Open Access Research Journal of
Engineering and Technology
Journals home page: https://oarjpublication/journals/oarjet/
ISSN: 2783-0128 (Online)

(REVIEW ARTICLE)

Digital Innovation in Urban Healthcare by enhancing infrastructure with Information Technology (IT)

Agnila Sen Gupta *

Department of Biomedical Engineering, North Eastern Hill University, Shillong, India.

Open Access Research Journal of Engineering and Technology, 2025, 08(01), 066-078

Publication history: Received on 18 January 2025; revised on 24 February 2025; accepted on 27 February 2025

Article DOI: https://doi.org/10.53022/oarjet.2025.8.1.0032

Abstract

The increasing urbanization of cities today has its disadvantages, especially in the healthcare sector where the provision of services faces a number of obstacles including barriers of accessibility, wastage of resources, and an overall unmet demand. One of the strategically possible ways to overturn these disadvantages as it is stated in the article is to industrialize the urbanization processes by incorporating Information Technology (IT). This paper seeks to look into the relationship between IT development and urban healthcare instruments development; through the usage of GIS, IoT, AI technologies. Some cases of urban healthcare practice are: Optimal positioning of healthcare facilities, promotion of equitable access to healthcare, and provision of effective healthcare by means of geography related ICT tools. Emerging smart cities such as Singapore and Seoul illustrate the vast influence of information technologies in improving patient experience especially through telemedicine, EHRs, and real time monitors. In addition, healthcare and other essential services have been centralized as IT assists in resilience, as witnessed during the pandemic where digital health enabled quick response and business as usual. With the rapid integration of IT within the urban development framework, it can easily foster efficiency within healthcare systems making them effective and equitable.

Keywords: Information Technology; Urban Planning; Healthcare Infrastructure; Artificial Intelligence (AI); Internet of Things (IoT)

1. Introduction

1.1. An overview of urban development

Urbanization became one of the greatest challenges of the 21st century. Looking at the broader picture, cities are now more than just urban units of population; they have become a major engine of economic growth and a centre for opportunity, wealth creation, innovation and social and cultural exchange [1,2,3,4]. More than half of the world (55%) are living in urban areas and this percentages are continued to increase. Urban population percentage is expected to rise to 68% by 2050, due to worldwide population growth and urbanization [1,5]. In the slums, health care systems in most developing nations remain fragmented and underfunded [6].

As the most disaster-prone region in the world, the Asia-Pacific is also home to a growing number of climate-related disasters in recent decades, and the impacts of climate change are already hurting peoples' lives across this space. Research found higher mortality rates, a greater number of people impacted and larger economic losses in cities with higher density during a disaster. The economic role of urban areas in the majority of Asian nations (65-90%, depending on how it is measured) and predictions that two-thirds of the world population will inhabit cities by 2030 indicates an important need for this form of land use. The need for action will only grow if nothing is done at the urban level because cities are bound to face more and more climate-related disasters. Therefore, addressing the increasing threat of climate-related disasters requires a focus on the local urban community. They were given but 48 hours to come up with the cash before they would be arrested [7].

* Corresponding author: Agnila Sen Gupta

1.2. Introduction to Information Technology (IT) in healthcare

Rural-urban healthcare access inequality refers to the gap between rural and urban populations in accessing quality healthcare, especially for severe conditions. A study in China [8] explores the potential of health information technology (HIT) to address this issue, linking HIT interventions with societal-level transformations. It contributes to theory by examining how micro-level HIT effects lead to macro-level outcomes and offers policy insights on adapting HIT to tackle complex societal challenges.

Urban health is a great concern in the present century characterized by high levels of urbanization which significantly affect health. There are available solutions in information technology that could help address a great number of problems that modern day cities are encountering. The research reviewed 164 articles, reports and articles on such Richards CiDEN, mobile phones, wire technologies, GIS, RFID and cards used for urban health. Thirty sources formed the basis of the final analysis. The information underscores the importance of information and communication technology (ICT) in promoting health and enhancing the quality of life. For ICT to be effectively utilized, there is need to not only identify the suitable and applicable aspects but also the drawbacks and challenges while formulating appropriate strategies taking into consideration the social, economic, technological, legal and administrative elements [9].

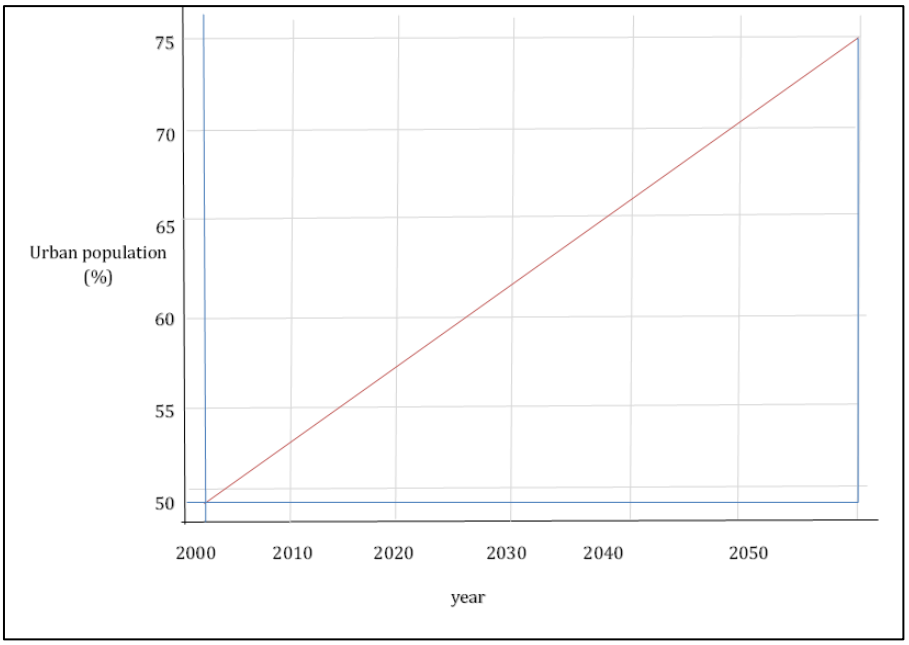

Figure 1 Urbanization Growth vs Healthcare Demand (2000-2050)

1.3. Historical concept of urban development in healthcare

JN Day (et al.) [10] describes an overview which offers a theoretical and historiographical analysis of recent developments in medical centers, examining their influence on urban growth. It also explores how local, state, and federal governments have played roles in promoting public health and contributing to urban revitalization efforts in cities. Here is a summary of the historical overview of urban development in healthcare:

Table 1 Historical Concept of Urban Development in Healthcare (2004–2024)

Year/ period	Developments	Key characteristics	Achievements in healthcare	Developments in healthcare infrastructure	Real-life examples
2004-2009	Expansion of e-Health	Digital health records; telemedicine advancements	Improved patient data management; remote access	National EHR systems; telehealth pilot programs	UK's NHS Digital; Kaiser Permanente EHR systems

2010-2014	Rise of Smart Cities	IoT integration; urban health monitoring systems	Enhanced public health surveillance	IoT-enabled health infrastructure; GIS for planning	Songdo, South Korea; Rio Operations Centre
2015-2019	Focus on AI and Predictive Analytics	AI in diagnostics; predictive modelling for outbreaks	Faster disease detection; improved outcomes	AI-supported clinical decision-making	IBM Watson Health; AI in India's TB screening
2020	COVID-19 Pandemic Response	Global urban health emergency; telemedicine expansion	Rapid vaccine rollout; remote care systems	Pandemic preparedness centres; contact tracing apps	Aarogya Setu (India); COVIDSafe (Australia)
2021-2023	Adoption of Blockchain in Healthcare	Data security for health records; decentralized networks	Enhanced trust; interoperable health systems	Blockchain for health data; vaccination tracking	Estonia's e-Health; MediLedger Project
2024	Integration of AI and IoT in Urban Health	Real-time monitoring; personalized healthcare	Advanced predictive healthcare; seamless access	Smart hospitals; AI-driven health networks	Singapore's Smart Nation; Cleveland Clinic AI use

1.4. Objective and Scope of the Review

The main objective of this review is to explore the history of development of urban healthcare, outlining the way in which technology, infrastructure, and innovative practice break the barriers to urban healthcare challenges. Key milestones in e-health, smart cities, AI, and IoT integration are considered and assessed for their impact on accessibility, efficiency, and public health outcomes. The scope encompasses worldwide trends, focusing on urban planning strategies, technological advancement, and real-world applications in healthcare infrastructure. This review will cover the comprehensive understanding of the synergy between the innovations in urban development and healthcare.

2. Background and Conceptual Framework

2.1. Urban health and development

Urbanization is one of the significant trends in the 21st century which directly affects public health; the majority of this growth is anticipated to happen within developing nations already dealing with myriad health challenges. In the last century, society has transitioned from being majorly rural to largely urban [11]. According to the United Nations (UN) [12], 'World Urbanization Prospects 2018' [13] report predicts, as of 2018, 56.61% of the world's population already lived in cities and towns, projected to grow to 68% by 2050. Urban health is concerned with complex relations between city infrastructure, such as access to green spaces, noise levels, and opportunities for social interaction, and their impact on health outcomes. Of course, mechanisms and policies affecting urban development also fall within its scope. As an interdisciplinary field, urban health remains evolving, composed of multiple professions, traditions, and academic disciplines. A healthcare system, according to the World Health Organization (WHO) (2000) [14], includes all institutions, organizations, and resources provided with the aim of promoting health [15].

2.2. Smart cities

Smart cities integrate traditional urban infrastructure with advanced information technologies (IT), including IoT [16] sensors to foster social and economic success while delivering sustainable urban services [17]. This is achieved by a collaboration between the public and private sectors through the implementation of IT platforms that are capable of processing large data volumes for automated and intelligent systems [18]. These include a smart economy marked by innovation, entrepreneurship, and global competitiveness. The idea of smart mobility emphasizes accessible, sustainable, and secure transportation and communication systems [19,20]. Smart governance concerns itself with transparent policies, public participation, and high-quality public services. Smart environment emphasizes ecological sustainability as well as resource management. Smart people underscore education, diversity, and social capital. Finally, smart living improves quality of life through healthcare, housing, education, and culture. Although IT-based healthcare has been widely reviewed, the systematic studies on the implementation of smart city are limited. This article tries to bridge that gap by exploring applications within the infrastructures of the smart city-the developments that really hit healthcare-a very important area of smart living [21].

2.3. Information technology (IT) in healthcare

Information Technology refers to the application of digital tools and systems which are available and user-friendly for quality improvement in health care. however, healthcare organizations spend less on IT as compared to other information-intensive sectors such as banking or aviation, where significant quality improvements can be done with greater IT utilization. The potential areas of improvement would be to automate error-prone processes and computerized decision support systems. This can increase efficiency, quality, and the measurement of care outcomes. The current state of IT applications in healthcare is highlighted, the potentials of expansion of such uses, and then problems toward potential success [22]. Increasingly, the sector of healthcare quality and patient safety uses health information technology to try to prevent reportable incidents, detect issues in time for taking corrective action, and confront events considered unavoidable. But it is often uncertain where financial and human resources should be directed as healthcare organizations begin to implement this technology. [23].

2.4. Healthcare infrastructure

Health infrastructure includes physical and operational aspects that support healthcare delivery while hospitals integrate as a hub for the acute and inpatient care system. It facilitates seven key quality domains [24]: patient experience, effectiveness, efficiency, timeliness, safety, equity, and sustainability. Infrastructure comprises built environment, equipment, IT systems, effort to sustain it, and the workforce with characteristics allowing transitions between care settings without compromising patient's privacy and dignity [25]. Its goal is to raise standards of care and better care conditions for the patient [26] and support health promotion, prevention, and self-care for the population. Hospitals are also significant in reaching the concealed and benefitting populations and the well-being of staff required for good quality care [27].

2.5. Theoretical Framework

Information technology (IT) is now an essential part of urban health-care sector which contributes to the better efficiency, accessibility, and innovations. It enables the integration of individual components of health care to benefit urban citizens through telemedicine, advanced diagnostics, and data-driven decision-making. For example, GIS are really important for urban planning - pinpointing underserved areas and the placement of health care facilities [28]. IT facilitates healthcare development and quick delivery/response in urban areas through telemedicine, Geographic Information Systems (GIS), Internet of Things (IoT), and blockchain technology.

2.5.1. GIS in healthcare

Geographical information system tools have revolutionized a way where healthcare facilities could be more accessible by identifying unserved areas, by mapping healthcare facility locations and by optimizing facilities in rural areas.

Geographic Information Systems (GIS) are instrumental in enhancing our comprehension and control over mental health service delivery. Mental health disorders impact a considerable segment of society, with studies suggesting that 20-25% of individuals will encounter mental health issues during their lives. Geographic Information Systems (GIS) play a vital role in increasing our understanding and management of mental health service delivery. Mental illness affects a significant proportion of society, as studies indicate 20-25% of people will experience mental illness throughout their lifespan. Particularly in Greece, research has shown 14-16% of the population experiencing mental health problems, the vast majority stress-related. Mental health problems are one of the main causes of disability and have important socio-economic impacts. Most notably, environmental modifications like urbanization and land use alterations are increasingly linked to mental health problems, especially among vulnerable populations such as the elderly. GIS then becomes an important tool for medical professionals by creating a map of the availability of mental health services and determining obstacles in access. Geographic conditions, such as proximity to medical centers, play an important role in the use of services, and most people migrate towards regions with improved healthcare accessibility. With the careful examination of the spatial patterns of these services, GIS makes it possible to create networks offering universal access to care and therefore reducing health inequities. Further, GIS brings together data related to mental disorders, service access, ethnic minorities, and levels of education and provides an integrative overview of healthcare requirements. Apart from mental health, GIS has wide use in healthcare service planning. It optimizes home healthcare by creating efficient travel routes for healthcare staff, aids private health sectors in strategic growth, and predicts the areas with higher demand for particular healthcare services. GIS also supports emergency preparedness and response by synchronizing and making health services easily accessible. For example, it helps in routing patients to nearby healthcare centers or medical devices such as CT scanners, thereby improving the effectiveness of healthcare delivery. GIS use is applied in environmental health management, with the system having a pivotal element in environmental hazard mapping and auditing, public health decision-making, and solution of complex health-environmental issues. The systems have an integral role to play in healthcare service planning and optimization,

improved access, and enhanced health equity. GIS becomes a critical tool for health professionals by mapping the spread of mental health services and identifying hindrances in access. Geographic factors, including the distance to healthcare facilities, play a major role in the use of services, and many people migrate towards areas with better access to healthcare. By accurate examination of the spatial pattern of these services, GIS allows for the development of networks that ensure equitable provision of care, thereby reducing health inequities. Additionally, GIS combines information related to mental health disorders, service accessibility, ethnic origins, and education levels, providing a holistic view of healthcare needs.

This paper focuses on a case study using Geographic Information Systems (GIS) applications to understand healthcare infrastructures and accessibility in Taraba State. The research covers spatial distribution of healthcare services and evaluates how effective they are in meeting the need of the people concerning geographic barriers, poor transport infrastructures, and inequitable distribution of resources. It also highlights the fact that some examples of the findings were in identifying space that had inadequate coverage, using GIS for optimum site selection for new health facilities to achieve equity and efficiency in health service delivery. The study emphasizes how critical spatial analysis is in health planning to address disparities and improve health outcomes in the population. It also illustrated how GIS might be elected as a useful tool for visualization and knocking on accessibility holes in areas such as Taraba State [29].

2.5.2. Telemedicine

Telemedicine has revolutionized the urban healthcare system by providing remote consultations and diagnostics in unserved and densely populated areas [30]. Examples like Aarogya Setu played a very vital role in India to maintain healthcare services during the COVID-19 pandemic. It is a case study by Basu (2021) [30], covering the ethical and public health aspects of the mandatory application of Aarogya Setu during the time of the COVID-19 pandemic in India. Aarogya Setu, as a contact tracing app, has been used for alerting people using Bluetooth and GPS-based systems concerning the proximity of probable virus exposure and prominent hotspots. Unlike several other democracies, India mandated the adoption of the application for certain cohorts, including employees in large organizations and travelers. Such a requirement has drawn up the debate regarding its ethical implications. Proponents of the app regarded the app as a major breakthrough in the public health campaign to raise efficiency in tracing and saving lives during the national emergency. Opponents, however, questioned the issues of privacy with regard to data taxation and surveillance and even reached unfair conclusions about digitally exclusionary communities. The Aarogya Setu finally concluded that while it might be a tool of justified public health in times of emergency, its design should consist of solid measures for data protection, transparency, and democratic oversight to uphold individual rights. [31].

Telehealth is an overarching term, encompassing a broad spectrum of healthcare services over and above telemedicine, that ranges from preventive care to clinical consultations conducted over distance, to medical education presented online, record management, and healthcare administration. eHealth represents a subset of telehealth comprising all electronic health services delivered on the internet ranging from educational, informational websites through professional healthcare delivery and electronic handling of health information. mHealth, or mobile health, aims at using cellular devices such as smartphones, PDAs, and wireless networks for healthcare provision, incorporating elements such as SMS, GPS, and Bluetooth to extend accessibility and remote monitoring. uHealth, or ubiquitous healthcare, provides real-time tracking of health through wearable or implantable sensors that take vital signs such as heart rate, blood pressure, and chemical levels, enabling early diagnosis and remote treatment by means of smooth wireless communication. Telecare, one of the extensions of telehealth, utilizes information and communication technology (ICT) to enable older and at-risk people to live independently with remote monitoring of health and intelligent home systems. Health Telematics, as a larger grouping, incorporates electronic communication technologies in healthcare for world health promotion, prevention of diseases, distance learning in medicine, and effective healthcare management, augmenting patient care and system performance.

In a telemedicine system, the patient is the source of medical information, which is acquired at the site of examination. Recording vital information like name, age, gender, contact number, and symptoms comes first, followed by further tests like blood work, imaging, ECG, or tissue biopsy if deemed necessary. Telemedicine unifies multiple data types, such as audio, visual, and text information, patient history and symptoms are dictated from speech into written form, biochemical test results are retained in their original format, and medical images from pathology and radiology are examined for diagnosis. The system carries personal and medical records, audio information (heart and lung sounds), still images (X-rays, MRIs, dermatology scans), and video material** (echocardiography and teleconferencing for distant consultations). Through multimedia computing, telemedicine facilitates synchronous communication among patients, doctors, and experts and asynchronous consultation as well. A complete electronic patient record (EPR) is essential for providing easy access to medical information when required.

2.5.3. IoT in Healthcare

Integrating Internet of Things (IoT) technologies and healthcare results a revolutionary change in healthcare systems with markable benefits [32]. Such as, real-time health monitoring, improving chronic disease management and so on. This has greatly improved services such as continual health monitoring, chronic disease, personal health and elderly care, and emergency response. Similar technology assistance m-Health IoT (m-IoT) with smart health connected to e-health: AAL systems are enhanced remotely by a sensor and a network for collection health monitoring. IoT networks can power local and rural healthcare systems, while AI can help detect adverse drug reactions by monitoring drug interactions to prevent harm. Wearable devices allow continuous monitoring of patients and semantic medical access that enhances the organization, sharing and retrieval of all varieties of medical data. In such scenarios, IoT enables the indirect healthcare response for disaster and accident cases. New technologies such as EGC (Embedded Gateway Controller) and ECP (Embedded Cloud Protocol) are used for connecting medical devices with the internet, and are used in conjunction with predictive analytics due to the use of IoT medical devices to improve healthcare.

IoT has a vital application in healthcare as it facilitates real-time tracking and management of multiple health conditions. In prevention of diabetes, IoT-supported blood glucose tracking assists patients in monitoring their blood glucose levels, organizing meals, organizing medication, and avoiding complications. ECG monitoring enables ongoing monitoring of cardiac activity, helping to diagnose arrhythmias, myocardial ischemia, and extended QT intervals, hence minimizing circulatory system-related fatalities. Likewise, blood pressure monitoring supports remote exchange of information between health centers and patients for early identification of cardiovascular conditions. Body temperature monitoring is critical for homeostasis, with IoT sensors in wearable devices able to sense variations and transmit data for prompt medical action. Oxygen saturation monitoring is improved with IoT-enabled pulse oximeters, allowing for constant, non-invasive monitoring of blood oxygen saturation. In rehabilitation, smart rehabilitation systems use IoT to automate therapy and enhance patient recovery, especially for stroke patients and elderly populations. Medication management is yet another vital area where IoT ensures monitoring of prescription timetables, minimizing errors and costs on healthcare systems. IoT-enabled smart wheelchairs provide improved mobility solutions for disabled patients. The integration of IoT with pulse oximeters has revolutionized oxygen saturation monitoring by offering continual, non-intrusive observation of blood oxygen levels. In the realm of rehabilitation, innovative systems equipped with IoT capabilities streamline therapy processes and enhance the recovery of patients, especially those recovering from strokes and the elderly. In the field of medication management, IoT proves invaluable by overseeing prescription timetables, thereby minimizing errors and reducing economic strains on healthcare infrastructures. For individuals with disabilities, smart wheelchairs enhanced with IoT technology provide superior mobility options. Moreover, the Remote Monitoring and Management Platform for Healthcare Information (RMMP-HI) harnesses IoT sensors to gather, preserve, and disseminate patient health information among medical professionals, facilitating prompt interventions, early detection of illnesses, and heightened overall healthcare productivity.

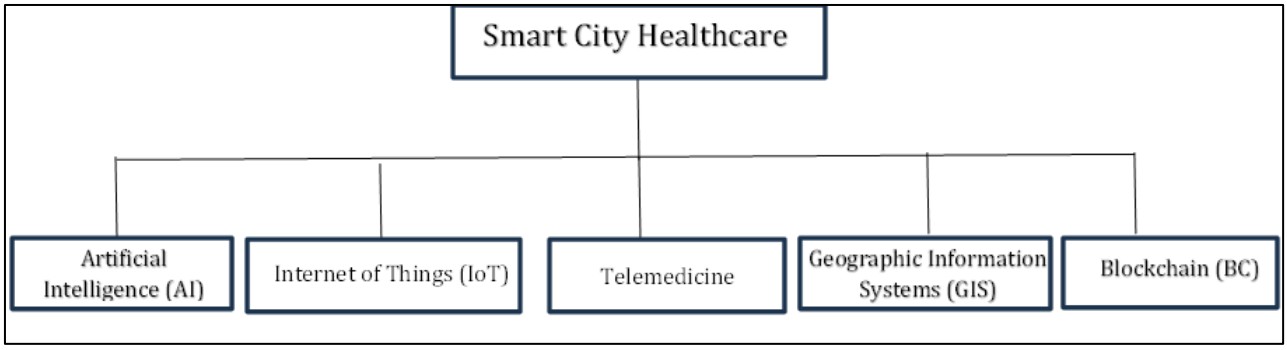

Figure 2 Smart City Healthcare Framework

2.5.4. AI in healthcare

Artificial intelligence (AI) has a transformative impact in healthcare as it integrates various domain which impacts multiple aspects including drug delivery, personalized medicine, diagnosis etc. [33]. Despite this, the healthcare sector has poured hundreds of millions into A.I. technologies and is increasingly adopting them in clinical practice, yet the extent of their impact is hard to gauge because there are so few peer-reviewed evaluations of them. AI is one of those technologies that could improve healthcare outcomes when used with other technologies such as AR, VR, robotics, and IoT. Artificial intelligence is greatly helpful in chronic disease management, through virtual assistants to support medication adherence, diet and activity tracking, risk prediction models, and adaptive interventions.

There's the rise of wearables and mobile health apps, with AI startups raking in $4.3 billion for everything from smart clothing to cancer-detecting wearables. For instance, Just-in-Time Adaptive Interventions (JITAIs) leverage sensor data in real time to deliver tailored treatments — they sense potentially damaging behavior and provide in-the-moment intervention. AI also allows connected devices — for instance, glucometers and smart refrigerators — to improve health monitoring and behavioral management.

2.5.5. Blockchain technology

Blockchain technology has become a vital tool in this era which provides a secure framework for managing digital healthcare records and facilitates transforming healthcare data safely across urban healthcare systems [34].

Blockchain is a decentralized ledger system that stores digital transactions through encryption and algorithms, providing security, transparency, and anonymity. Blockchain enables digital information to be shared without duplication, creating the basis for a safer internet. Operating on a peer-to-peer network, blockchain achieves consensus by periodically verifying transactions and grouping them into timestamped blocks linked with hash pointers. Its tamper-resistant architecture excludes unauthorized changes, rendering it a trustworthy system for data integrity. Initially designed for Bitcoin, blockchain successfully solved the double-spending problem, with digital currency transactions not being able to be replayed without the need for a central authority. The worldwide healthcare market is enormous but extremely inefficient, with the United States alone spending $3.55 trillion in 2017, which is estimated to be more than $5.5 trillion by the year 2025. But 20-30% of such spendings are wasteful because high administrative charges, excessive testing, unneeded treatments, fraud, and prevention opportunities missed occur. Lack of communication among providers translates to $875 billion in services that are a duplication, as over $500 billion is wasted on administration and data protection. In the United Kingdom, the NHS had a £30 billion funding gap by 2020, yet had unused but valuable health data. Blockchain technology would make data sharing more efficient by enabling safe data sharing, faster patient access, lower costs, and increased innovation in medical research. Consent management, though, is problematic since healthcare institutions would need to seek patient consent for data usage time and time again, which would be impractical. Utilizing blockchain-based consent infrastructure would facilitate trust-based, permissioned data sharing with compliance of GDPR and the Declaration of Helsinki, as well as upholding transparency, security, and patient control of their information.

Table 2 Key IT Components in Healthcare

IT components	Integration methods	Functionality	Key benefits	Challenges	Examples
Geographical information system (GIS)	Spatial mapping of healthcare facilities	Identifies underserved areas; optimizes resource allocation	Ensures equitable access to healthcare; aids urban planning	High implementation costs; requires updated datasets	Mapping health access in Africa; WHO GIS-based models
Telemedicine	Video consultations, remote diagnostics	Connects patients and providers remotely	Enhances access for mobility-restricted and rural urban populations	Limited digital literacy; broadband dependency	Teladoc Health; Aarogya Setu (India)
IoT in Healthcare	Wearable devices, smart sensors	Monitors vital signs and environmental factors	Real-time health monitoring; supports preventive care	Data privacy issues; interoperability problems	Fitbit; Smart Hospital sensors
Artificial Intelligence (AI)	Predictive analytics, decision support systems	Analyses data to predict health trends, detect diseases	Early disease detection; data-driven resource allocation	Bias in algorithms; lack of clear regulatory frameworks	IBM Watson Health; AI for TB screening in India
Blockchain	Secure, decentralized databases	Manages patient records; secures transactions	Ensures data integrity and interoperability; enhances trust	Scalability; high energy consumption in some networks	MediLedger (US); Estonia's e-Health System

Big Data Analytics	Aggregation and analysis of health data	Tracks disease patterns; improves operational efficiency	Facilitates informed decision-making; enables epidemic tracking	Data silos; integration across platforms	COVID-19 heatmaps; Google Flu Trends
EHR (Electronic Health Records)	Centralized digital health records	Stores patient data for easier access and sharing	Streamlines workflows; reduces redundancies	Cybersecurity risks; high initial costs	Epic Systems; NHS Digital
Smart Healthcare Facilities	IoT-enabled infrastructure, automation	Optimizes energy use; automates hospital operations	Improves patient experience; reduces operational costs	High implementation costs; technology adoption hurdles	Cleveland Clinic Smart Hospital
Mobile Health Apps	Smartphone-based health management tools	Tracks fitness, medication, and appointments	Empowers patients; improves adherence to treatment plans	Data security; limited reach among non-tech-savvy populations	MyFitnessPal; Medisafe
5G and Connectivity	High-speed internet for real-time healthcare	Enables high-quality video consultations; IoT connectivity	Enhances telemedicine; ensures real-time data transfer	Cost and accessibility barriers in low-income areas	5G-enabled telehealth in South Korea
Digital Twins	Simulated models of urban healthcare systems	Tests infrastructure changes and healthcare delivery	Optimizes urban planning without physical interventions	Data accuracy requirements; complexity in modelling	Smart Nation Singapore's urban health simulation
Cloud Computing	Remote servers for storage and computation	Hosts large-scale health databases	Scalable data storage; cost-effective for large cities	Latency issues; data breaches	AWS Health Data Lakes
Virtual Reality (VR)	Simulated training environments	Trains healthcare providers; improves patient education	Enhances skills; reduces training risks	High development costs; requires specialized equipment	VR surgery simulations at Johns Hopkins
Chatbots and Virtual Assistants	AI-driven communication tools	Provides health advice, triages patients	Reduces workload on healthcare professionals; offers 24/7 assistance	Limited ability to handle complex queries	Babylon Health; Woebot
Digital Health Platforms	Integrated IT ecosystems for healthcare systems	Unifies different IT tools into a single framework	Enhances system efficiency; offers seamless integration of tools and platforms	Complexity in integration; vendor lock-in	Microsoft Cloud for Healthcare

2.6. Urbanization trends and the increasing demand for healthcare services

Rapid urbanization creates a challenge for health care like crowded facilities, unequal access, and insufficient allocation of resources [35]. It includes greater urban population densities' contribution to the rise of non-communicable diseases (NCDs) [36] like diabetes and hypertension, leading to sedentary lifestyles, environmental pollution etc. [37].

Two key trends in Global Urbanization and Healthcare Demand-

- Aging urban population calls for developing infrastructure in long-term care. Research in Urban China has examined the "community elderly care model" to improve service delivery in healthcare [38].
- Rapid urbanization leads to degrading the environment further; air pollution aggravates, and waterborne diseases are common. Innovative health systems in countries like China and India are using IT integration to address these problems [39].

The demand for healthcare services will continue to grow as cities expand, mainly in low-income urban neighborhoods. Contributing factors to this end are trends of aging populations, lifestyle-related diseases, and the proliferation of informal settlements [40]. Urban centers will therefore have to juggle acute care for infectious diseases and provide long-term care for non-communicable diseases like diabetes and hypertension.

Table 3 Global IT Solutions in Healthcare

Country	IT technology	Solution	Purpose	Impact	Examples
India	Mobile Apps, AI	Telemedicine and COVID-19 Management	Remote consultations, contact tracing	Enhanced access to care during COVID-19; mitigated spread	Aarogya Setu app; e-Sanjeevani teleconsultation platform
Singapore	IoT, Data Analytics	Smart Nation Initiative	Real-time monitoring of chronic diseases	Reduced hospital readmissions; improved patient outcomes	Remote health monitoring through wearable devices and apps
Estonia	Blockchain	e-Health System	Secure and interoperable health records	Ensured patient data integrity; simplified data sharing across providers	Blockchain-based patient portals and record-keeping
South Korea	IoT, Automation	Smart Hospitals	Streamlined hospital operations	Optimized resource utilization; reduced patient's wait times	Samsung Medical Centre's IoT-driven hospital management
China	AI, Big Data	AI-Powered Diagnostics	Early disease detection and diagnostics	Faster and accurate medical decisions; predictive health analytics	AI in radiology for COVID-19 detection; Tencent's AI healthcare solutions
United States	Telemedicine, Cloud	Virtual Health Platforms	Remote healthcare access	Improved access for rural and urban populations; reduced patient costs	Teladoc Health; Kaiser Permanente's virtual care solutions
United Kingdom	Electronic Health Records	NHS Digital Transformation	Centralized patient information	Increased efficiency in healthcare delivery; reduced redundancy	NHS Spine system for integrated healthcare services
Japan	Robotics, IoT	Robotic Healthcare Solutions	Assistance for elderly care	Enhanced support for aging populations; reduced burden on caregivers	Paro therapeutic robots; HOSPI automated delivery robots
Australia	Satellite Internet, Cloud	Telehealth for Rural Urban Balance	Healthcare access in remote areas	Improved equity in healthcare; reduced travel for patients	National Telehealth Strategy; My Health Record
Germany	Simulation, Big Data	Digital Twin Technology	Testing healthcare infrastructure changes	Enhanced healthcare planning; resource optimization	Urban health simulations for emergency preparedness
Canada	Cloud, Mobile Apps	Integrated Healthcare Portals	Unified patient data access	Enhanced patient engagement; efficient care coordination	Toronto's Digital Health Portal
Finland	AI	AI for Mental Health	Early detection of mental health issues	Improved mental health intervention outcomes	AI chatbots for depression and anxiety assessment

3. Challenges and limitations in IT-Based Urban Health Care

3.1. Technological barriers

Urban health care faces numerous technological barriers. Firstly, infrastructure gaps hinder it. Many urban cities are still behind the curve in developing and sustaining the art IT infrastructures for facilitating technologies such as telemedicine and IoT-enabled health care. Secondly, it is difficult to interlink diverse healthcare IT systems due to the interoperability problem [41]. Therefore, they fail to share information with ease or work together effectively on health care issues [42].

3.2. Socio-economic barriers

Digital divide remains of the ethical and key challenges for urban healthcare. The usage of IT-enabled services is predominantly a preserve of the wealthy and other economically disadvantaged groups are under served [43]. Socioeconomic inequalities increase the gaps of access to technologies such as wearable health monitors or AI-driven diagnostics. This constraint is most pronounced in informal urban settlements, where access to even basic healthcare is already minimal [44].

3.3. Regulatory and ethical considerations

Data privacy and compliance become significant ethical hurdles in integrating IT into urban health systems, given the vast amounts of sensitive patient information. The blockchains-enabled health records, like all others, also need to be brought in line with the existing regulatory systems. Their inconsistency presents a risk for regional-specific acceptance and implementation of these health care IT solutions in global urban areas [45].

4. Emerging Trends and Future Directions in IT-Driven Urban Healthcare

4.1. Technological Trends

Technological changes in the form of Artificial Intelligence (AI), Machine Learning (ML), and predictive analytics are changing the way how urban healthcare is delivered. AI is increasingly being used in diagnostics, resource allocation, and even disease prediction. For example, predictive models in hospitals have helped improve patient outcomes by early identification of risky cases [46]. Machine Learning algorithms [47] improve urban healthcare delivery through dynamic modelling and personalized care strategies.

4.2. Policy and Governance

Effective policies and governance strategy are essential for the adoption of IT in urban healthcare. Policies that focus on interoperability and public-private partnerships have been successfully used to push IT adoption forward. Policy-driven use of digital twins in urban planning is an example that improves management of healthcare resources [48].

4.3. Sustainability

Green IT and energy solutions [49] must be a part of health-related services in sustainable urban practices. Renewable energy sources should enable the use of IoT technology with smart hospitals to reduce carbon prints further. Sustainable data centers do not have a sizeable carbon footprint while maintaining adequate levels of efficiency [50].

5. Conclusion

It examines explores the inter connection between urban development and its relationship with Information Technology in health care systems. Tracing history, it starts from public health infrastructure in cities to modern smart cities-the evolution of urban health-care. This would include a trend analysis of urbanization with the demand for health-care services. The paper shows how these trends increase with the increase in population, aging populations, socio-economic gaps, and more, leaving the already crowded situation needing even more innovative solutions.

IT in this regard becomes a transforming tool, wherein it includes technologies like GIS, telemedicine, IoT, and even blockchain, for which health care becomes more accessible, efficient, and equitable. Case studies of countries like Singapore, India, and Estonia, among many others testify to the ICT-powered interventions in urban healthcare around the world. This paper touches on the limited number of variables such as technological discrepancies, socioeconomic

differences, and ethical issues regarding confidentiality and compliance with laws. This portrays how sterile the process becomes when someone wants to incorporate IT in cities.

Ultimately, these review outlines future direction by focusing on sustainable urban planning, equitable access to technology and data, as well as interdisciplinary collaboration that will foster resilient healthcare systems. This way, urban healthcare will meet the demands of increasing population while utilizing technology for a healthier future.

References

[1] Michalina, D., Mederly, P., Diefenbacher, H., & Held, B. (2021). Sustainable urban development: A review of urban sustainability indicator frameworks. Sustainability 13/16: 9348.

[2] Newman, P., Matan, A., & McIntosh, J. (2015). Urban transport and sustainable development. In Routledge International Handbook of Sustainable Development (pp. 337-350). Routledge.

[3] Ahvenniemi, H., Huovila, A., Pinto-Seppä, I., & Airaksinen, M. (2017). What are the differences between sustainable and smart cities?. Cities, 60, 234-245.

[4] Verma, P., & Raghubanshi, A. S. (2018). Urban sustainability indicators: Challenges and opportunities. Ecological indicators, 93, 282-291.sss

[5] United Nations. (2004). World urbanization prospects: the 2003 revision. UN.

[6] Azalekor, M. S. (2024). A Systematic Review of Digital Health Interventions in Ghana (Doctoral dissertation, Ensign Global College).

[7] Sharma, A., Surjan, A., & Shaw, R. (2011). Overview of urban development and associated risks. In Climate and disaster resilience in cities (Vol. 6, pp. 1-16). Emerald Group Publishing Limited.

[8] ong, Y., Tan, C. H., Sia, C. L., Shi, Y., & Teo, H. H. (2022). RURAL-URBAN HEALTHCARE ACCESS INEQUALITY CHALLENGE: TRANSFORMATIVE ROLES OF INFORMATION TECHNOLOGY. MIS Quarterly, 46(4).

[9] Reza, S., Marjan, G. S., & Maryam, Z. (2012). Information Technology (IT): A New Revolution In Urban Health Development. Payavard Salamat, 6(3).

[10] Day, J. N. (2016). Health care and urban revitalization: a historical overview. Journal of Urban History, 42(2), 247-258.

[11] Tonne, C., Adair, L., Adlakha, D., Anguelovski, I., Belesova, K., Berger, M., ... & Adli, M. (2021). Defining pathways to healthy sustainable urban development. Environment international, 146, 106236.

[12] Gareis, S. B. (2012). The united nations. Bloomsbury Publishing.

[13] Ritchie, H., Samborska, V., & Roser, M. (2024). Urbanization. Our world in data.

[14] World Health Organization. (2000). The World Health Report 2000: Health systems: improving performance.

[15] Sivaramakrishnan, L., & Dahiya, B. (2024). Urban health in the 21st century: Challenges and opportunities. Developments in Environmental Science, 15, 3-16.

[16] Gokhale, P., Bhat, O., & Bhat, S. (2018). Introduction to IOT. International Advanced Research Journal in Science, Engineering and Technology, 5(1), 41-44.

[17] AlDairi, A. (2017). Cyber security attacks on smart cities and associated mobile technologies. Procedia computer science, 109, 1086-1091.

[18] Lazaroiu, G. C., & Roscia, M. (2012). Definition methodology for the smart cities model. Energy, 47(1), 326-332.

[19] Vanolo, A. (2014). Smartmentality: The smart city as disciplinary strategy. Urban studies, 51(5), 883-898.

[20] Giffinger, R., & Gudrun, H. (2010). Smart cities ranking: an effective instrument for the positioning of the cities?. ACE: architecture, city and environment, 4(12), 7-26.

[21] Pacheco Rocha, N., Dias, A., Santinha, G., Rodrigues, M., Queirós, A., & Rodrigues, C. (2019). Smart cities and healthcare: A systematic review. Technologies, 7(3), 58.

[22] Bates, D. W. (2002). The quality case for information technology in healthcare. BMC medical informatics and decision making, 2, 1-9.

[23] Feldman, S. S., Buchalter, S., & Hayes, L. W. (2018). Health information technology in healthcare quality and patient safety: literature review. JMIR medical informatics, 6(2), e10264.

[24] Atkinson, S., Ingham, J., Cheshire, M., & Went, S. (2010). Defining quality and quality improvement. Clinical Medicine, 10(6), 537-539.

[25] Britain, G. (2005). Creating a patient-led NHS: delivering the NHS improvement plan. Department of Health.

[26] Boorman, S. (2009). NHS Health and Well-being. Department of Health.

[27] Luxon, L. (2015). Infrastructure–the key to healthcare improvement. Future Healthcare Journal, 2(1), 4-7.

[28] Mondal, S., Parveen, M. T., Alam, A., Rukhsana, Islam, N., Calka, B., ... & Zhran, M. (2024). Future Site Suitability for Urban Waste Management in English Bazar and Old Malda Municipalities, West Bengal: A Geospatial and Machine Learning Approach. ISPRS International Journal of Geo-Information, 13(11), 388.

[29] HASSAN, M. A. (2024). GIS-BASED MAPPING OF HEALTH INFRASTRUCTURE AND ACCESS TO HEALTHCARE SERVICES IN TARABA STATE, NIGERIA. Journal of Advanced Science and Optimization Research.

[30] Azar, R., Chan, R., Sarkisian, M., Burns, R. D., Marcin, J. P., Gotthardt, C., ... & Haynes, S. C. (2024). Adapting telehealth to address health equity: Perspectives of primary care providers across the United States. Journal of Telemedicine and Telecare, 1357633X241238780.

[31] Basu, S. (2021). Effective contact tracing for COVID-19 using mobile phones: an ethical analysis of the mandatory use of the Aarogya Setu application in India. Cambridge Quarterly of Healthcare Ethics, 30(2), 262-271.

[32] Li, C., Wang, J., Wang, S., & Zhang, Y. (2024). A review of IoT applications in healthcare. Neurocomputing, 565, 127017.

[33] Zeb, S., Nizamullah, F. N. U., Abbasi, N., & Fahad, M. (2024). AI in Healthcare: Revolutionizing Diagnosis and Therapy. International Journal of Multidisciplinary Sciences and Arts, 3(3), 118-128.

[34] Tariq, M. U. (2024). Revolutionizing health data management with blockchain technology: Enhancing security and efficiency in a digital era. In Emerging Technologies for Health Literacy and Medical Practice (pp. 153-175). IGI Global.

[35] Liao, Z., Shi, X., Liao, Y., & Zhang, Z. (2024). Source identification of water distribution system contamination based on simulated annealing–particle swarm optimization algorithm. Environmental Monitoring and Assessment, 196(12), 1216.

[36] Budreviciute, A., Damiati, S., Sabir, D. K., Onder, K., Schuller-Goetzburg, P., Plakys, G., ... & Kodzius, R. (2020). Management and prevention strategies for non-communicable diseases (NCDs) and their risk factors. Frontiers in public health, 8, 574111.

[37] Zhang, Y., Xi, C., Zhang, R., & Yu, C. W. (2024). GIS technology for sustainable urban water system. Indoor and Built Environment, 1420326X241299668.

[38] Yang, Y., Li, C., & Zhou, D. (2024). Study on the Characteristics of Community Elderly Care Service Facilities Usage and Optimization Design Based on Life Cycle Theory. Buildings, 14(9), 3003.

[39] Zhong, B., Wu, S., Wu, N., Sun, G., He, C., Liu, L., & Chen, H. (2024). Constructing ecological security pattern based on spatio-temporal evaluation of ecosystem services and ecological health in Chengdu, Southwest China. Frontiers in Environmental Science, 12, 1415301.

[40] Satterthwaite, D. (2013). The political underpinnings of cities' accumulated resilience to climate change. Environment and Urbanization, 25(2), 381-391.

[41] Adejare, J. A., Jelili, M. O., & Muili, A. B. (2024). Socioeconomic Status and Healthcare Facilities Patronage among Residents in Urban Slums and Informal Settlements in Ibadan Metropolis. Lagos State University of Science and Technology (LASUSTECH) Journal of Management and Social Sciences (LAJMSS), 1(1), 1-17.

[42] Imash, A., Smagulova, G., Kaidar, B., Keneshbekova, A., Kazhdanbekov, R., Velasco, L. F., & Mansurov, Z. (2024). Chemoresistive Gas Sensors Based on Electrospun 1D Nanostructures: Synergizing Morphology and Performance Optimization. Sensors, 24(21), 6797.

[43] Rasanathan, K. (2024). How can health systems under stress achieve universal health coverage and health equity?. International Journal for Equity in Health, 23(1), 1-3.

[44] Haynes, J. A. (2024). Enhancing Crisis Response in Rural Communities: A Novel Co-Responder Program (Doctoral dissertation, Capella University).

[45] Lévy, J. C., & Fernandez, D. B. (2024). The superego of the city: Integrating psychoanalytic theory with sustainable urbanization in the age of industry 4.0. Management Research Quarterly, 1(3), 4-11.

[46] Sato, S. (2024). The Recent Demographic and Economic Trends in India, Pakistan, and Bangladesh: A Comparative Analysis. Authorea Preprints.

[47] Mahesh, B. (2020). Machine learning algorithms-a review. International Journal of Science and Research (IJSR).[Internet], 9(1), 381-386.

[48] Pandey, P. K., Pandey, P. K., Mahajan, S., Paul, J., & Iyer, S. (2025). Digital Twin and Virtual Reality, Augmented Reality, and Mixed Reality. In Digital Twins for Smart Cities and Villages (pp. 273-293). Elsevier.

[49] Liu, X., & Ansari, N. (2019). Toward green IoT: Energy solutions and key challenges. IEEE Communications Magazine, 57(3), 104-110.

[50] Kumar, K., Kaur, R., & Rani, V. (2025). Different Methodologies for Smart City and Urbanization System. In 5G Enabled Technology for Smart City and Urbanization System (pp. 36-55). Chapman and Hall/CRC.