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INFORMATION TECHNOLOGY PLATFORM FOR MONITORING INFECTIOUS DISEASES

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Summary. *Research conducted to curb the spread of infectious diseases in cities confirms that technology is making a significant contribution. A significant number of scientific studies analyze the impact of technology on the covid-19 pandemic in various aspects. However, the problems associated with the implementation of monitoring systems based on the Internet of Things are not studied in depth, they are related to the design of systems, their implementation in everyday life. This research provides an up-to-date analysis of how technology is helping to fight infectious diseases. Along with this, we consider the main challenges faced by users of such technologies, namely: privacy, security, scalability, etc. As a result, we can say that related technologies have a significant impact on the detection, tracking and containment of viruses. The organization and movement of a person has a great influence on the frequency of contacts, which, as a result, affects the transmission, spread and persistence of disease-causing pathogens. The search for contact structures of infectious diseases in view of human mobility requires a clear consideration of the spatial and temporal dimensions of pathogen transmission, which depend on the type of pathogen and the method of its transmission, the number of contacts and location. A platform that can help collect and analyze data mainly depends on having access to accurate details about various factors. Therefore, obtaining information is of prime importance for the development of this kind of technological platform.*

Using advanced technologies and tools such as IoT, remote monitoring devices, GPS, artificial intelligence and data analytics, contact tracing programs can provide an extra layer of protection when it comes to monitoring and controlling people's lives and health. The proposed approach to ensure the effective implementation of the IT platform for monitoring infectious diseases, as well as the formed group of roles. This approach makes it easier to launch the platform, distributing work between assigned roles and reducing the burden on health care resources and other city services.

Key words: *internet of things, information technology platform, remote monitoring devices, artificial intelligence, data analytics, contact tracing, viral diseases.*

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Statement of the problem. In the era of development and application of technology in cities, contact tracing and location of infectious patients are becoming increasingly important. This is especially true in densely populated cities, where the risk of infectious disease outbreaks is higher. With the help of IoT devices, contact tracing and location technology, cities can quickly and accurately track and detect outbreaks, thus enabling them to respond more quickly and effectively.

Contact tracing includes identifying people who have been in close contact with an infectious patient and providing them with information on how to protect themselves from infection. Contact tracing also helps health authorities determine the places the patient has visited.

In urban areas, contact tracing and geolocation can be done using various technologies such as GPS, Bluetooth, and Wi-Fi networks. These technologies allow health authorities to quickly identify those who have been in contact with an infectious patient so that they can take the necessary precautions to prevent the further spread of the disease.

In particular, the capabilities of the Internet of Things (IoT) are crucial in the fight against infectious diseases. The data collected from IoT devices can be used to create predictive

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models that can identify areas at high risk of infection. This data can be used to develop public health policy, helping cities create better strategies for preventing and controlling infectious diseases.

To effectively control the spread of an infectious disease, it is important to have an information technology platform that allows for monitoring, contact tracing and location tracing. This platform can be used to identify people who have been in contact with an infected person and track their movements. It also allows healthcare professionals to track the course of the disease by observing its spread among the population. The creation of such an information technology platform requires careful planning and coordination among various stakeholders, including healthcare professionals, government institutions, and technology suppliers. At the same time, using advanced technologies, such as contact tracing apps and AI-powered location services, will ultimately help to restrain the spread of infectious diseases.

In this investigation we will study will analyze the existing strategies for preventing the spread of coronavirus infection in cities, as well as the possible new measures based on modern technologies, and propose a model of an information technology platform.

Analysis of available research. The number of people affected by infections in cities is growing annually, so there is a need for an organised platform for prevention and fighting such diseases [1]. In this context, a key challenge is to explain and prevent the spread of infections such as the coronavirus and to enable doctors to provide appropriate treatment to their patients. Let's analyse the research on the impact of technology in the fight against infectious diseases. For an effective analysis, we divide the research in relations to technologies related to this topic.

Internet of Things. The Internet of Things (IoT) is a network of interconnected physical objects with built-in sensors, software and algorithms that constantly receive and collect data from the outside world [2]. The collected data are processed to obtain the information necessary to perform certain actions. The IoT is a scalable and automated solution [3]. IoT has changed our perception of technology and its potential use. Taking into account challenges faced by cities such as infectious diseases, it is important to understand how IoT can be used to fight the virus.

Due to the covid-19 pandemic the world has experienced significant changes in everyday life, politics, and the economy and faces serious challenges in fighting future infectious disease outbreaks [4–5]. Let's consider the latest research conducted using IoT along with other innovative technologies. IoT has already been deployed to monitor social distancing [6] and quarantine patients, track the virus, clean up infected areas [7], and provide contactless treatment in healthcare [8–10].

The important role played by IoT in the fight against infectious diseases, including covid-19, can be summarised as follows:

- Timely and effective diagnostics, data collection on infected patients.
- Detection and control of the spread of infection.
- Locating the infected and quarantine measures.
- Contact tracing of infected patients.
- Support for healthcare professionals and medical staff.
- Provision of medical equipment, medicines, food and other necessary items.
- Remote monitoring of patients.

According to the WHO, crowd control and social distancing are the two goals of the healthcare system in the face of infectious disease challenges [11].

Both external and internal monitoring is needed to assess the spread of the virus. In most cases, infected people have a history of movement. Therefore, it is very important to monitor the location of people and check their health status in a timely manner. Smartphone applications can easily trace the location of individuals, for example, those registered using the Global Positioning System (GPS) [12].

A study by the Massachusetts Institute of Technology (MIT) on contact tracing of infected patients showed that overlaying the IoT mobile data with geographic information systems (GIS) allows epidemiologists to identify people who have been in contact with the infected patients [13].

Given the rapid development of IoT in the healthcare sector, it is worth reconsidering all aspects of security. Over the past decade, many IoT-based healthcare applications have witnessed major developments [14]. Researchers are working on a reference model for IoT implementation. In [15], a standard framework for the development of IoT applications for healthcare is proposed. It is guided by three main perspectives: Cloud-centric IoT, Network-centric IoT, and Data-centric IoT.

Remote monitoring devices. Remote monitoring devices, such as wearable devices, IoT sensors and mobile apps, can help a healthcare provider remotely monitor a patient's health status. These devices can monitor vital signs, respiratory rate, and oxygen levels, enabling healthcare professionals to detect early signs of deterioration.

Networked sensors embedded in the body or wearable devices can collect data on physical and mental health. Particularly, the availability of information, combined with a new generation of intelligent processing algorithms, can accelerate progress in the medical field, from current post-facto diagnosis and treatment to an early stage of a proactive disease prediction paradigm combined with prevention and treatment.

In recent years, the number of wearable devices has increased, and there are many personal health and fitness devices on the market today. Healthcare professionals have studied the use of such devices for continuous monitoring, management and medical access to patient physiological information in remote health monitoring systems [16–17].

Given the available technological developments, we can predict the possibility of continuous physiological monitoring using inexpensive wearable sensors, preceding an inpatient medical examination. Throughout the entire period of wearing the devices, their sensors will constantly record signals related to the physiological parameters of the wearer and transfer the data to a database linked to medical records. In this case, the doctor not only has the usual hospital observations based on laboratory tests, but also a more comprehensive, dynamic record of the state of physiological indicators. This makes it possible to diagnose the patient much better and recommend early treatment. This revolutionary technology could have a groundbreaking impact on global healthcare systems, reducing healthcare costs and improving the speed and accuracy of diagnostics. For example, a research [18] focuses on the relation between the level of adoption of wearable technology among doctors and users. The findings show that 60% of medical professionals agree to use such devices. However, 51% of non-medical staff agree to the use these devices for medical purposes, which is still a low figure.

Thus, remote monitoring devices on an information technology platform provide overall patient care and can include two key functions:

a) patient location and tracking: accurate information on the location of patients is useful as it allows for timely response to urgent care.

b) patient's health monitoring: the doctor or medical staff should have the current state of critical or normal indicators constantly available to them. Depending on the type of pathology, there is a need to monitor the patient's health status (movement, heartbeat, pulse, respiration, temperature, etc.), and automatically detect abnormal changes in these parameters [19].

Most of the proposed remote healthcare and monitoring projects use an architecture of the following layers [20]:

- Sensor layer:

The sensor or sensing layer consists of sensors that collect data about people's health status. These sensors can be wearable devices such as smartwatches or fitness bracelets, i.e. a wireless body area network (WBAN) that monitors vital signs.

- Layer of data collection:

The data collected from the sensors is sent to the data collection layer, which is responsible for storing and processing the data. The layer of data collection can consist of peripherals, microcontrollers that can perform pre-processing tasks, such as aggregation, filtering and compression, before sending the data to the cloud.

- Communication layer:

The communication layer connects the sensors and data collection layer to the cloud. This layer can use different communication protocols: Wi-Fi, Bluetooth or LoRaWAN, depending on the specific requirements of the system.

The platform operates in the cloud. It receives data from the data collection layer, performs advanced analytics and machine learning algorithms to draw information from the data, and provides real-time alerts and notifications to relevant stakeholders such as doctors, caregivers, and family members. The cloud platform can also host applications, dashboards and APIs that allow users to interact with the system.

Security and privacy are critical components of a cloud platform. The platform must ensure that the data collected is encrypted and securely stored. It must also provide strict access controls to ensure that only authorised personnel can access the data. In addition, the system must comply with relevant regulations such as HIPAA, GDPR, and CCPA to protect the privacy.

By using remote monitoring devices, information technology platforms can allow cities to provide personalised healthcare services to citizens, prevent the spread of viral diseases and reduce the burden on healthcare.

GPS technology. With the help of the Global Positioning System (GPS), the location of the device user is updated in real time. GPS technology has the potential to provide accurate location data for contact tracing and geolocation of a patient with an infectious disease.

Limiting contact between healthy and sick patients is a key measure to reduce the spread of a viral disease. Quarantine is usually the solution, and any tracking system can be used to determine the location of infected people.

People who have travelled from areas with a high risk of infection and have had physical contact with infected people are isolated and placed in quarantine zones for 10–14 days. In many countries, mandatory quarantine orders are issued for those coming from abroad. Effective tracking of the infected is a challenge. One successful solution is to provide periodic data on the location of infected people. Such reports can be provided daily or instantly [21–22].

The development of technologies such as mobile phones, GPS-enabled devices, wireless local area networks, and personal digital assistants has provided quantitative evidence that human behaviour in space is recursive and dominated by highly reproducible scaling laws [23–24]. People tend to visit several places where they spend most of their time, and the availability of alternative means of transport and movement facilitates their movement across multiple spatial and temporal scales [25].

Mobile phone data is the most widely used technology for recording and describing human mobility in cities. By combining GPS and GPRS, a real-time tracking system analyses data received from a GPS device, making it possible to track a person's location at any given date and time. Information about distance violations, etc. is constantly sent to the relevant services for real-time action.

Artificial intelligence and data analytics. Artificial intelligence (AI) and data analytics play a key role in the fight against viral diseases, such as covid-19. These technologies help healthcare professionals predict the spread of the virus, analyse patient data, and plan treatment. For example, AI algorithms can help analyse X-rays and CT scans to detect pneumonia caused by covid-19.

The combination of artificial intelligence (AI) and geographic information systems (GIS) creates GeoAI. The role of GeoAI in health and healthcare, as location is an integral part of monitoring systems.

Artificial intelligence, such as machine learning techniques, is increasingly being used in the healthcare, especially with the advent of high-performance and cloud computing capabilities [26–27]. «Health intelligence» refers to the specific application of AI methods and instruments and scientific data to provide accurate, efficient, and leading insights into healthcare and medicine [28]. Such applications include social media analysis for surveillance [29], modelling to identify high risk of disease [30], telemedicine [31], and others.

To sum up, technology can help to monitor patients at high risk of infection and provide useful data for healthcare professionals to take appropriate action. In this regard, contact tracing apps can be very useful in identifying who is in close proximity to a confirmed case of infection.

Contact tracing software. Contact tracing apps use Bluetooth or GPS technology to track person-to-person distances and identify potential exposure to infectious diseases. These apps can quickly identify people who may have been exposed to a virus and alert them to get tested or self-isolate. We can analyse the characteristics of mobile applications that have been used to control and counteract the covid-19 infection as presented in Table 1.

Table 1

Mobile applications that were used to control and counter the COVID-19 coronavirus infection

Country	*App name*	*Platform*	*Architecture framework*	*Wireless technology*	*App providers*
1	*2*	*3*	*4*	*5*	*6*
Austria	Stopp Corona	Android 6+ iOS	Open-source Google/Apple	BLE	Government structures Public organizations Private companies
Bulgaria	ViruSafe	Android iOS	Closed-source	GPS	Private companies
Croatia	Stop covid-19	Android iOS	Open-source Google/Apple	BLE	Government structures
Cyprus	CovTracer	Android iOS	Closed-source	GPS, IP, GSM, Bluetooth	Private companies
Czech Republic	eRouska	Android iOS	Closed-source	BLE	Government structures
Denmark	Smittestop	Android iOS	Open-source Google/Apple	BLE	Government structures Private companies
Estonia	Hoia	Android iOS	Open-source Google/Apple	BLE	Government structures Public organizations

End of the table

1	3	3	4	5	6
Finland	Koronavilkku	Android iOS	Open-source Google/Apple	BLE	Government structures Public organizations Private companies
France	StopCovid	Android iOS	Closed-source ROBERT	BLE, ultrasounds	Government structures Private companies
Germany	Corona-Warn-App	Android iOS	Open-source Google/Apple	BLE	Government structures Private companies
Hungary	VirusRadar	Android iOS	Closed-source	BLE	Private companies
Ireland	covid Tracker	Android iOS	Open-source Google/Apple	BLE	Government structures Private companies
Italy	Immuni	Android iOS	Open-source Google/Apple	BLE	Government structures Private companies
Latvia	Apturi Covid	Android iOS	Open-source Google/Apple	BLE	Government structures Private companies
Netherlands	CoronaMelder	Android iOS	Open-source Google/Apple	BLE	Government structures Private companies
Norway	Smittestopp	Android iOS	Closed-source	Bluetooth, GPS	Government structures Private companies
Poland	ProteGO	Android iOS	Open-source Google/Apple	Bluetooth	Government structures Private companies
Portugal	StayAway covid	Android iOS	Open-source Google/Apple	BLE	Government structures Private companies
Slovakia	ZostanZdravy	Android iOS	Closed-source	BLE, GPS	Public organizations Private companies
Slovenia	OstaniZdrav	Android iOS	Open-source Google/Apple	BLE	Government structures
Spain	RadarCOVID	Android iOS	Open-source Google/Apple	BLE	Government structures
Switzerland	SwissCovid	Android iOS	Open-source Google/Apple	BLE	Government structures

Mobile apps have become an important tool in the fight against viral infections. They allow people to easily access information on symptoms, treatment and prevention measures. They can also track their health status and receive timely reminders to take medications or get vaccinated. Besides, mobile apps can be used to alert relevant services to potential outbreaks and help them respond quickly. This is especially important in regions where access to medical care is limited or not available.

Presentation of the material. The spread of the coronavirus pandemic has posed a serious threat to cities around the world. It is important for cities to take measures to prevent the spread of infectious diseases and protect their citizens. For this purpose, they should implement various strategies, such as social distancing, contact tracing, and the use of technologies discussed in the analysis of the research.

It should be noted that in urban areas, contact tracing and the location of infectious patients are becoming increasingly important. With the help of advanced technologies such as

AI and IoT, it is now possible to develop a contact tracing system that can accurately track the movements of infected individuals.

People regularly perform activities that vary in relative frequency and duration, as well as geographic location, and their spatial behavior influences changes in social, economic, and security contexts [32].

Early mathematical models of infectious diseases assumed that people have equal chances of transmitting and being exposed to disease agents (i.e. homogeneous mixing), ignoring stochastic variations in transmission potential or heterogeneity of contact samples. Empirical evidence shows that contact rates are indeed highly variable [33], partially due to the complexity and dynamism of human social relationships [34].

Thus, individual social structure and movement patterns play a significant role in modulating contact rates, which affect the transmission, spread and persistence of pathogens. The search for contact patterns of infectious diseases in relation to human mobility requires a clear consideration of the spatial and temporal dimensions of pathogen transmission, which depend on the type of pathogen and its mode of transmission, number of contacts, and location. Acquiring detailed information on such factors is of great interest for the development of an information technology platform with multiple data collection and analysis factors.

In order to ensure full control over monitoring, contact identification, and patient location, it was determined that it is expedient to propose a model of an information technology platform for monitoring, contact tracing, and patient location. Fig. 1 shows the set of players of the information тут потрібно додати назву платформи technology platform.

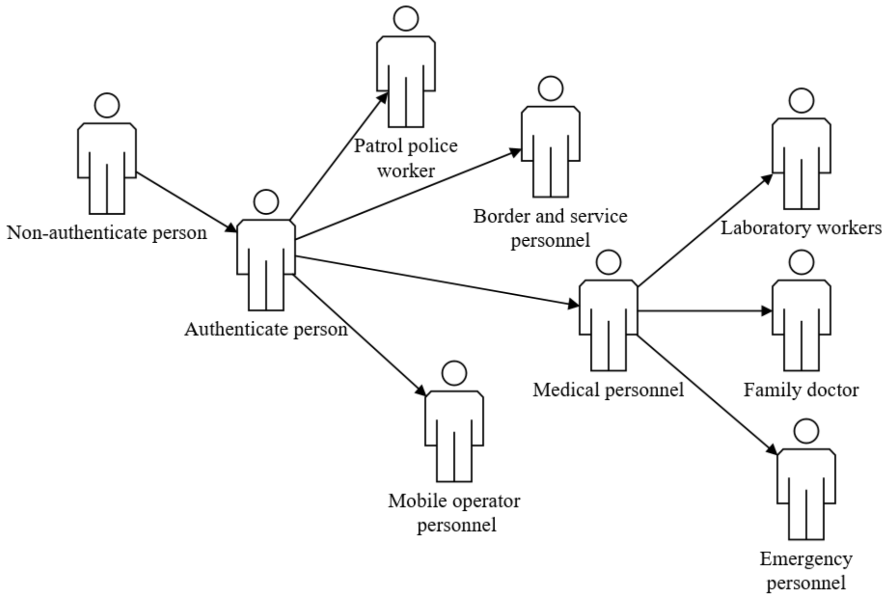

Figure 1. Roles in the information technology platform for monitoring infection diseases

Let us consider and describe the roles of the participants in the system:

● Person (healthy person, suspected infected person, infected person and healthy person after treatment).

● Doctor and laboratory staff (emergency doctor, inpatient doctor, mobile teams).

● Family doctor.

- Patrol police officers.
- Employees of the Border Guard and Customs Service.
- Mobile phone operators.

Each participant is important for the functioning of this system, as each participates in the process of the strategy to fight the spread of infectious diseases.

Let's consider the scenario model for the «Person» role in Fig. 2.

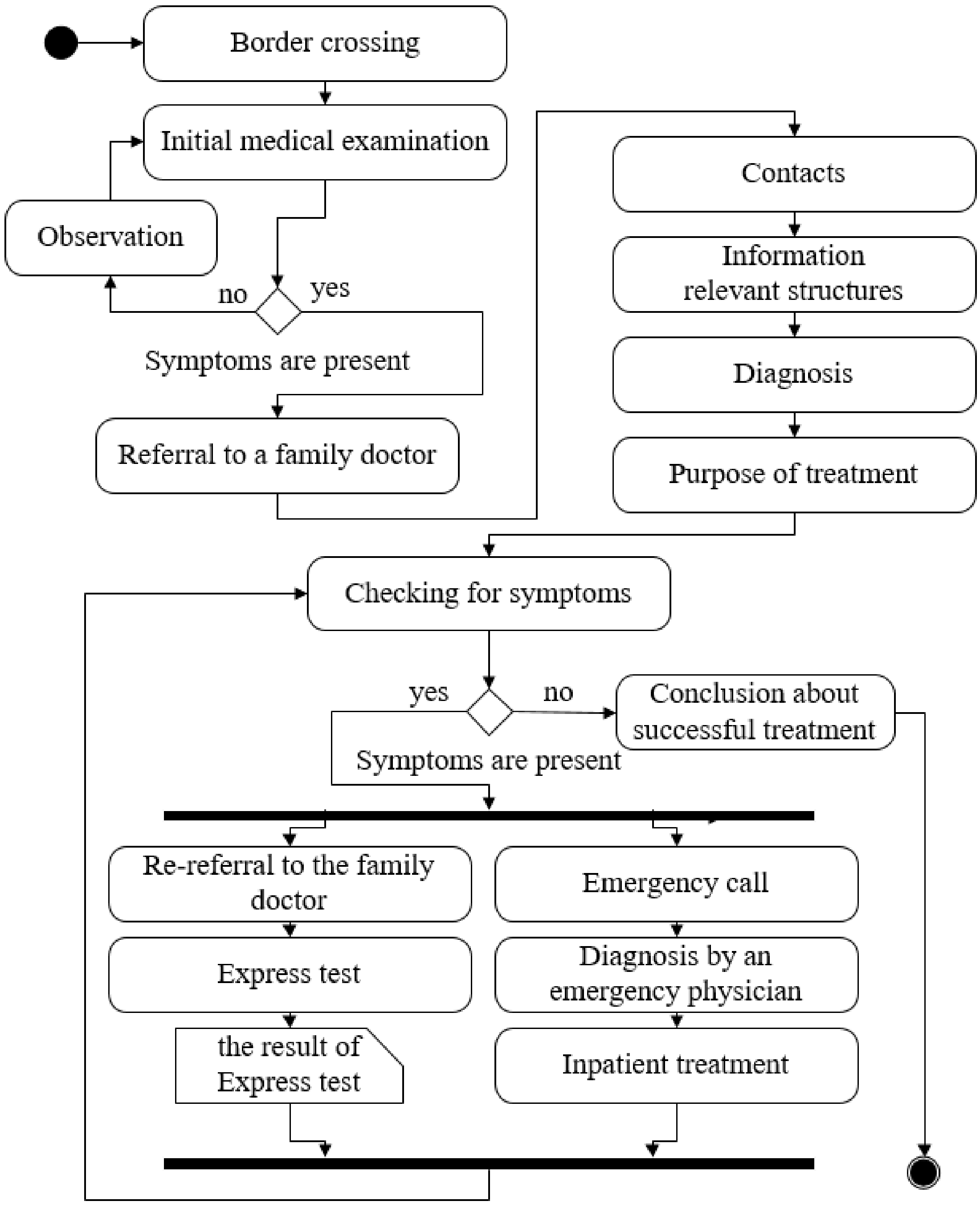

Figure 2. Scenario model for the «Person» role

Contact tracing and location technology is essential for protecting the public from potentially dangerous infectious diseases. This platform can identify individuals who have been in contact with an infected person and warn them of any potential danger.

By taking advantage of the information technology platform, we can identify and deter infectious individuals more effectively and quickly apply effective countermeasures. This will enable us to assess the location of individuals and help us to control potential outbreaks more quickly.

When crossing the border, if a person is suspected of having a disease, they must undergo a special test to determine whether they have an infection and/or stay two weeks in quarantine. This is an established procedure that must be followed.

If the test result is negative, there are no symptoms and the observation period is over, people can return to their daily lives. It is very important to stay at home if you have a positive test result and any potential signs of infection. In addition, you should contact your doctor by phone or, if necessary, request a home visit from a mobile team of specialists.

All these measures are necessary to avoid infection.In order to stay safe and healthy during the coronavirus pandemic, it is recommended to follow all the suggested precautions. In addition, medical experts should analyse the virus for optimal actions and solutions.

Fig. 3 a) shows a model of scenarios for a member of the «Doctor» system.

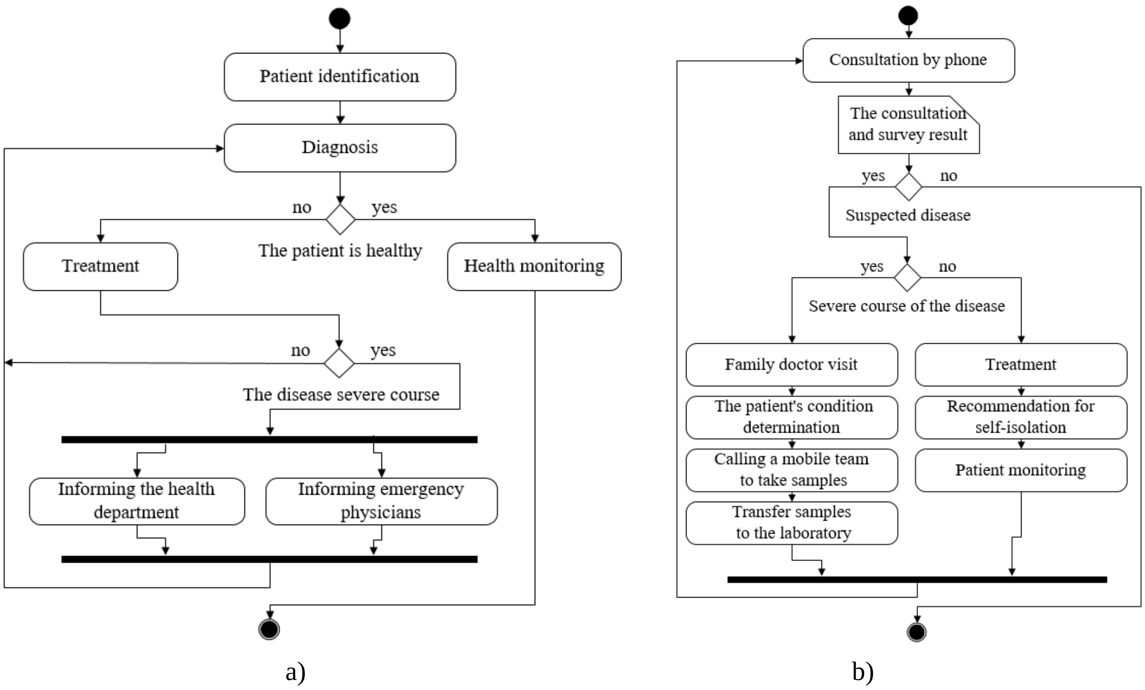

Figure 3. a) Scenario model for the role «Doctor» b) Scenario model for the role «Family doctor»

After consulting the patient, the family doctor assesses the situation and prescribes certain steps. As can be seen in Figure 3 b), this demonstrates the precedent model for the role of «Family Doctor».

If a patient has a family doctor, they should be informed of the situation. If they do not, a mobile team should be dispatched to perform a PCR test on the patient. Figure 4 a) shows a model that should be followed by border and customs personnel.

At all Ukrainian checkpoints, border guards meet people who cross the border. They also have a sanitary control post that checks each person and tests them for covid-19 cases. The guards have to make sure that everyone crosses the border legally and also help contain the virus in quarantine.

Thus, it is vital for them to be vigilant and take all necessary precautions to protect themselves from infection, as well as to ensure the safe passage of people to and within the Ukrainian borders.

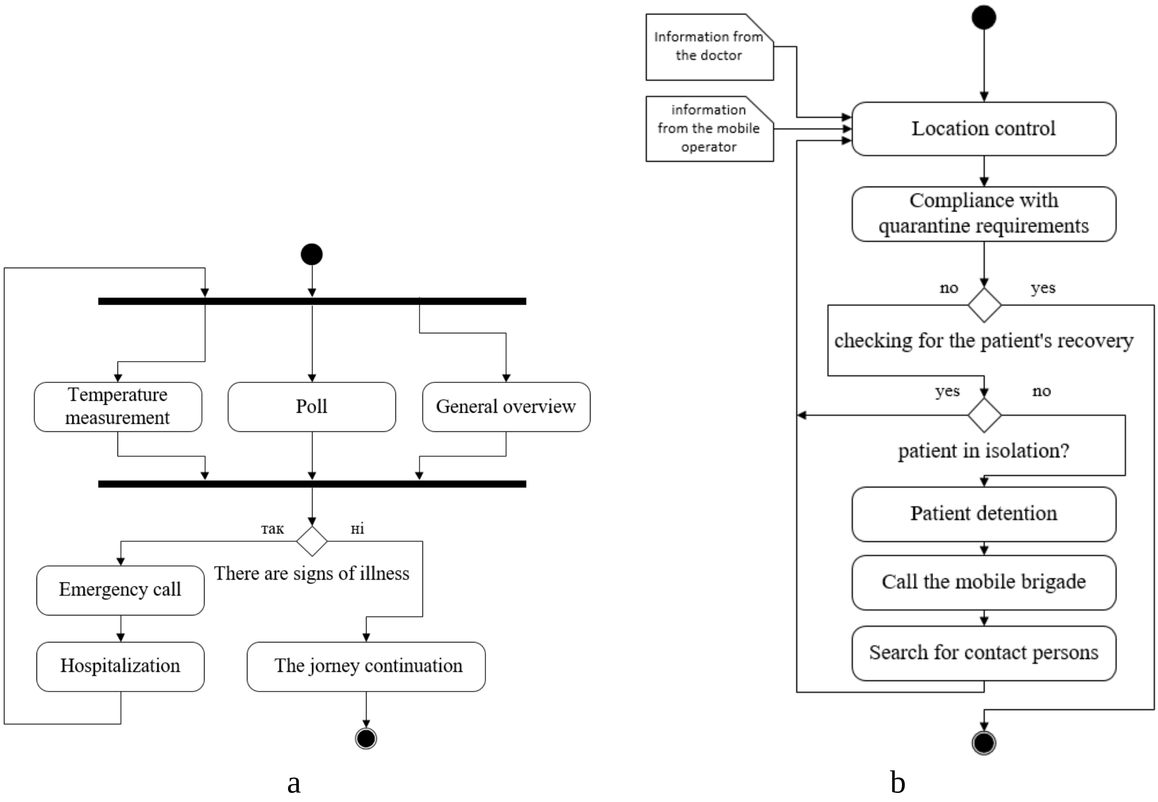

Figure 4. a) Scenario model for the role «Border and Customs Service», b) Scenario model for the role «Patrol Police»

Border guards conduct general checks and interviews the people to understand their condition and information about the countries they have returned from. Law enforcement officers monitor observation centres and medical facilities where covid-19 patients or those suspected of having the disease are staying.

Consider the scenario model for the role of the «Patrol police» shown in Figure 4 b) and the scenario model for the role of the «Mobile operator» shown in Figure 5.

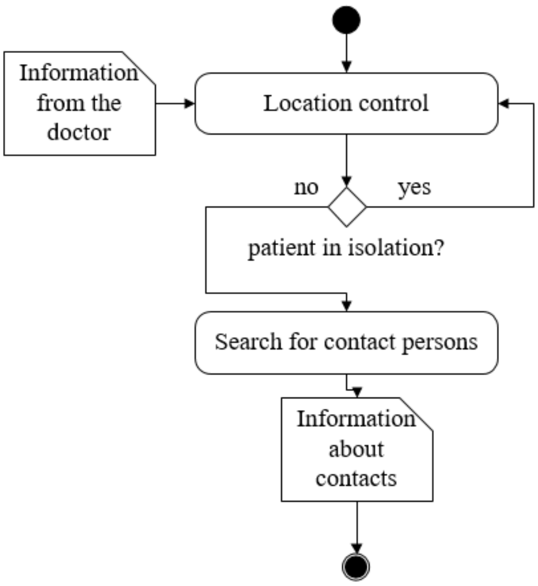

Figure 5. Scenario model for the role «Mobile operator»

If an infection is suspected, the police can request mobile operators to provide the coordinates of a person's current location to better monitor their movements. This system contributes to public safety and protection against disease.

Conclusion. The analysis of the study on fighting the spread of infectious diseases in cities using technologies confirms their relevance and practical application. The use of technologies and instruments such as the Internet of Things, remote monitoring devices, GPS, artificial intelligence and data analytics, and contact tracing applications provides an additional layer for protecting, monitoring and controlling human life and health.

The article proposes an approach to the development of a group of roles for an information technology platform for monitoring infectious diseases in cities. The distribution of roles in terms of their functions allows for the further active and phased implementation of this platform, while reducing the burden on the healthcare system and other special services.

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ІНФОРМАЦІЙНО-ТЕХНОЛОГІЧНА ПЛАТФОРМА МОНІТОРИНГУ ІНФЕКЦІЙНИХ ЗАХВОРЮВАНЬ

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Резюме. *Дослідження, проведені для стримування поширення інфекційних захворювань у містах, підтверджують, що технології вносять свій вагомий внесок. Значна кількість наукових досліджень аналізують вплив технологій на пандемію covid-19 у різних аспектах. Однак проблеми, пов'язані з упровадженням систем моніторингу на базі Інтернету речей, не досліджуються глибоко, вони пов’язані з проектуванням систем, їх імплементації в повсякденне життя. Це дослідження надає актуальний аналіз, як технології допомагають боротися з інфекційними захворюваннями. Поряд з цим розглядаємо основні виклики, з якими стикаються користувачі таких технологій, а саме: конфіденційність, безпека, масштабування тощо. В результаті можемо стверджувати, що пов’язані технології мають значний вплив на виявлення, відстеження та стримування вірусів. Організація й пересування людини має великий вплив на частоту контактів, що, як наслідок, впливає на передавання, поширення та стійкість хвороботворних патогенів. Пошук контактних структур інфекційних хвороб з огляду на мобільність людини – вимагає чіткого врахування просторових і тимчасових вимірів передавання патогенів, які залежать від типу збудника і способу його передавання, кількості контактів та місця розташування. Платформа, яка може допомогти збирати й аналізувати дані, в основному залежить від наявності доступу до точних деталей щодо різних факторів. Отже, отримання інформації має першочергове значення для розроблення такої технологічної платформи.*

Використовуючи передові технології та інструменти, такі, як IoT, пристрої віддаленого моніторингу, GPS, штучний інтелект та аналіз даних, програми відстеження контактів можуть забезпечити додатковий рівень захисту, коли йдеться про моніторинг і контроль життя та здоров’я людей. Запропоновано підхід для забезпечення ефективного впровадження IT-платформи моніторингу за інфекційними захворюваннями, а також сформовано групу ролей. Такий підхід полегшує запуск платформи, розподіляючи роботу між призначеними ролями та зменшуючи навантаження на ресурси охорони здоров’я й інші міські служби.

Ключові слова: *Інтернет речей, платформа інформаційних технологій, пристрої віддаленого моніторингу, штучний інтелект, аналітика даних, відстеження контактів, вірусні захворювання.*

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