and American Sociological Associations in 2001. It was declared that urban sociology faces a variety of challenges with expanding of numerous issues and themes (Perry and Harding 2002). From the scattered topics investigated within the urban sociology, scientific discourse is more and more shifting to the understanding of the interrelated integrity of the urban community. Sociologists need to treat the city as an autonomous social unit, and the better definition is the sociology of the city (Wu 2016). “Urban social” as a sociological category includes globalization, trans-local and non-human technological influences (Amin 2007), as well as social trust, economic equality and equality of opportunity, fight against corruption, education, health care, and labor market (Rothstein and Uslaner 2005). It is extremely important today to develop a sociological theoretical approach to the creation of smart cities’ theoretical concepts based on a deep and comprehensive understanding of the tasks and needs of the urban population. This scientific task concerns the embracement of “urban social” and frames it into the digital architecture of a smart city.

In essence, a smart city concept is about improving citizens’ lives (Thompson 2016; World Economic Forum 2018). Smart city means Big Data collection and data governance with the Internet of Things (IoT) and Artificial Intelligence (AI). Digital technologies must be the assets in addressing the United Nations Sustainable Development Goals, SDGs (United Nations General Assembly 2015; National Academies of Sciences, Engineering, and Medicine 2016) that include ensuring healthy lives and promote well-being for society. The soft city, IT urban infrastructure, city dashboards, urban cybernetics, city digital twin, Internet of Health, smart health care community are the definitions which reflect monitoring of society data flows to make urban society safe, sustainable, well-being, and healthy (Allen et al. 2019).

World Health Organization’s Belfast Charter for Healthy Cities declared the values for urban society: equity, human rights, sustainable economic development, and right to health (2018). Despite the significant progress that has been made in health care at the global level, there is still the dangerous risk of emerging following: lethal pandemics including COVID-19, a lot of serious diseases, harmful risk factors, and causes of death, which even according to the optimistic forecast will highly increase the years of life lost in 2040 and beyond (Foreman 2018). Technologies have already transformed health care, breaking down the barriers (clinics walls) and turning medicine into a network of ubiquitous social communications with the new opportunity to decline morbidity and mortality rate, as well as allowing to provide medical care during pandemic via telehealth services without visiting clinics. AI and IoT make it possible to create a digital architecture of a city in order to maintain health at the population level.

A smart city is built on smart spaces and smart platforms that are ubiquitous and mobile (Balletto et al. 2018; McClellan et al. 2017). Big Data is accumulating in real- time mode. One of the problems is data governance, how to overcome the combinatorial explosion and create such a framework, which will solve the task of data flow routing with massive parallelization and coverage of a city population by a smart network. But the more important problem is how to use technology for improving urban community life while the health issues come to the fore. In this study, we provide some of the comprehensive approach to modeling complex digital architecture for a smart & healthy city taking into account the needs of people, the urban social characteristics, and the complexity of social governing information flows. A smart city is a new and broad concept with 90% of sociology and only 10% of infrastructure issues, that require new approaches, planning, and engagement of the city community at large (Sandel 2017). We asked ourselves whether it is possible to construct a hybrid sociological and technological concept of a smart city with matched sociological and technological solutions, complementary to each other, which would be a holistic sociomic framework for society and will provide the new opportunity for social development.

Materials And Methods

Study design, materials and methods. The way to embrace social values

This study is original and based on the investigation of the new trends of the digital age. The study has had two phases. *The first phase* was aimed at API-sociology that is the text Big Data analytics using API-access to Google text global data storage. The morphological matrix of several keywords was collected. *The second phase* was dedicated to getting insights from the text Big Data analytics and modeling Value Chain Map and Logical AI schemes for a smart & healthy city that is the contribution to the emerged sociological theory of smart urban community life.

During *the first phase* of this study, related to API-sociology as well as computational sociolinguistics (Michel 2011), we used API-sociology as a modern trend in sociology, showing the possibilities of the Internet and computational sociolinguistics for deep sociological investigation. The global Internet environment is some kind of global audience discussion about various themes. Google captures all sorts of Internet texts: news, articles, advertising, analytics, blogs, and comments. Analyzing text arrays from the Internet we study the global society and global agenda. We can make an assessment of global society reflection in information systems. Many keywords about many issues can be investigated. Internet reflects different complex processes and activities from every human to local countries' issues and global world issues. API- sociology is aimed to find the hidden patterns and meanings in the frequency distribution of selected keywords. API-sociology uses a Big Data approach, which assumes that the collected data isn't absolutely perfect. The number of counted words may vary over time due to the variability of the Internet itself. But such aggregate measurement allows all variability to be drawn into the investigated general trend.

Three levels of global society behavior in the Internet space should be taken into account.

Level "Activity" – active presence on the Internet that is different for different countries and depends on the number of computers in the country, literacy, IT education, number of IP connections, Internet accessibility, number of Internet services, amount of country's population, the intensity of discussion in society, citing of the country on the Internet. Countries activity on the Internet was investigated by k-means cluster analysis (Supplementary information, S.I. Table 1). Level "Knowledge"– different countries have different features of the technological revolution that are reflected in the Internet's open resources. People write about those technological and economic processes, which have a place in their life, business, country's agenda. Level "Involvement"– reaction to stress, people write more about those problems which concern them more. Because of differences related to these three levels, the preferable way to analyze data is the cluster analysis within the selected groups of keywords.

Words have become data that can be analyzed to obtain new knowledge and awareness about the situation. There are some successful examples of extraction knowledge through Google text Big Data analytics: Google Flu project, Google Books Ngram Viewer, Google Trends. In our study, we extracted data from Google using API special software, which has been created at Vladivostok State University of Economics and Service. Selected keywords were counted in million in conjunction with 100 countries' names. Data collection (data mining) was implemented during the 2016–2018 years that is now of unique value because there was no unforeseen distorting global pandemic impact on global society that makes a reflection on the Internet, thus we can estimate society under normal conditions to modeling the processes of usual life in smart cities. This is the frequency-morphological analysis of open texts. The morphological matrix of 52 keywords was collected for countries in the English language (Supplementary information, S.I. Table 2). Our study has been going on for six years, and we have gradually chosen keywords, which can reflect in total the processes taking place in society and in the economy.

Results

From morphological matrix to Value Chain Map

The morphological matrix was analyzed by cluster analysis (Fig. 1). The single-linkage clustering (nearest neighbor clustering) was implemented in iPython (NumPy, Pandas, and Sklearn). This quantitative technique classifies data into homogeneous subgroups. The vertical axis of the dendrogram represents the distance or dissimilarity between clusters. The horizontal axis represents the objects (keywords, its frequency) and clusters. The dendrogram shows the two big clusters and six subclusters. Based on the keywords division into subclusters the six combined global social topics were defined which are important for society.

The revealed by API-sociology combined global social topics have in common with the SDGs (Table 1), which are the result of a complex worldwide negotiation process and reflect the needs of people around the world. Our findings confirm the ability of API-sociology to identify signs of the true discussion in society, as well as points out the importance of themes related to SDGs for people. We ranked six combined global social topics from first to last depending on the intensity of the frequency of mention and created the Value Chain Map which has synergetic incorporated SDGs (Fig. 2).

During *the second phase* of this study we considered Value Chain Map as an interrelated chain of growth drivers for modern social reality in that people are beginning to live in smart cities with digital data governance. Raw data collected from smart city systems first passes through three filters which determine the future of data usage. There is a confrontation with three forces: respect for freedom, ensuring security, and corruption penetration. Bad equilibrium with data closure and corruption increases risks of data governance fails that will make citizens' well-being worse and leads to trust loss within society. Digital technologies, especially AI and robotics, have a strengthening disruptive effect on society. Together a pronounced social impact by technologies with risks of corruption and data hiding will lead to the formation of a new negative social reality. Nowadays the formation of data governance rules for the smart city concept determines future risks.

Despite that economic development is a source of well-being we placed health issues at the more important place on Value Chain Map. The current transition to the digital economy carries with it risks to humanity which hasn't been in history before. Care about people should be at the center of digital progress. According to the World Economic Forum report alongside with demand of digital technology specialists, the greatest growth sector in the job market is care roles that more transform economy to "care economy" (Ratcheva et al. 2020). Special attention should be paid to digital medicine as it dissolves in the Internet of Things. Medicine is becoming an essential part of the digital economy where health (wellness) is a resource for economic growth. Digital medicine provides a personal ubiquitous approach and care, thus we can consider the wellness of personality instead of the health of depersonalized statistical humans. The main feature of the future will be the reaching of a longer life. During the next twenty years, life expectancy will increase up to 90 years (Foreman 2018). Longevity can be denoted as the goal of the current cybernetic revolution.

Modeling of smart & healthy city

Value Chain Map based on findings related to SDGs was applied to the strategy of the digital economy of a smart city. In this way, we modeled Logical AI schemes, which are designed to data governance the digital infrastructure of a city of the future, which will be a place for healthy life and longevity. We presented examples of four schemes that can be called architectures for smart city data governance (Tables 2–5; Supplementary Information, S.I. Fig. 1–7). The architectures reflect the hybrid matched sociological and technological solutions. Parameters for Input include the most important challenges that must be addressed to ensure the well-being of society. Parameters for Output contain the new technologies and approaches for solving the selected problems. Some of the technologies are just at the beginning of implementation or discussed in the various Internet resources as emerging technologies. The digital design of a smart city should be focused on the most modern and future technologies.

The architecture "Health as a personal safety issue" includes basic health care tasks for city community wellness (Fig. 3). Determined ten tasks can be solved through several technological directions in different combinations that are shown on the AI scheme. For example, the task "reduction of hospital readmission rate" is important for health care. A patient can be successfully treated at a smart home with mHealth, different Apps, and wearable devices. AI technology in a smart hospital helps to shorten the length of inpatient treatment. No less important than digital technologies is the policy for social inclusion and public sector management. Social management should be changed according to technological progress. The inclusion of all tasks into the unified scheme allows integrating each solution with several options (Supplementary Information, S.I. Fig. 1–4).

The architectures “Free enterprise and human rights to live without poverty”, “Democracy as the condition for prosperity”, and “Fighting corruption for ensuring food security” are shown in Supplementary Information (S.I. Fig. 5–7). These schemes reflect the economy, social rights, and conditions for urban population well-being including tasks of the United Nations Decade of Action on Nutrition (Rodrigues Birkett 2018). In the presented digital architectures, we demonstrated the wide range of applications of new technologies and approaches to comprehensively solve daily basic problems for the urban population. A city’s digital architecture should not distort basic social processes. Moreover, digital technologies make it possible to take into account the SDGs in data governance, which are demanded by society.

Data governance for a smart city should be based on the framework for massive parallelization to overcome the combinatorial explosion. The cybernetic bionic approach can be implemented in our sociological modeling. The best model is the thalamus – the brain’s structure. Thalamus function can be compared with relay or commutator that redirects all sensory or motor inputs to different areas of the cerebral cortex. In nature, information is redirected by three forms due to functional differences of thalamic nuclei (Melchitzky and Lewis 2009).

The specific relay nuclei process input from a single sensory modality and project it to a specific area of the cerebral cortex. A specific relay way can be extrapolated to data governance as the information flow of personal problems and solutions. The association relay nuclei receive highly processed input from more than one source and project it to larger areas of the cerebral cortex. An association relay way can be extrapolated to analytical information and problem solving for a sector. The diffuse-projection nuclei receive input from diverse sources and project it to widespread areas of the cerebral cortex. A diffuse-projection way can be extrapolated to IoT Big Data flows and sociomic comprehensive regulation. Considering that a smart city needs the relevant digital environment with High-Performance Computing, this should be a multiprocessor environment with four components of Flynn’s taxonomy: for specific relay data flow – single instruction & single data; for association relay data flow – multiple instruction & single data and single instruction & multiple data; for diffuse-projection data flow – multiple instruction & multiple data.

Due to the proposed cybernetic bionic approach, the coverage of the whole city population together with personalized support for each citizen can be achieved by the thalamus-like smart network. Trying to overcome the technological problem related to massive parallelization we had to propose the bionic approach like the “brain” governs whole “organism”. This fact points out to technological necessity for the smart city to be an autonomous and united social unit. Also, this confirms the accuracy of the modern definition “sociology of the city” with treating the city as an autonomous interrelated social unit. The digital architecture of a smart city can be called a city digital twin. It is very important to understand the holistic nature of a smart city. In fact, creating digital architectures for cities we should shape the digital twin of the city as a whole social “organism”.

Discussion

Health-focused digital city framework

It can definitely be said that the topic of smart cities is now beyond the scope of computer science and becoming an advanced tool for health care and social managing. A smart city is the best investment in public health. The priority of health as a primary asset is considered worldwide for development planning in the following decades (Kruk et al. 2018; Davies et al. 2018). The most fundamental shift affecting global development is the rising burden of disease and mortality (Schäferhoff 2015). It is necessary from the very beginning to put health care priority developing digital architectures of smart cities. For citizens' community, all problems affecting health can be monitored comprehensively including ecology, nutrition, psychological health, safety, ergonomics, employment, and income. Open, interoperable data and free data sharing (as FHIR API) are the key conditions for digital society wellness. Open IoT platforms with AI will drive governance of all processes including health care (Batra et al. 2019; Brack and Castillo 2015; Cygan et al. 2018). Multilevel architectures of a smart city should have a security system for protection against hacking and failures.

Today pharmacological companies are the most active in the development of digital services for citizens. They create digital logistics schemes to purchase the necessary medicines in the city pharmacies network with discounts and delivery, as well as to get the doctors consultations online or in a clinic. There are some other advanced cloud- based projects, for example, Atrium Health and Cerner HealtheIntent in the USA. Atrium Health connects citizens with on-demand care and provides the region's primary care network. Service aggregates different data: DNA sequencing, health monitoring parameters, environmental pollution. Cerner HealtheIntent is the health management platform that enables to aggregate, transform and reconcile data across the continuum of personalized care (citizens' data from clinics, hospitals, homes, fitness centers, retail pharmacies, workplaces). Such systems are a significant step towards creating a full- fledged digital architecture of a smart & healthy city.

We investigated the topics that were mentioned in the scientific articles about smart cities. We implemented three queries using IEEE Xplore Digital Library API Dynamic Query Tool: smart city, smart healthy city, and smart city + artificial intelligence (Supplementary Information, S.I. Fig. 8–10). IEEE library consists of millions of articles written around the world. The investigation revealed the most mentioned terms with respect to smart cities: data, IoT, communications, architectures, applications, networks, sensors, ecosystem, ecology environment, waste management, air pollution, water quality, and plastic waste of households. Among the worldwide publications about smart & healthy cities the many different topics were mentioned: wireless and mobile technology, elderly citizens, healthy aging, healthy lifestyle, immunization monitoring, emotional wellness, disaster evacuation management, security environment, urban mobility, food safety, healthy products, and green energy. In articles dedicated to smart cities with AI the most mentioned terms were Big Data, machine learning, engineering, and electrical energy. Overall researchers have paid the most attention to the technologies, ecology, and energy of a smart city. But there is insufficient attention to the complex medical aspects incorporated into the sociology of a city.

Modern health policy aims to create community-based programs and foster a culture of health in society (Acosta et al. 2016; Plough et al. 2018; Teno et al. 2017). It is time to rethink past approaches and construct smart cities in order to reduce morbidity and mortality rates for the next decades by digital urban infrastructure. We modified the Culture of Health Action Framework (Fig. 4), especially for smart cities. Primary Culture of Health Action Framework was developed by the Robert Wood Johnson Foundation & RAND Corporation. The four action areas include a health-focused digital city framework; cross-sector complex AI architectures aimed at wellness and longevity; open, interoperable data and free data sharing; and equal access to digital infrastructure.

Conclusion

Transition from city to smart home – Can we bring SDGs to every home?

In this study, we make the contribution to scientific discourse about the sociology of the city in a modern context related to “smart” digital technologies and SDGs implementation. We set the task to construct a hybrid sociological and technological concept of a smart city with matched sociological and technological solutions, complementary to each other. The shown AI schemes (architectures) are devoted to finding the solution of this task and they correspond to revealed actual global social topics by our API-sociology approach. Based on revealed social values and also on our view about the importance of health issues for the society we described the model of “smart city”. Our modeling with the bionic solution for ensuring sufficient data governance clearly showed that smart city in comparison with the traditional city is tightly interconnected inside like social “organism”.

We have entered a decade during which the world will change by moving closer towards SDGs targets 2030 as well as by the transformation of cities and their digital infrastructures. We can absolutely sure that all new technology such as IoT, AI, the Internet, mobile cloud, will be used in cities. But without a special strategy, there is no guarantee that in smart cities these technologies will make cities clean, fair, green, sustainable, safe, healthy, affordable, or resilient with higher ethical values of liberty, and equality (Sterling 2018). The United Nations initiative “United for Smart Sustainable Cities” (U4SSC) coordinated by the International Telecommunication Union (ITU) has facilitated the development of internationally recognized key performance indicators for cities to make infrastructure relevant to equity and social inclusion, quality of life, and environmental sustainability. Smart city concept should be elaborated to solve all together SDGs in a synergetic mode like it was made implementing The United Smart Cities program initiated by The United Nations Economic Commission for Europe (UNECE). This is also the responsibility of political leaders at the local, regional, and global levels to ensure Smart Cities facilitate and don't hamper the realization of the SDGs (Schwarz-Herion 2020).

The current Fourth Industrial Revolution with its fundamental transformation brings the opportunity to adapt and modernize governance models, to reduce social inequalities, and to commit to values-based leadership of emerging technologies (Schwab 2018). A smart city is the basic product of 4.0 technologies. Nowadays the digital infrastructure of a city becomes the center of society and all social processes of the urban population undergo the centripetal influence of the digital infrastructure of the city. The present time is characterized by the growing role of smart cities in the implementation of social policy. But Alvin Toffler in the 1980s predicted that in the future during “information third wave” the center of society will be at home, at “digital cottage” (2004). The quarantine and self-isolation which the countries had to keep for several months can be called a hyperbolical forerunner of future home-centered society model. It is obvious that the sociology of the city gradually transforms into the sociology of a smart city and will reflect the fundamental sociological changes with which society in the future will adopt a model of human-centered personal space or “Toffler’s digital cottage” (smart home).

It is important to recognize the large vector of sociological transformation as smart cities are just a transition phase. One of the features of a large vector of changes is the comprehensive and holistic care of the person as a unit of society. In this way, the most value for a human is health or wellness. The definition “sociology of smart city” doesn’t reflect enough the process of development toward the future per se. The “process” is more important in the digital world than “infrastructure” (for example, the process can include technology of augmented and virtual reality or the governance of the city relies on AI). The definition “sociology of smart city lifeway” is more relevant, and also the “sociology of smart citizen” reflects the trend of transition to home-centered (smart home) urban society. The term “sociology of smart citizen” seems to be the most perspective in front of the developing Fourth Industrial Revolution for which the main feature is cyber-physical systems, including the brain-computer interface. Although it is difficult today to predict which exact definition will be the most relevant in the future for a sociological study of a smart city in which city residents are connected to data and process management through a brain-computer interface, the “sociology of smart citizen” can be the right way on the next stage of technological evolution.

The vector of sociological transformation is leading to “atomization” of the world urban population, to the local level of smart city (functioning as interconnected “organism”), and to a smart home personal place. This raises the gap problem in achieving SDGs because of different approaches to constructing digital architectures for smart cities or smart homes in countries. Digital technologies are indispensable tools to eliminate gap within regions and cities with respect to achievement of the SDGs (Johnson 2018; García Zaballos 2019). At the beginning of the decisive decade for people and the planet while the window of opportunity is closing fast UN Secretary- General António Guterres said: “We must connect the dots across all that we do – as individuals, civic groups, corporations, municipalities and the Member States of the United Nations – and truly embrace the principles of inclusion and sustainability” (Global Sustainable Development Report 2019). The strategy of creating smart cities in this decade should bring each citizen closer to SDGs at the individual level, laying in the personal space the principles of sustainable development and wellness of personality. Proposed by us approach is aimed at gap elimination on an individual level for each citizen in smart cities.

Declarations

Authors contributions

Olga Kolesnichenko: Conceptualization, Project administration, Data curation, Formal analysis and investigation, Writing – original draft preparation, Writing – review and editing. **Lev Mazelis:** Data curation, Methodology, Formal analysis and investigation, Writing – review and editing. **Alexander Sotnik:** Project administration, Writing – review and editing. **Dariya Yakovleva:** Data curation, Methodology, Formal analysis and investigation. **Sergey Amelkin:** Formal analysis and investigation, Writing – review and editing. **Ivan Grigorevsky:** Formal analysis and investigation, Writing – review and editing. **Yuriy Kolesnichenko:** Project administration, Formal analysis and investigation, Writing – review and editing. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Data availability

The study data is available from the investigators on reasonable request. Requests should be directed to the corresponding author by email.

Declarations of interest

We declare no competing interests.

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Tables

Table 1 Matching of API-Sociology insights (combined global social topics) with UN Sustainable Development Goals

Combined global social topics*, API-Sociology	UN Sustainable Development Goals**
1. Free enterprise and human rights to live without poverty	Goal 1. End poverty in all its forms everywhere Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation Goal 12. Ensure sustainable consumption and production patterns
2. Health as a personal safety issue	Goal 3. Ensure healthy lives and promote well-being for all at all ages
3. Electricity availability with containment of price growth	Goal 7 Ensure access to affordable, reliable, sustainable and modern energy for all
4. Democracy as the condition for prosperity	Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all Goal 5. Achieve gender equality and empower all women and girls Goal 10. Reduce inequality within and among countries Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
5. Mortality in the aspect of crime	Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable
6. Fighting corruption for ensuring food security	Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture Goal 6. Ensure availability and sustainable management of water and sanitation for all

*Ecology and humaneness to nature / animals weren't considered in this study, despite the importance of these issues.

**Goals 13, 14, 15, 17 are not mentioned.

Table 2 Architecture “Health as a personal safety issue” for smart city data governance*

Parameters for Input	Parameters for Output
prevention of diseases	genetic risk assessment, CRISPR gene editing
prevention of disease’s complications	pharmacogenetics
treatment of incurable diseases	drug modeling In Silico
reduction of hospital readmission rate	Smart Home, IoT, mHealth, Apps
reduction of patient length of stay in hospital	Smart City, IoT, mHealth, Apps
reduction in infertility rate	early screening and monitoring, electronic health records
reduction in maternal and child mortality	Smart hospital, AI
improving life quality for people with disabilities	wearable devices, exoskeleton, brain–computer interface
longevity achievement	3D–printing, implant–tissue interface, neuron–like electronics, neurogenesis
improving life quality for elderly people	policy for social inclusion, public sector management

*Note for tables 2–5: The emerging technologies are described in detail on web resources: World Economic Forum Strategic Intelligence platform (https://intelligence.weforum.org/) and Envisioning Technology Radar platform (https://viz.envisioning.io/wgs-citizenship/).

Table 3 Architecture “Free enterprise and human rights to live without poverty” for smart city data governance

Parameters for Input	Parameters for Output
simple registration of a new private business	ecosystem for innovation–driven entrepreneurship
accelerators and venture funding	new job creation
tax cut and tax exemption	agile governance, smart tax, real time individual tax planning
low loan interest rate	social impact–driven entrepreneurship
minimization of administrative checks	smart contract, administrative intelligence
law enforcement control	blockchain
reduction in spending on infrastructure	Smart City, IoT, Mobile Apps, AI Energy Grid
employer's tax incentives for disabled employees	Smart Home, IoT, Mobile Apps
increasing economic literacy	digital public policy, urban sensor Web
gender and age equality and support for pregnant	corporate social innovation

Table 4 Architecture “Democracy as the condition for prosperity” for smart city data governance

Parameters for Input	Parameters for Output
overcoming information inequality	free wireless ubiquitous access to the Internet
freedom of speech and expression	encrypting, biometric identification
common values	citizen–driven crowdsensing platform, virtual city
local government	Hybrid Cloud, distributed edge
Open Data	Government Cloud
equal access to education and skills	Virtual and Augmented Reality, gamification of life
equal access to medical care and drugs accessibility	Smart City, IoT platforms, AI, Smart Home, mHealth, Mobile App
mobility and property rights	virtual world passport, e–residency
rights to work and retire	human enhancement, full body avatar
rights to have family and children	administrative intelligence for public civil services

Table 5 Architecture “Fighting corruption for ensuring food security” for smart city data governance

Parameters for Input	Parameters for Output
eradicating hunger and malnutrition	social impact–driven entrepreneurship
eradicating food deserts	Smart City, e–commerce, e–retail, marketplace
fight with obesity, anemia, deficiency of vitamins	Smart Home, IoT, mHealth, Apps, electronic product code
food pricing control	citizen–driven crowdsensing platform
GMO regulation and control	Government Cloud, administrative intelligence

Figures

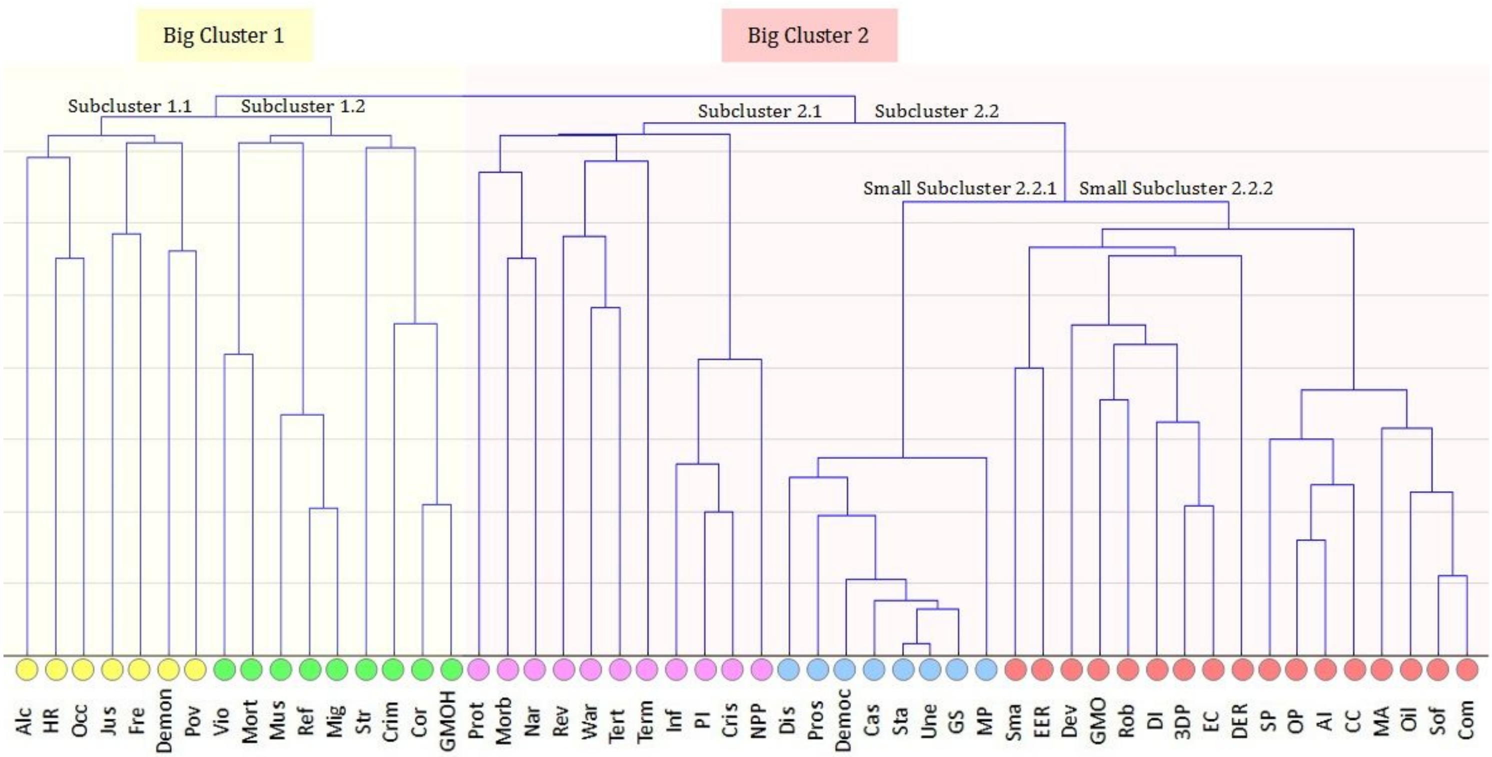

Figure 1

The dendrogram of the morphological matrix, 52 keywords, and 100 countries; analyzed parameters – keywords (Google API) Note: Subcluster 1.1: Alc (alcoholism), HR (human rights), Occ (occupation), Jus (justice), Fre (freedom), Demon (demonstration), Pov (poverty). Subcluster 1.2: Vio (violation), Mort (mortality), Mus (Muslims), Ref (refugees), Mig (migrants), Str (strike), Crim (crime), Cor (corruption), GMOH (GMO harmful). Subcluster 2.1: Prot (protest), Morb (morbidity), Nar (narcotic), Rev (revolution), War (war), Tert (terrorist), Term (terrorism), Inf (inflation), PI (price increase), Cris (crisis), NPP (nuclear power plant). Subcluster 2.2.1: Dis (dismissal), Pros (prosperity), Democ (democracy), Cas (casualties), Sta (stability), Une (unemployment), GS (gas supplies), MP (mobile phone). Subcluster 2.2.2: Sma (smartphone), EER (euro exchange rate), Dev (development), GMO (GMO), Rob (robotics), DI (drip irrigation), 3DP (3D printing), EC (electric cars), DER (dollar exchange rate), SP (solar panel), OP (oil price), AI (artificial intelligence), CC (cloud computing), MA (mobile app), Oil (Oil), Sof (software), Com (computer).

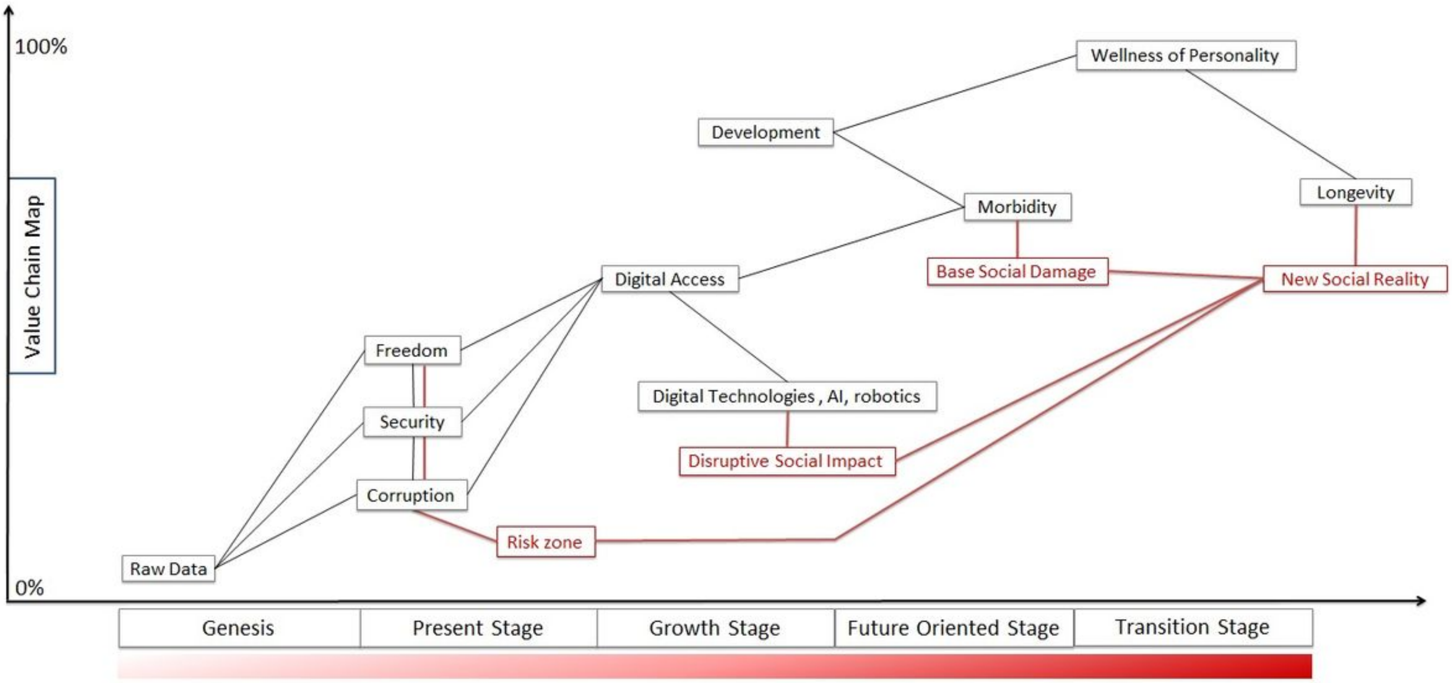

Figure 2

The Value Chain Map for results of text Big Data analytics (Google API) related to Sustainable Development Goals

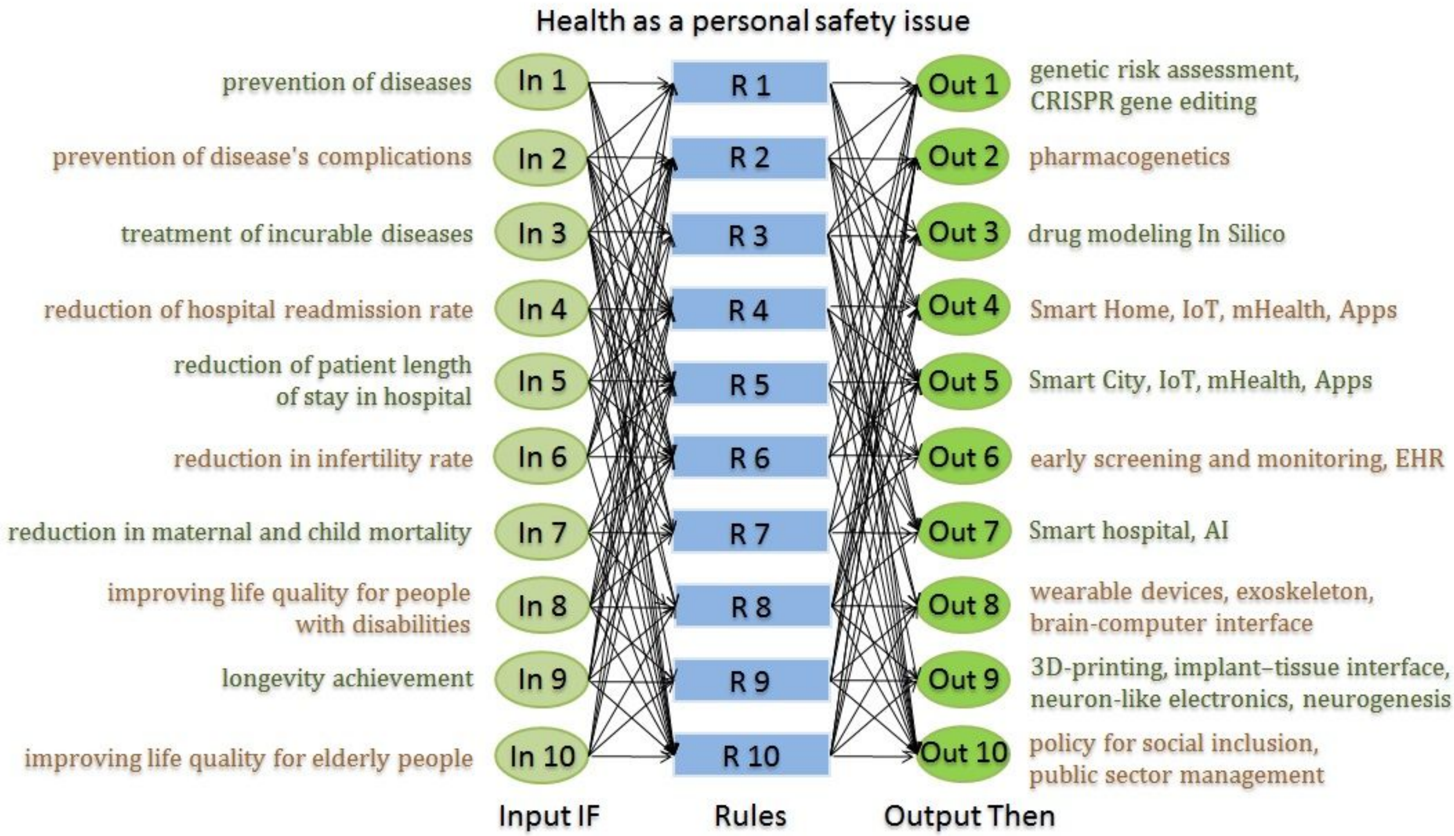

Figure 3

Logical AI scheme “Health as a personal safety issue” for a smart city

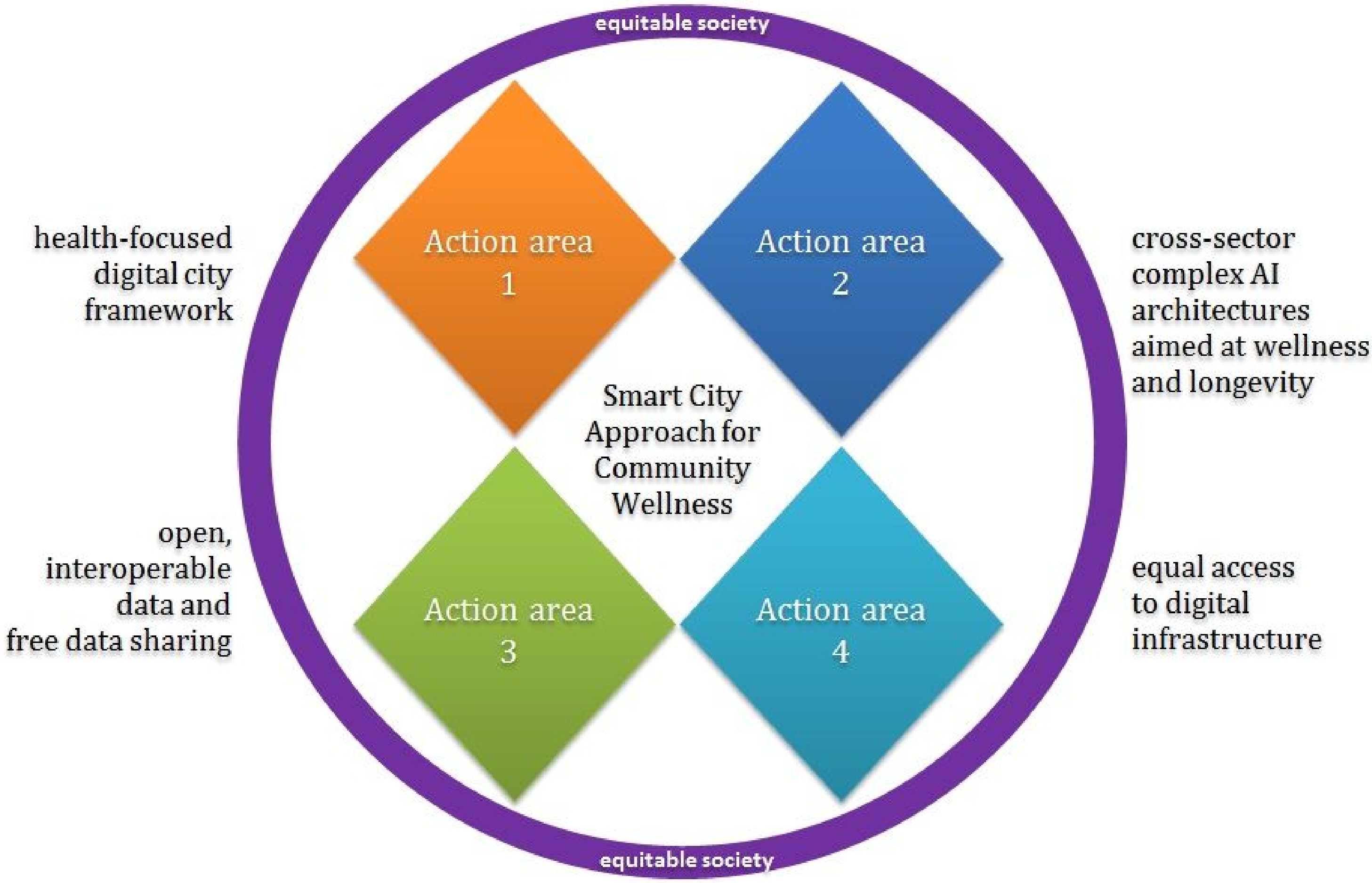

Figure 4

Smart City Approach for Community Wellness – Culture of Health Action Framework adapted for Smart City. Primary Culture of Health Action Framework was developed by Robert Wood Johnson Foundation & RAND Corporation (Acosta et al., 2016; Plough et al., 2018)

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Supplementaryinformation.pdf