Stay Healthy: Slovenian users' Opinions about the Covid-19 Contact-Tracing Mobile Application

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Abstract

This paper aims to provide a systemic vision of the role and specifics of a Covid-19 contact-tracing mobile application, which can be presented as a data-driven mobile application for citizens in urban data management processes and is essential for a sustainable urban ecosystem to inform the user about contact with a potentially infected person. The study aims to reveal the behaviour of adults when using such an application. We also attempt to discover how the Covid 19 pandemic has changed communication and why users use mobile phones and their features, such as Bluetooth and GPS. The research focused on Slovenia and was conducted during the Covid-19 pandemic in April 2021. Five hundred adults were surveyed. The mixed-method survey investigates the determinants of adult citizens' behaviour in the Republic of Slovenia concerning the #Ostanizdrav application from three perspectives (installed app, activated app, and app used to report infection). In addition, the study examines the barriers and levers to using a contact tracing application to combat the pandemic in Slovenia. The second part of the study involves developing a Deep Learning-based predictive model trained on the data collected due to the survey.

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Introduction

On 11 Mar 2020, the World Health Organization (WHO) declared an outbreak of the Covid-19 global pandemic caused by the SARS-CoV-2 virus. The pandemic consequences have been seen in disruptive changes in the human environment (both private and educational and economic) and affected social development (WHO, 2020). In 2020 and 2021, humankind has witnessed the challenges in medicine and the emergence of social issues related to society's development in the post-Covid era and the preparation of strategies to defend against further opportunities for pandemic outbreaks. In addition to the medical, chemical, and biological professions, the technology industry has also become involved in the fight against the pandemic. The position of WHO is that, in addition to vaccines and medicines, emphasis must be placed on controlling and monitoring the contacts of those infected. WHO believes mechanisms must be implemented to control people's contacts to combat the virus, including contact identification, listing, and tracing. Contact tracing is a key strategy to stop the transmission of SARS-COV-2 and reduce mortality due to Covid-19 (WHO, 2021). To this end, the development of digital tracing has taken place.

In 2020, governments, healthcare institutions, universities, and non-governmental organizations began promoting Corona mobile applications (apps). The primary goal of the Corona apps is to enable a public response to Covid-19. In line with the trends of the information society in recent years, the first front in the fight against the coronavirus has been occupied by smartphone apps, with which various initiators are attempting to analyse the spread of the virus and to help individuals find out relatively easily whether their behaviour has increased the ability of government services to have a better overview of the situation on the ground. In 2020 and the first quarter of 2021, mobile tracing apps were developed with different aspects, such as quick Covid-19 patient assessment based on user-provided symptoms integrated with contact tracing, volunteer help during quarantine, UAV-based Covid-19 outdoor safety surveillance, test scheduling, and an AR-based pharmacy shop assistant. (Al-Emran et al., 2021). In the European Union, most member states had apps in use from the middle of 2020; only Greece and Slovakia are still developing their apps, and Romania is exploring its development (European Commission, 2021).

Researchers believe that contact-tracing apps alone cannot control a pandemic. However, research has shown that the apps are useful with political support and properly integrated into public health systems (Lewis, 2021). According to a University of Oxford study, 56% of people in the UK would download a contact-tracing app sufficient to self-manage the condition. The study's authors pointed out that even a smaller number of user apps have positive effects (Hinch et al., 2020). However, it must be remembered that it is relatively difficult to conclude that the application prevented infection and death. "Having people notified by the exposure notification does not mean that they would not have ended up on the radar of manual contact tracing" (Lewis, 2021).

Interestingly, one of the most commonly used standards in developing Covid-19 infection tracing apps was developed by Google and Apple as a result of an exemplary collaboration between the two giants, which is expected to result in rapid development, wide usability, and high usability (Michael et al., 2020). Several countries worldwide have started using applications developed with the unified protocol. This traceability setup includes the back-end infrastructure and the protocols used for communication between subsystems. The mobile applications are installed on smartphones and connected to the back-end infrastructure (Ramakrishnan et al., 2020).

Data security and privacy issues arise in developing various communication protocols and applications. For example, two protocols are currently in force in the European Union: PEPP-PT (Pan-European Privacy-Preserving Proximity Tracing) and DP-3T (Decentralized Privacy-Preserving Proximity Tracing). Both are based on Bluetooth technology but differ in the way they communicate. Some countries warned that Google could detect the Android operating system user in the first operation period. For example, the Danish Ministry of Health announced that their agency would enter into a dialogue with Google about location data in general (Singer, 2020). However, in the Netherlands, developers retrieved online files containing 200 names, emails, and encrypted passwords of another application (Muncaster, 2020) when they attempted to access the source code. In addition, several governments (USA, Qatar, etc.) worldwide have warned about its vulnerability to hacking or cyberattacks from the beginning (Starks, 2020).

These reasons have led the European Commission to provide legal instruments such as the EU Recommendation 2020/518 (Commission Recommendation (EU) 2020/518, 202) and the Commission Communication 2020 / C 124 I / 01 (Communication from the Commission, 2020). The starting points are recommendations from the European Commission and the supervisory authorities, which the legislator and the applications will follow. The point is that applications cannot replace manual contact by trained healthcare professionals. In particular, advising on the next steps should not rely solely on automated processing. Tracing individuals' locations is also not proportionate; contact tracing is a priority. Since contact tracing applications can work without directly identifying individuals, appropriate measures should prevent re-identification.

We predict that the implications of our study's practice will help the researchers and policymakers understand citizens' behaviour in the case of the Covid-19 contact tracing mobile app and predict the identification of potential mobile app users (and other apps) based on demographic characteristics. For this reason, we addressed the following questions: Which reasons led Slovenians to decide to or not to download the Covid-19 contact tracing mobile application? Furthermore, how can we use a deep-learning-based predictive model to identify potential mobile app users based on demographic characteristics?

The study is based on the questionnaire used in the national survey of attitudes toward digital contact tracing of Covid-19 in the Republic of Ireland (O'Callaghan et al., 2020). However, some questions were modified for our research, which analyses users' views of the tracing application. Respondents are already well informed, both from the media and their own experiences, unlike in the Irish survey conducted before the application was introduced. Therefore, they express their views in advance. The questionnaire comprises 24 questions, six of which also had open-ended sub-questions. The first part includes questions about Covid-19 and the meaning of contact tracing and the use of technology due to the limitations of socializing (three questions); the second part includes questions about mobile phone usage and characteristics (ten questions); the third part includes questions about using the #Ostanizdrav app (five questions). The last part includes demographic questions (six questions).

The authors prepared a survey that includes two parts. The first includes the mixed-methods study to investigate the determinants of adult citizens' behaviour in the Republic of Slovenia regarding the #Ostanizdrav application (Gov. si, 2020) from the three perspectives (installed app, activated app, app used to report the infection). In addition, the study research examines the barriers and levers to using a contact tracing application to control the Covid-19 pandemic in Slovenia. The second part of the research includes developing a deep learning-based (Bengio, 2009) predictive model trained on the data collected as the outcome of the previously presented survey.

The survey was submitted through the online platform SurveyMonkey, using a platform pool of respondents in the Republic of Slovenia. The survey had a quota-sampled group of Slovenian adults (N=500, Margin of error = 4%). The survey was released on the platform on 7 Apr and finished on 8 Apr 2021.

Of the 500 respondents, 248 (49.7%) male and 251 (50.30%) female respondents were included in the study. In the age group 18–29 years, 212 (42.4%) respondents were included. In the age group 30–44 years, 160 (32%) respondents were included; in the age group 45–60 years, 99 (19.8%) respondents were included; and above 60 years, 29 (5.8%) respondents were included. There were 2 (0.4%) respondents with no completed education, 25 (5%) respondents with completed primary school, 65 (13%) respondents with three years of vocational school, 219 (43.8%) respondents with secondary education, 105 (21%) respondents completed first Bologna degree, 56 (11.20%) completed second Bologna degree (MA) and 28 completed third Bologna degree (MSc and Ph.D.) 5.60%) of the respondents. One hundred and sixty-six (33.20%) of the respondents lived in a rural area (a place with less than 1000 inhabitants), 145 (29%) in a smaller town (up to 5000 inhabitants), and 189 (37.8%) in a small town and 189 (37.8%) lived in regional centers (major Slovenian cities). Ninety (18%) respondents did not want to provide an answer about the amount of the monthly salary, 172 (34.4%) respondents stated that they receive a monthly salary of up to €1000, 146 (12,6%) receive from €1001 to 1500 and 29 (5,8%) over €2000.

According to the Statistical Office (2021), 97 percent of the Slovenian population aged 16 to 74 used a mobile phone in the past year. Of these, 81 percent used a smartphone, and 19 percent were owners of a "normal" or classic mobile phone. Among the latter, most are pensioners.

The internet has become a source of information, communication, and a venue for shopping. More than three-quarters of Slovenian users find out about products or services, slightly fewer read news, newspapers, or magazines, and more than half listen to online music. In addition, a good third of website users share photos, videos, and texts on social networks such as Facebook, Snapchat, Instagram, and TikTok or via apps such as Viber and WhatsApp.

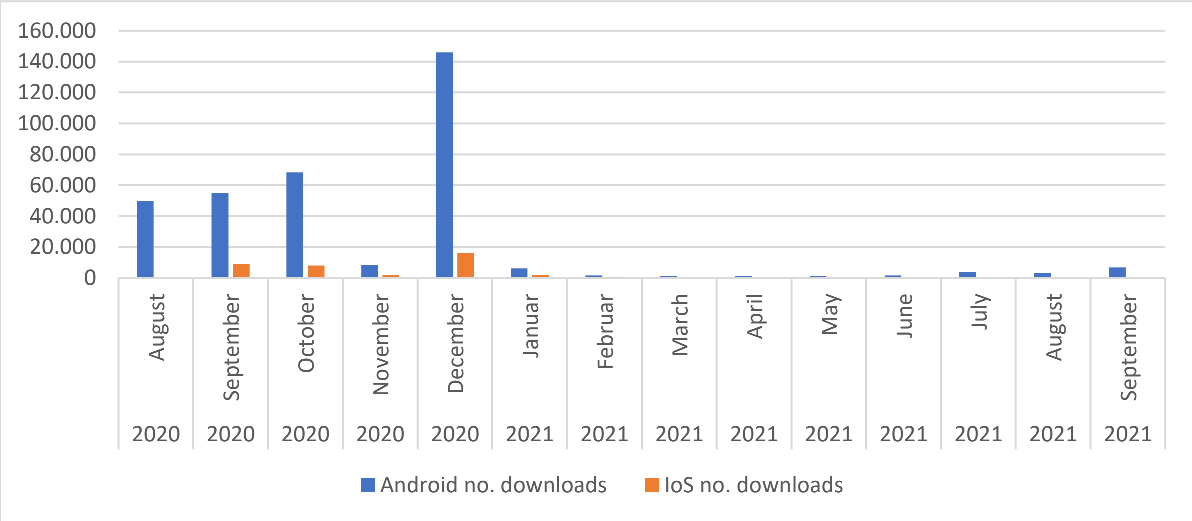
According to mobile operators, there were 337,115 broadband internet connections in Slovenia at the end of 2007, both in households and businesses. By the end of 2020, this number had almost doubled to 651,604 (Agency for Communication Networks and Services of the Republic of Slovenia, 2021)

According to the Digital Economy and Society Index, calculated under the auspices of the European Commission, the overall penetration of fixed broadband connections was 83 percent in 2019, well above the EU average of 78 percent. In the first quarter of this year, fixed broadband services were available to 85.4 percent of Slovenian households, according to data from the Agency for Communication Networks and Services of the Republic of Slovenia (2021).

Presentation of #Ostanizdrav (Stay healthy)

In Slovenia, where the research was conducted, a mobile application called #Ostanizdrav (meaning Stay "Healthy") has been available to Android users since August 2020 and IoS users since September 2020. It is a localization of the German Corona Warn application. Figure 1 presents the number of downloads from August 2020 to September 2021. As can be seen, the highest number of downloads was recorded in December 2020, when the government lessened the restriction of movement between municipalities in regions with an epidemiologically clear picture, but only for those with the application. Between August 2020 and September 2021, 354,175 app downloads on Android and 41,392 app downloads on iOS were recorded. Data on issued TAN codes change daily (depending on the number of infected per day), so we do not provide them (for comparison, the 14-day average number of TAN on 12 Oct 2020 was the number of issued TAN codes: 455, and the number of TAN codes entered in the application: 282. On 25 Sept 2020, the number of issued TAN codes was 18,855, and the number of TAN codes entered in the application was 632) (Gov. si, 2021).

Figure 1.
Monthly downloads from both stores, Google Play Store and App Store.



Source: Gov. si

The #Ostanizdrav app records contacts between people who have the app installed. Individuals must install the app before a possible SARS-CoV-2 infection, as this is the only way that the confirmed infected individual can alert all individuals with the stored transmission TAN code to the risky contact by transmitting tag keys. Installing it after a confirmed infection does not make sense because the app does issue an alert when an infected person approaches a person in real time. The #Ostanizdrav app exchanges the individual's transmission codes with all apps that use the system to notify you of infection from Google and Apple. The exchange occurs by connecting the back-end system of the #Ostanizdrav app to the central European server (under the auspices of the European Commission), from where it receives the daily keys of users from other EU countries and sends the keys of Slovenian users to the central server. Included cross-border exchange are Austria, Belgium, Croatia, Denmark, Finland, Germany, Ireland, Italy, Latvia, the Netherlands, Poland, and Spain (Gov. si, 2021). The main problem with using the app is that success would require an estimated 60 percent of the Slovenian population to use it (Gov si, 2021).

Technological solutions and problematic aspects of applications

In most countries worldwide, governments have encouraged the development of some applications to provide better protection against coronaviruses and prevent the spreading of infections. Thus, the applications are used in countries including Australia, Austria, Bulgaria, China, Cyprus, Czech Republic, Finland, France, Germany, Ghana, Iceland, India, Iran, Ireland, Israel, Italy, Malaysia, Netherlands, Norway, Poland, Northern Macedonia, Singapore Slovenia, Switzerland, Turkey, USA, United Kingdom.

The main difference between them is how they handle individual privacy and ensure the application's usability. Most tracing apps (72 percent) use Bluetooth, the best compromise between user privacy and security because it only works over short distances. The data is usually not exported to cloud services but remains on the user's device. Simultaneously, these applications usually do not record the user's geographical location but only the proximity of another user of the same application; thus, the privacy protection is greater (Gov si, 2021). A good third (37 percent) of the infection tracing applications analysed to use the more problematic monitoring of the user's physical location via GPS; the applications thus record the user's physical location and compare it on the server side with the geographical location of another user. However, that solution opens up new possibilities for abuse and control, as the application user must send their geographic location to a server, where the central system compares it to the locations of other users (Elkhodr et al., 2021; Mbunge, 2020).

As already noted, the question of the use of protocols is important. The question arises as to which application protocol is best. In seeking an answer to this question, it is necessary to note that the best protocol definition varies from individual to individual. Protocols solve the same primary challenge; differently, each sacrificing something different: in one case: ease of use, but in the other, privacy. There is a struggle between Eastern and Western civilizations in application and protocol development. The fundamental difference is based on individual privacy attitudes and concepts (Martin et al., 2020).

Thus, two protocols are currently in force in the European Union: PEPP-PT (Pan-European Privacy-Preserving Proximity Tracing) and DP-3T (Decentralized Privacy-Preserving Proximity Tracing). Both are based on Bluetooth technology but differ in the way they communicate.

PEPP-PT works so that in the first step, the user loads the application and marks himself as a coronavirus patient in case of illness. The data is uploaded to a central server, where the app searches the app's directory and, based on the proximity of the two smartphones, calculates with whom the owner has been in contact in the previous three weeks and calculates the possibility of infection based on several factors. It then issues a notification of an increased probability of infection to the selected people with the highest possible infection factor.

The DP-3T protocol was developed in response to PEPP-PT and is designed to be more privacy-conscious. Compared to PEPP-PT, DP-3T does not use a centralized location for analysis but performs all calculations on the user's phone, which protects their privacy better (Simmhan et al., 2020) (Zeinalipour-Yazti et al., 2020).

Finally, on Android, the application needs at least version six of the operating system, which is not a significant hurdle. It came out five years ago, and phones under the age of four mostly have it. However, Apple users need iOS 13.5, which was released in May 2020. It can be installed on iPhone 6S (2015), iPad Air 2 (2014) and newer, iPad mini 4 (2015), iPod touch seventh generation (2019), and, of course, all newer devices. New Huawei devices that do not have access to Google Play Services and thus to GAEN cannot use the CWA application nor the #OstaniHealth mobile application (Gov. si, 2021).

Consequently, the state is telling citizens that they have fewer rights if they have a smartphone that is slightly more than four years old or if they do not have a smartphone. Furthermore, it does not care that Germany considers this a violation of the GDPR and that Google and Apple do not allow such use of their technology (Urbaczewski et al., 2020).

The app #Ostanizdrav has a 2.4 rating on the Google Store and a slightly better 3.3 on Apple. However, the descriptive user reviews mainly complain about updates, crashes, and non-notification (no notifications for low-risk contacts have to be viewed manually). (Apple store, 20021; Google store, 2021).

The #Ostanizdrav app uses Google or Apple functionality (API), giving it constant Bluetooth access. At the same time, it ensures that Bluetooth cannot be used in the background for security reasons. In terms of use, this applies to the app providers: the Slovenian Institute for Public Health and the Slovenian Ministry for Public Administration (Gov. si, 2021).

It is noteworthy that the inventors of Bluetooth technology, Jaap Haartsen and Sven Mattison, pointed out in an interview that the technology is unsuitable for measuring objects' distance (Biddle, 2020). Even the improved version of Bluetooth Low Energy still has significant accuracy problems. In addition, Bluetooth signals are extremely sensitive to obstacles, such as trees, objects, and even fabric, when we have the phone in our pocket, which can significantly skew the distance feet, leading to false positive or negative perceptions of contacts (Trivedi et al., 2020).

The usefulness of Bluetooth and its importance in using the contact tracing mobile app led us to ask respondents if they knew why "Bluetooth technology" is used. 82% of respondents answered that they know why to use Bluetooth technology, 10% do not, and 8% are unsure why to use it.

Since it is necessary to turn on Bluetooth and GPS functions to use the application, we asked the respondents how often they turned on Bluetooth on their mobile phones: 149 (29.8%) said that they have Bluetooth switched on all the time, 74 (14.8%) said at least once a day, 90 (18%) said several times during the week respondents, 82 respondents (16.4%) said several times a month, 80 respondents (16%) never; the other 25 respondents (5%) said that they use Bluetooth because driving a motorbike or car or riding a bike to have their hand's free car. They also mention that they use it very rarely, maybe only once time a year.

Respondents in our study most often turn on Bluetooth to: "connect with the appliances in the car,"; "to make phone calls in the car,"; "connect with other appliances (such as to listen to music, transfer photos, connect to the radio, transfer information, connect with smartwatch, use the internet, connect with appliances at home; connect with ANGi and CarPlay; connect with Apple Watch and Apple Earpods; connect with Covid-19 app)"; "due to emails"; "transfer databases"; "for finding the right location"; "for connecting with friends"; "use application Ostani zdrav".

A total of 409 (81.8%) respondents answered positively to the question if they use the GPS function on their mobile phone, while 70 (14%) respondents answered that they have never done so, and 21 (4.2%) were not sure if they have ever used the GPS feature.

The respondents said that they most often use the GPS/geolocation function to find an address or location, find their location when they are performing different free-time activities (driving with a motorbike, climbing), when they have to identify borders of the forest, for the #Ostanizdrav app, for searching social contacts (e.g., Tinder app), figuring out petrol consumption, finding a car (e.g., so that they can go picking mushrooms in the forest), for highlight location on photos and posts on social media, to use sports tracker application (e.g., cycling, running, walking measuring), different health apps (e.g., Samsung health app), to inform parents or partners where they are, especially when they are abroad.

Specific views of the study respondents about the use of the Stay Health # app

To resolve the sampling issues with weighting, the respondent sample size did not significantly alter our main findings (see Table 1).

Table 1
Participant demographics education, Covid-19 related worry, and understanding of the meaning of contract tracing versus downloading, active usage, or reporting the contact tracing app – weighted response

	Weighted responses (weighted by gender, age, and educational attainment)					
	Download	**Activated**	**Diagnose report**	**Total**	**%**	
Gender						
Female	51 (27%)	43 (45.2%)	9 (9.3%)	103	54.5	
Male	38 (20.1%)	40 (21.1%)	8 (7.7%)	86	45.5	**p=0.0076**
Total	89 (47.1%)	83 (43.9%)	17 (9%)	189	100	
Education						
Primary school	4 (2.1%)	5 (2.6%)	2 (1.1%)	11	5.kol	
High school (3 years)	14 (7.4%)	7 (3.7%)	3 (1.6%)	24	12.srp	
High school (4 years)	33 (17.5%)	37 (19.6%)	9 (4.8%)	79	41.8	
First Bologna degree	25 (13.2%)	19 (10.1%)	1 (0.5%)	45	23.kol	**p=0.0053**
Second Bologna degree	9 (4.8%)	8 (4.2%)	1 (0.5%)	18	18	
Third Bologna degree	4 (2.1%)	7 (3.7%)	1 (0.5%)	12	12	
Total	89 (47.1%)	83 (43.9%)	17 (9%)	189	100	
Covid-19 related worry						
Very worried	18 (9.5%)	13 (6.9%)	4 (2.1%)	35	18.svi	
Moderately Worried	23 (12.2%)	38 (28.5%)	4 (2.1%)	65	34.4	
Not Very Worried	28 (23.5%)	19 (10.1%)	3 (4.5%)	50	26.svi	**p=0.0089**
Not Worried	20 (10.6%)	13 (6.9%)	6 (3.2%)	39	20.lip	
I am not sure	0	0	0	0	0	
Total	89 (47.1%)	83 (43.9 %)	17 (9 %)	189	100	
Meaning of contact tracing						
Yes	76 (40.2%)	68 (36%)	15 (7.9%)	159	84.1	
Not	5 (5,7%)	5 (2,6%)	2 (1,1%)	12	6,3	**p=0.00529**
I am not sure	8 (4,2%)	10 (7,9%	0	18	9,5	
Total	**89 (47,1%)**	**83 (43,9%)**	**17 (9,0%)**	**189**	**100**	

Source: Authors' work

In the first part of the questionnaire, respondents were asked how concerned they were about the Covid 19 pandemic outbreak in Slovenia; 79 (15.8%) said they were very concerned, 148 (29.6%) were concerned, 132 (26.4%) respondents were fairly concerned, and 141 (28.2%) were not concerned. When asked if technology has helped them overcome the barriers associated with limited movement due to Covid-19 in Slovenia (option of choosing three answers), 201 (40.2%) respondents said that it enables them to work from home; 153 (30.6%) respondents said that technology helps them stay in touch with their friends and family; 12 (2.4%) said that technology helps them stay in touch with the local community and religious community; 45 (9%) respondents said that technology helps them communicate with the public administration while organizing administrative procedures. Forty-five (9%) respondents think that despite using technology and apps, they have not had any help in overcoming obstacles since the movement restriction through Covid-19; 58 respondents (11.6) think that they have not used technology/apps since the movement restriction through Covid-19 (11.6%; 58 participants and 1 (0.2%) thinks that the participant technology has helped him in other ways through the internet.

Consistent with the survey content, respondents were asked if they understood what was meant by contact tracing due to covid-19 or other infectious diseases; 360 (72%) answered that they understood, while 93 (18.6%) were not sure if they knew, and 47 (9.4%) answered that they did not know. Only 12 (2.4%) respondents answered that they do not have a mobile phone (of any type). In the continuation of the research, we replaced these 12 respondents with a mobile phones. On the question of how much time they spend browsing social networks on their mobile phone on a normal working day, 294 (58,8%) respondents answered that less than one hour, and 206 (41,2%) spend more than one hour. On average, they spend 3 hours per week, which can be related to many respondents representing the younger generation. Due to the impact of phone characteristics on using the #Ostanizdrav app, 134 (26.8%) respondents up to one year old had a mobile phone, 171 (34.2%) respondents between 1 and 2 years of age, 131 (26.2%) respondents between 2 and 4 years of age and over four years of age 51 (10.2%) respondents. At the same time, 13 (2.6%) answered that they were not sure.

In the second part of the questionnaire, the respondents were asked if they had downloaded the #Ostanizdrav app; 39.20% answered yes, and 60.8% answered no. Respondents who downloaded the app indicated that they installed the app (46%), activated it (26%), and used it to report the diagnosis (28%) (entered the TAN).

Table 2 presents the answers to the questions regarding whether they use or not use or not download the #Ostanizdrav app. Among other reasons for using the application, respondents cited that it was mandatory when crossing municipal boundaries and state regions, wanting to be a responsible citizen, personal information, and curiosity. The main reasons people did not download the app are connected with distrust in its benefits: information privacy violations, concern about possible public disclosure that a person was diagnosed with Covid-19, violating human rights, and not having a smart mobile phone that can activate the app. Respondents said that they do not want covid apps on their phones, that the phone does not have enough memory to store the app, that they did not know that this app exists and that they do not believe in its effectiveness. After all, they have a phone too old or a Huawei brand phone, a belief that the coronavirus is not worse than any other because of the faster discharge of the battery, because they can get data elsewhere, because the application was disturbing because of the constant warning that Bluetooth is not turned on.

As part of why they do not activate/use the #Ostanizdrav, respondents stated: that they are worried about the possibility of misuse of private information about places and people they have recently visited. They do not want to worry more than they already feel. They are worried that governments will use the continued use of the app as an excuse for increased control after a pandemic; they think the app will affect their device’s performance; they have survived Covid-19, so they feel compelled to download the app but do not want to use it, they do not want to get infected, and they are worried that tech companies will continue to use the app as an excuse for greater post-pandemic control.

Table 2
Reasons to use or not use the #Ostanizdrav app

Reasons why you use (select up to 3 claims)	**Total responses**	**% Responses**
It would help protect my family and friends	56	24.35
A sense of responsibility to the wider community	51	22.17
It would let me know my risk of being infected	52	22.61
It would help protect me	32	13.91
It would help reduce the number of deaths among older people	12	5.22
It might stop the epidemic	21	9.13
Nothing from that	3	1.30
Other (please specify)	3	1.30
Reasons why you did not activate/use the #Ostanizdrav (select up to 3 claims)		
I am concerned about the possibility of misuse of private information about locations and people I have recently visited	30	41.67
I'm having trouble using the app	9	12.50
The app affects the performance of my device	11	15.28
I feel like I was obligated to download it, but I do not want to use it	5	6.94
I got over covid 19	4	5.56
I will not get infected	4	5.56
I am concerned that technology companies will continue to use the app as an excuse for greater post-pandemic control	1	1.39
I do not want to feel more worried than I already feel	8	11.11
Reasons why you do not choose to download the #Ostanizdrav app (select up to 3 claims)		
I am concerned about the possibility of misuse of private information about locations and people I have recently visited	106	34.87
I am afraid my private information would go public if I were diagnosed with Covid-19	15	4.93
I have concerns about providing GPS location history	31	10.20
I believe that this would violate my human rights	75	24.67
I do not have a smartphone that can activate the app	17	5.59
Other	60	19.74

Source: Authors' work

The respondents stated, among other things, that they do not use the app because it does not work, that they do not know how to use it, that they follow all the stated rules and therefore do not need the app, that the app does not affect, that it is only used so that someone can make money from it, that it uses much battery on the phone; they do not trust the app because of its poor function and low usage among the population, they do not trust the tracing because when using Bluetooth battery the dies faster because they are mostly at home, they had the situation that the app did not recognize close contacts with infected people when their employees used it, because of the disrespectful and arrogant behaviour of the government and its representatives, and because when they go out, they mostly do not take their phones with them. Individuals also felt that the awareness of the National Institute of Public Health's need for action was extremely superficial. For example, it is not clear how up-to-date data entries on infected individuals are, there are no clear instructions on what it means when an application responds about a possible contact, nor is there a regulated status of an individual after such a contact (isolation, quarantine).

Human rights and privacy protection

The Slovenian application is a localization of the German application Corona Warn App. The German government explicitly emphasizes that its use is entirely voluntary. They encourage the public to use it wisely and as consistently but do not mandate it. Furthermore, according to the German government, the application would be mandatory if, for example, it is required by employers or businesses, which is contrary to the European GDPR (Bradford et al., 2020; Meijer et al., 2020).

The pandemic has raised concerns about privacy and basic human rights when digital technologies such as contact tracing and surveillance tools are used. Moreover, lawmakers and end-users have criticized the ICT industry in recent years due to the misuse of personal data, collaboration with government intelligence agencies, and the diminished security of information technology products. It is, therefore, necessary to ensure the anonymity of users of Covid-19 contact tracing apps. Ensuring anonymity starts with the applications' protocols as their basic building blocks (ethical standards). The key in Covid-19 applications is the data exchange between user devices, which must be simple, fast, and, above all, secure from user privacy (Morley et al., 2021).

Indeed, while this concern sensitive health data, at the same time, in the vast majority of cases, it is the user who decides how to use it, with no overarching unified control over the exchange or dissemination of this information. Morozov (2020) points to the reinforcement of the belief that technology is the answer to social problems and that only with technology can we achieve social breakthroughs.

In most countries, applications are used voluntarily. Thus, the user is responsible for the installation and use, and most countries do not encourage the use of the application through advertising campaigns or other measures. Exceptions are more repressive countries (China, India, Israel), where the authorities apply strict measures and sanctions to encourage Covid-19 applications. For example, Google explicitly states that the app may only be used for Covid-19 epidemic control (e.g., enforcement of individual quarantine), and any other use, including law enforcement or punishment, is prohibited. (Google store, 2021). Apple has similar prescriptions (Apple Store, 2021).

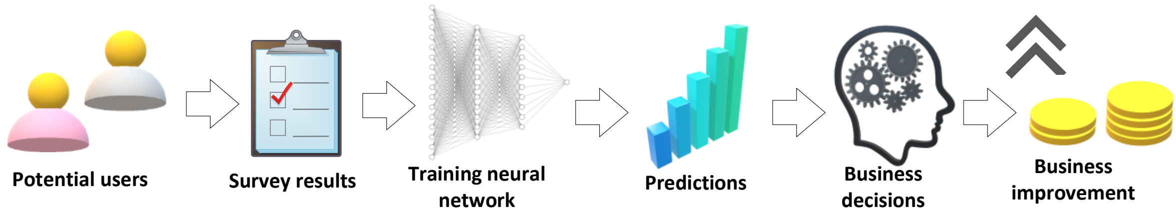
However, in Slovenia, there was a government decision in December 2020 that restricted a person must have a loaded and permanently activated mobile application for information about contacts with other users positive for the SARS-CoV-2 virus (application #OstZdrav) to move between municipalities within the region of permanent or temporary residence. Thus, the government has tied the constitutionally guaranteed right to freedom of movement (Article 32 of the Constitution), which is temporarily restricted due to the control of the epidemic, to the use of a mobile application (Sovdat, 2020).

Predictive model

Furthermore, this paper introduces a deep learning-based (Bengio, 2009) predictive model trained on the data collected as the outcome of the previously described survey. Deep learning is an approach in artificial intelligence that relies on artificial neural networks with multiple layers. Each layer consists of one or more artificial neurons (also known as perceptrons), which execute some activation function. For example, for hidden layers, ReLU activation is commonly used. On the other side, the output layer, sigmoid, and softmax are possible choices in classification, while linear activation is used for regression problems. Commonly, the so-called deep neural networks are trained on large data sets. Their goal is to predict some outcome of interest in a particular context, either categorical or numerical.

In our case, the proposed model takes user characteristics as input variables and predicts whether the user will likely install the application. In this manner, the preliminary analysis of application potential can be performed, starting from only basic facts about the demographics of potential users. Fig. 2 shows an overview of predictive model creation and usage workflow. The proposed approach is inspired by our previous works related to reservation cancellation prediction in the post-covid tourism sector (Petrovic et al., 2021) and churn prediction in the telecommunications industry (predicting if the customer is likely to cancel a subscription or not based on usage characteristics) (Petrovic, 2019).

Figure 2
Deep learning-based predictive model creation and usage workflow



Source: Petrovic et al. (2021)

First, the necessary data is queried and converted from the survey platform. The columns of interest are filtered, while the textual responses are changed with ordinal numbers. Moreover, the deep neural network implemented in Python relying on a PyTorch framework (Stevens et al., 2020) is trained on the previously prepared data in such form. After that, the previously trained deep neural network is ready to make new predictions by taking the user-related properties as input. Furthermore, the prediction results are interpreted in a particular business context – such as preliminary market analysis or segmentation. In this manner, the outcome of the predictive model can be further leveraged to achieve the organization's goal: additional profit or loss reduction.

In our case, when it comes to the predictive model, the problem is treated as a binary classification with two possible outcomes: the user installed the application (class "1") or not (class "0"). Table 3 shows the layout of data used for model training, showing the input and output variables.

Table 3
The layout of the dataset used for training of predictive model: white – input variables; grey – output variable

Gender	Age	Education	Region	Salary	Outcome [yes/no]

Source: Authors' work

The architecture of the underlying deep neural network is described in what follows. First, the input layer has five nodes, which must match the number of input variables. Moreover, there are two hidden layers, 30 nodes, each with a ReLU activation function. Finally, due to binary classification, there is only one node with sigmoid activation in the output layer. For this reason, the selected loss function was Binary Cross-Entropy Loss (BCELoss). Furthermore, regarding training, a stochastic gradient descent (SGD) optimizer was used with a learning rate of 0.003. Table 4 shows the architecture of the implemented deep neural network.

Table 4
Deep neural network architecture for predictive model

Layer	Number of nodes	Activation function
Input	5	-
Hidden 1	30	ReLU
Hidden 2	30	ReLU
Output	1	Sigmoid

Source: Authors' work

In contrast, in Figure 3, an excerpt of Python code responsible for the crucial parts related to implementing the previously described classification model is given. The code's first part represents a definition of neural network architecture, which corresponds to Table 4. The second part shows model object instantiation, with a selection of an appropriate optimizer and loss function. Finally, the third part of the given code shows how the model is trained iteratively by forwarding the inputs to the deep neural network and comparing the achieved outcome with real survey output. The prediction error is estimated by applying the appropriate loss function over these two values.

Regarding model evaluation, the dataset was split into training (80%) and test set (20% of all user surveys). In total, 500 samples were considered. The model was trained in 12 epochs, with batch size 10. The achieved percentage of correctly classified samples was 86% on training and 81% on the test set.

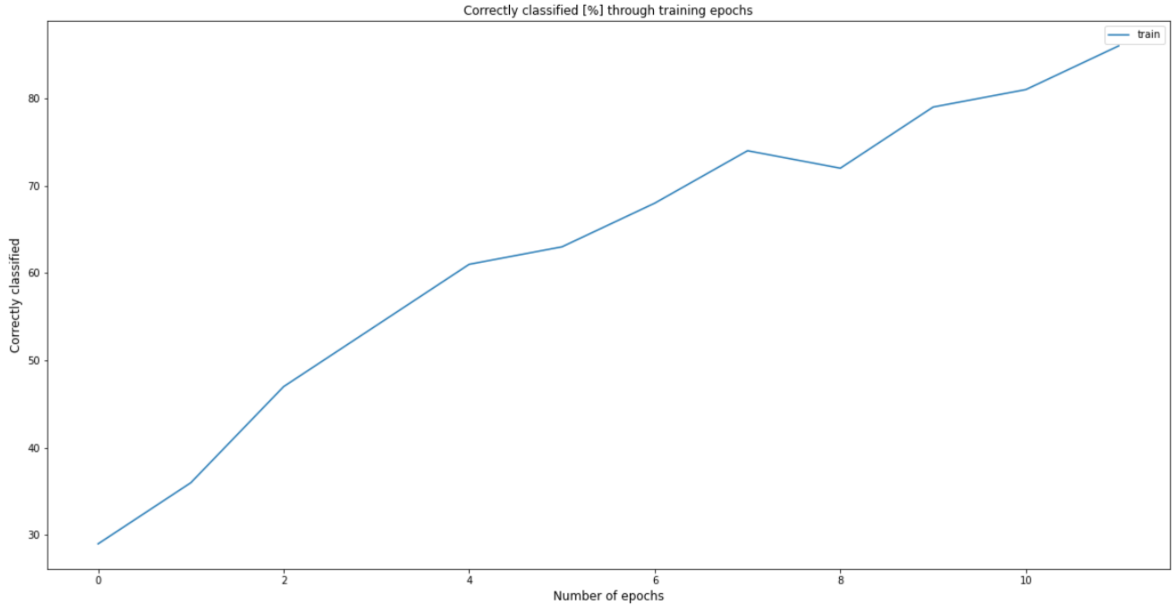
Regarding model evaluation, the dataset was split into training (80%) and test set (20% of all user surveys). In total, 500 samples were considered. The model was trained in 12 epochs, with a batch size of 20. The achieved percentage of correctly classified samples was 86% on training and 81% on the test set. Moreover, Figure 4 shows how the number of correctly classified samples changed through training epochs. The hyperparameters were determined experimentally, observing the model performance for varying learning rate values, batch sizes, and several epochs. In our increase, further increases in the number of layers, batch size, or epochs led to worse results.

Figure 3
Excerpt of classification model implementation Python code

```
#Model definition
class UserClassificationModel(torch.nn.Module):
    def __init__(self, input_length):
        super(UserClassificationModel, self).__init__()

          self.input_vars = input_vars

        self.layer1 = torch.nn.Linear(input_vars, 30)
        self.layer2 = torch.nn.Linear(30, 30)
        self.layer3 = torch.nn.Linear(30, 1)

    def forward(self, x):
        output = F.relu(self.layer1(x))
        output = F.relu(self.layer2(output))
        outcome = F.sigmoid(self.layer3(output))
        return outcome

#Creation of model instance
predictor=UserClassificationModel(5)
optimizer=opt.SGD(predictor.parameters(), lr=0.01)
loss_f=torch.nn.BCELoss()

#Train loop
epochs=12
for epoch in range(epochs)
     for i, (input, outcome) in enumerate(train_loader):
          predicted=predictor(input)
          loss= loss_f(predicted, outcome)
          loss.backward()
          optimizer.step()
          predictor.zero_grad()
```

Source: Authors' work

Figure 4
Percentage of correctly classified samples through training epochs



Source: Authors' work

Conclusion

Our findings support the fact that the aim of the policymakers and technology developers to control and monitor contacts of the population was (partly) accomplished with the app #Ostanizdrav as participants in our sample had used modern technology, such as geolocation function (GPS) before the outbreak of global pandemic for tracing, controlling, and monitoring their behaviour (e.g., during sports, traveling) and the behaviour of their loved ones (such as tracing their children in case of unusual behaviour).

Our findings showed that people activated the #Ostanizdrav app primarily to protect others: their families and friends (24.35%; 56 responses), their selves (22.61%; 52 responses), and the wider community (22,17%; 52 responses). When we think about ourselves and our benefits, the logic of consequences is prompted: Will I get sick? We, especially doctors and nurses, easily say no as they spend much time in the hospital, wash our hands regularly, and rarely get sick, so they tend to believe it is unlikely they would get ill (Grant, 2016). We are generally too self-confident regarding our vulnerability (Grant, 2016). When we think of other people, especially patients, the logic of appropriate behaviour is activated: What would a responsible person like me do in this situation? The thinking process changes from evaluating costs and benefits to an in-depth analysis of the values and what is right or wrong (Grant, 2016), especially in a cyber-physical social system that is a major evolution of a citizen's communication. Therefore, it is becoming increasingly important to use deep learning prediction systems to analyse assumptions about the usage of a mobile application as part of its development and to adapt applications to users' cautious behaviour based on their characteristics, as well as national data protection regulation. In a cyber environment, data-driven mobile applications have an important role in urban data management processes, which is essential to ensure a sustainable urban ecosystem for providing diversification between stakeholders and data sources. The realization of sustainable data-driven smart solutions based on an urban data platform that will enable citizen well-being in urban centers is needed to develop data-driven applications. For further understanding of the role of data-driven mobile apps and their impact on possible changes and adoptions in citizens' living conditions and economic and political subsystems is essential to determine the role of data-driven mobile apps and their impact on urban (sustainable) development, which is understood as a relevant part of smart governance reputation. For mobile apps, such as tracing apps, it is important to develop a trustful relationship between the community stakeholders so that their interdependence can best be understood through the urban ecosystem value chain. To ensure a smart, sustainable, and secure ecosystem, government regulators must develop regulatory rules to ensure data security and balance between data regulators and application developers (or data producers and consumers). Examples of such regulatory criteria are the General Data Protection Regulation (GDPR) of the EU or the US's California Consumer Privacy Act (CCPA).

The study's main limitation is that the research was done in Slovenia and that the sample was obtained within the Monkey Survey Pool. The researches show that the online respondent's demographic profile from Monkey online survey departed somewhat from the respective profile in the adult population; however, it must be taken into account that it is the average discrepancy rate of 5 to 10% between a particular demographic characteristic of online respondents and their known distribution in a population (Heen et al., 2014).

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