Bachelorarbeit

Artificial Intelligence in Prevention of Coronavirus

Challenges and Privacy concerns

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Wien, am _____

TECHNISCHE UNIVERSITÄT WIEN

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Introduction

In 2020, everyday life has changed radically. At the end of 2019, the first case of coronavirus was discovered in China, and by March 2020, the virus has spread all over the world. The virus is spreading at a rapid rate and many states were disorganized and unprepared at the time the virus struck them. One such country is Italy, which was in a catastrophic state in the middle of 2020.

Since the etymological origin of this virus is unknown, ways to control it still pose a serious challenge in the world. At least 246 vaccine projects have started against Covid-19 since January 2020 and according to listing as of 12th January 2021 the World Health Organization (WHO) currently counts 235 of them. Since vaccines have not been tested in practice before, they mostly cause distrust among citizens, and the suppression of this virus still relies on civic responsibility. Some of the measures that people should adhere to are: wearing the mask over the face and mouth, avoiding crowds, often washing hands, cleaning and disinfecting frequently touched surfaces daily, and many others**.**

As a result of the difficulty in controlling the spread of the virus, many states have announced a lockdown, thus disabling any human contact for an extended period. The duration and severity (strength of the measures) of the lockdown vary in different countries. The cessation of gastronomy and public services has also led to an economic

crisis and large losses, and the pressure on health facilities and the overburdening of health workers has never been greater. On the other hand, the advancement and development of technology have brought numerous innovations that could contribute to the suppression of coronavirus. Artificial Intelligence is of great importance for healthcare, as these tools can perform tasks that would otherwise be performed by medical professionals, and thus facilitate their work, and also provide objective and more accurate results.

Also, many of the company's software companies are focused on designing medical software that patients can use independently at home. For example, Apple updated their software to implement a personal electrocardiogram (ECG) and thus allow users to control their heart rate. Also, companies such as BlueDot and Metabiota have established platforms to monitor and forecast the further development and extent of the spread of the virus. Many contact tracing applications have been established that will use Bluetooth to monitor the user's movements and inform him/her if he/she has been in direct or indirect contact with an infected person, to isolate and prevent further spread of the infection. Austria's "Stopp Corona" application has already been downloaded 1.25 million times.

However, in addition to the many contributions of these technologies, there are many risks they bring with them. These are most often risks of potential invasion of the user's privacy and the security of private data. AI technologies process and have access to the patient's private data, and there is no 100% guarantee that this collected data will be used only for health purposes and also deleted after use. Some companies have been accused of misusing patients' private data by unauthorized use and forwarding of collected information.

This paper discusses how Artificial Intelligence has been applied to control the coronavirus, as well as the measures and laws that the software used for these purposes must comply with.

1. Coronavirus

The coronavirus pandemic is a new health crisis that threatens the world since the beginning of 2020. Coronavirus 2019 (2019-nCoV) or severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) originates from bats and is transmitted to humans through unknown intermediate animals in Wuhan, Hubei Province, China in December 2019[1]. On 31st December 2019, the World Health Organization received a report from China, the most populous country in the world, about cases of pneumonia of unknown etymology. By 3rd January 2020, a total of 44 cases of pneumonia had been detected, and as early

[1] Singhal, T. A Review of Coronavirus Disease-2019 (COVID-19). *Indian J Pediatr* **87,** 281–286 (2020). https://doi.org/10.1007/s12098-020-03263-6 Accessed 20.01.2021.

as 7th January 2020, Chinese research authorities announced that they had isolated a new virus from the seafood market in Wuhan, named as 2019-nCoV[2].

So far, 99,587,084 of total cases of coronavirus (COVID-19), 54,920,146 recovered cases and 2,148,260 deaths have been reported[3]. According to data published on 25.01.2021 in the world there are 25,863,201 of currently infected patients, where 25,754,394 (99.6%) of them are in mild condition, while 110,681 (0.4%) of them find themselves in serious or critical state[4].

The disease is transmitted by inhalation or contact with infected droplets, and the incubation period ranges from 2 to 14 days. Symptoms are usually: fever, cough, sore throat, shortness of breath, fatigue, malaise. On the average, most infected people tolerate the disease well, with the elderly (over 60 years) and people with concomitant diseases falling into the critical category, because in them the disease can progress to pneumonia, acute respiratory distress syndrome (ARDS) and dysfunction more organs.

Some people are asymptomatic and the diagnosis is made by demonstrating the virus in the respiratory secretion with special molecular tests. Common laboratory findings include normal or low white blood cell counts with elevated C-reactive protein (CRP). Computed tomography of the chest is usually abnormal even in those without symptoms or mild disease.

Prevention of COVID-19 currently relies mostly on home isolation of suspected cases and those with minor illnesses, and strict infection control measures that include precautions in case of contact and drops. The virus spreads faster than its two ancestors SARS-CoV and Middle East Respiratory Syndrome Coronavirus (MERS-CoV), but has lower mortality.

The reason why this virus grew into a global pandemic is a high spread rate or a high "infection rate ratio". Infection rate ratio or the reproductive number R0, is the number of people that one infected person can infect. For example, the Zika virus has an R0 equal to 3.0 - 6.6, which makes it super contagious. Seasonal flu has R0 = 1.3 while COVID-19 has value of R0 between 2 and 2.5. One person is likely to infect 12-18 people with coronavirus.[5]

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[2] Kumar D, Malviya R, Kumar Sharma P. Corona Virus: A Review of COVID-19. EJMO. 2020; 4(1): 8-25 https://ejmo.org/10.14744/ejmo.2020.51418/ Accessed 20.01.2021.
[3] Ibid.
[4] Ibid.
[5]"*Coronavirus is not the flu. It's worse.* (2020, April 1). [Video]. YouTube. https://www.youtube.com/watch?v=FVIGhz3uwuQ Accessed 23.01.2020.

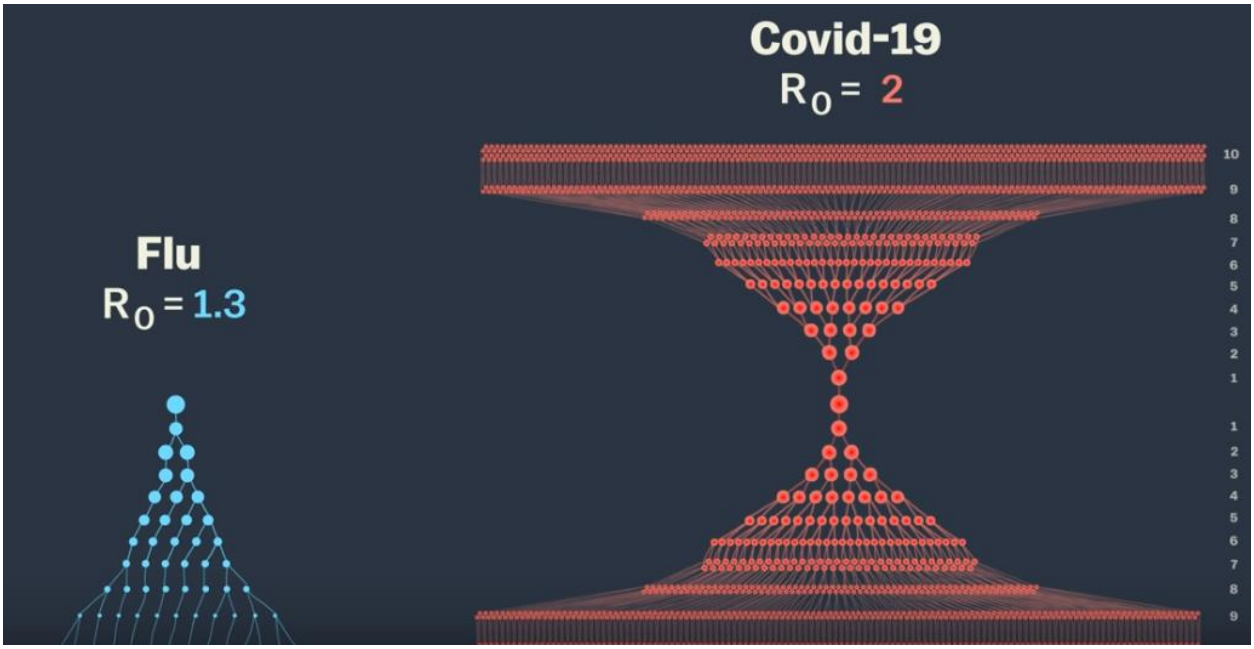

Figure 1[6]

Figure 1 shows the spread rate of COVID-19 in comparison to seasonal flue, where the points represent infected individuals. It can be concluded that COVID-19 is spreading much faster. If one person infects the other two persons, those two persons infect two more people…, after 10 rounds there can be up to 2047 new cases, while with the common flu this number reaches the maximum of 56 people[7]. The main obstacle to fighting the virus is that the vaccine for COVID-19 has only recently been let in use, and is still causing distrust among people, what makes virus prevention to rely on civic responsibility. This includes isolation of individuals and reduced human contact.

Already in early March 2020, Europe surpassed China in the number of infected cases and the WHO declared it an active center of the COVID-19 pandemic[8]. The number of cases doubled in Europe every 3 to 4 days, and in some countries in every two days[9]. By March 17th, all European countries except Montenegro had reported the first cases of COVID-19. Montenegro is the last European country to report coronavirus. At least one death has been reported in every country in Europe, apart from the Vatican City.

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[6]"*Coronavirus is not the flu. It's worse.* (2020, April 1). [Video]. YouTube. https://www.youtube.com/watch?v=FVIGhz3uwuQ Accessed 23.01.2020..

[7] Ibid.

[8] *Fredericks B (13 March 2020). "WHO says Europe is new epicenter of coronavirus pandemic"* https://nypost.com/2020/03/13/who-says-europe-is-new-epicenter-of-coronavirus-pandemic/ Accessed 22.01.2021.

[9]Max Roser, Hannah Ritchie, Esteban Ortiz-Ospina and Joe Hasell (2020) - "Coronavirus Pandemic (COVID-19)". *Published online at OurWorldInData.org.* https://ourworldindata.org/coronavirus Accessed 23.01.2021.

As a result of the difficulty in controlling the spread of the virus, many states have announced a lockdown, thus disabling any human contact for an extended period of time. The duration and severity (strength of the measures) of the lockdown varies in different countries. Until end of March, more than 250 million people were in lockdown in Europe[10].

There are in general two types of lockdowns:

- Internal lockdown – may represent the isolation of the individual, the introduction of new measures such as limiting the number of people at gatherings or even curfew.
- External lockdown – many states closed their borders during the pandemic. Some of them thus banned entrance to all citizens, while some banned entrance only to foreign citizens without a residence permit or citizenship. This has caused great surprise and outrage among most EU citizens, as it violates freedom of movement, but this right is guaranteed by Article 21 of the Treaty on the Functioning of the EU (TFEU).[11]

Since the etymological origin of this virus is unknown, ways to control it still pose a serious challenge in the world. At least 246 vaccine projects have started against Covid-19 since January 2020 and according to listing as of 12th January 2021 the World Health Organization currently counts 235 of them. Since vaccines have not been tested in practice before, they mostly cause distrust among citizens, and the suppression of this virus still relies on civic responsibility. Some of the measures that people should adhere to are: wearing the mask over the face and mouth, avoiding crowds, often washing hands, cleaning and disinfecting frequently touched surfaces daily, and many others**.**

2. Big Data and Artificial Intelligence in Managing the COVID-19 Pandemic

In the last year, Artificial Intelligence (AI) has made great contributions in the field of medicine. In the medical industry, it has become necessary to find a way to control and monitor the spread of the virus, as well as the ability to accurately predict its further development.

The advantage of Machine learning (ML) tools is that they enable monitoring of virus spread, identification of high-risk patients, as well as prediction of mortality risk based on

[10] *Henley, Jon (18 March 2020). "More than 250m in lockdown in EU as Belgium and Germany adopt measures".* https://www.theguardian.com/world/2020/mar/18/coronavirus-lockdown-eu-belgium-germany-adopt-measures Accessed 20.01.2021.
[11] Article 26 Consolidated version of the Treaty on the Functioning of the European Union Accessed 20.01.2021

patient data[12]. This technology has a good predisposition to reduce the treatment process and improve the health conditions of the infected ones. When it comes to recognizing the symptoms of a virus, AI performs test analyzes and pattern recognition with the greatest possible precision.

Thanks to the latest improvements in the field of computational techniques and information and communication technologies (ICTs), artificial intelligence and Big Data can help handle a huge, extraordinary amount of data. Data can be related to public health surveillance, real-time epidemic outbreaks monitoring, trend now-casting/forecasting, regular situation briefing and updating from governmental institutions and organisms, and health resources utilization information[13].

Big Data is defined through three main characteristics:

- Velocity - Big Data is known also as "fast data" and it requires an extraordinary speed of data acquisition, processing, and manipulation.
- Volume - High amount of information available.
- Variety - There are many different sources and channels that can produce and release Big Data.

Based on source, there are different types of Big Data, and some of them are:

- molecular Big Data - obtained by means of wet-lab techniques and OMICS-based approaches, such as genomics, and post-genomics specialties, including proteomics, and interactomics[14].
- imaging-based Big Data - like radionics or the massive data-mining approach to extract clinically meaningful, high-dimensional information from images[15].
- sensor-based Big Data

[12] Raju Vaishya, Mohd Javaid, Ibrahim Haleem Khan, Abid Haleem, Artificial Intelligence (AI) applications for COVID-19 pandemic, Diabetes & Metabolic Syndrome: Clinical Research & Reviews, Volume 14, Issue 4, 2020, Pages 337-339, ISSN 1871-4021, https://www.sciencedirect.com/science/article/pii/S1871402120300771#bib1 Accessed 10.12.2020.

[13] Bragazzi, N. L., Dai, H., Damiani, G., Behzadifar, M., Martini, M., & Wu, J. (2020). How Big Data and Artificial Intelligence Can Help Better Manage the COVID-19 Pandemic. *International Journal of Environmental Research and Public Health*, *17*(9), 3176. https://doi.org/10.3390/ijerph17093176 Accessed 11.12.2020.

[14] Bragazzi, N. L., Dai, H., Damiani, G., Behzadifar, M., Martini, M., & Wu, J. (2020). How Big Data and Artificial Intelligence Can Help Better Manage the COVID-19 Pandemic. *International Journal of Environmental Research and Public Health*, *17*(9), 3176. https://doi.org/10.3390/ijerph17093176 Accessed 11.12.2020.

[15] Ibid.

- digital and computational Big Data – incredible wealth of information produced by the internet, smart phones, and other mobile devices[16].

In the following articles will be discussed some of the major possible applications of AI and Big Data for the management of COVID-19.

2.1 Controlling the Spread of COVID-19 Infection

Advances of Artificial Intelligence gained special significance in 2019 with the emergence of the newly formed COVID-19 virus. The virus took seven days to get identified, what is a significantly shorter period of time compared to SARS Coronavirus (SARS-CoV), that appeared in 2013 and was identified for the first time after four months[17]. The AI algorithm identified the COVID-19 virus for the human population and sent an alert on the 31st of December, 2019, seven days before the World Health Organization issued official publishing of the epidemic. Big Data Models and Machine Learning make a major contribution to model training and prediction model development, and thus more quickly identify the danger of a rapid spread of infection to take the necessary measures as soon as possible. Artificial Intelligence can provide monitoring, analysis, early warning, diagnosis, and prognosis also as social control.

Big Data can be used to control and analyze disease outbreak as it comes. The coronavirus epidemic differs from the earlier pandemics in a way that open-access datasets containing the daily number of new infections are disaggregated by country. Based on this information in combination with the stored information on human movement, Artificial Intelligence can, with mathematical modeling, monitor the spread of the virus, as well as determine its degree of danger.

Big data collected through social media enable the remodeling of the early epidemiological story of the outbreak[18]. For example, Sun and colleagues[19] collected research data from health-care-oriented social network DXY.cn, global news media

[16] Bragazzi, N. L., Dai, H., Damiani, G., Behzadifar, M., Martini, M., & Wu, J. (2020). How Big Data and Artificial Intelligence Can Help Better Manage the COVID-19 Pandemic. *International Journal of Environmental Research and Public Health*, *17*(9), 3176. https://doi.org/10.3390/ijerph17093176 Accessed 11.12.2020.

[17] World Health Organization (WHO), "Severe Acute Respiratory Syndrome (SARS)" https://www.who.int/ith/diseases/sars/en/ Accessed 10.11.2020.

[18] Bragazzi, N. L., Dai, H., Damiani, G., Behzadifar, M., Martini, M., & Wu, J. (2020). How Big Data and Artificial Intelligence Can Help Better Manage the COVID-19 Pandemic. *International Journal of Environmental Research and Public Health*, *17*(9), 3176. https://doi.org/10.3390/ijerph17093176 Accessed 11.12.2020.

[19] Sun, K., Chen, J., & Viboud, C. Early epidemiological analysis of the coronavirus disease 2019 outbreak based on crowdsourced data: A population-level observational study. Lancet Digit. Health 2020. https://www.thelancet.com/journals/landig/article/PIIS2589-7500(20)30026-1/fulltext#seccestitle80 Accessed 20.12.2020

sources, national governments, and health authorities to study the outbreak development in China. The study included an assessment of the delay between the onset of symptoms, hospitalization and reporting of increased awareness of increased spread of infection. Study was published in real time.[20]

Then as well, Qin and coworkers forecasted the number of new infected cases by using Big Data. "They used a backlog of "Social media search indexes" (SMSI) for various keywords, including clinical symptoms of COVID-19 (such as dry cough, fever, chest, and pneumonia)" [21]. The authors found that by applying techniques such as the subgroup selection method, new suspected and confirmed cases of COVID-19 could be detected up to 10 days in advance, respectively.

Metabiota, one of the epidemiological surveillance companies, which used a predictive AI tool to search data from news, airline tickets, and animal disease outbreaks to determine and warn that countries such as Thailand, South Korea, Taiwan, and Japan are immediately vulnerable to coronavirus outbreak one week before it is officially confirmed in those countries.[22]

ML is the basis for developing smartphone applications to monitor the geographical spread of coronavirus and identify the riskiest regions. Through the application, each user will be informed about the current potential foci of infection, so that he/she can avoid them. There are many AI tools for this purpose such as the BlueDot infection risk detection platform, that uses chat boxes used as virtual assistants to provide virus information, or diagnostic robots to diagnose the disease.[23]

Legal frameworks play an important role in guiding issues such as data collection and exchange, leading to greater receptivity by the health community. Nonetheless, the lack of protocol standardization also means that the scope of the analyzed data is limited to certain areas. Hence, results from certain medical and geographical regions may not apply to others.[24]

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[20] Sun, K., Chen, J., & Viboud, C. Early epidemiological analysis of the coronavirus disease 2019 outbreak based on crowdsourced data: A population-level observational study. Lancet Digit. Health 2020. https://www.thelancet.com/journals/landig/article/PIIS2589-7500(20)30026-1/fulltext#seccestitle80 Accessed 20.12.2020

[21] Qin, L., Sun, Q., Wang, Y., Wu, K.F., Chen, M., Shia, B.C., & Wu, S.Y. Prediction of Number of Cases of 2019 Novel Coronavirus (COVID-19) Using Social Media Search Index. Int. J. Environ. Res. Public Health 2020, 17, 2365. https://www.mdpi.com/1660-4601/17/7/2365 Accessed 19.12.2020.

[22] Monitoring and risk analytics for the 2019 novel coronavirus(COVID-19) epidemic, Metabiota Risk Report No. 3, 25.02.2020, https://metabiota.com/sites/default/files/inline-files/Metabiota_Risk_Report_No.3-25Feb2020-COVID-2019_0.pdf Accessed 8.11.2020.

[23] Tang, V., (October 15, 2020), How BlueDot Leverages Data Integration to Predict COVID-19 Spread, Safe Software, https://www.safe.com/blog/2020/10/bluedot-leverages-data-integration-predict-covid-19-spread/ Accessed 07.11.2020.

[24] Allam, Z., Dey, G., & Jones, D. (2020). Artificial Intelligence (AI) Provided Early Detection of the Coronavirus (COVID-19) in China and Will Influence Future Urban Health Policy Internationally. *AI*, *1*(2), 156–165. doi:10.3390/ai1020009 Accessed 07.11.2020.

BlueDot and Metabiota are companies who made a great contribution to the monitoring and forecasting of COVID-19. These two companies were among the first to recognize the virus and give accurate predictions of risky countries.

2.1.1 BlueDot

BlueDot, a Toronto-based digital healthcare company, has reached its peak during the last year as an innovator in the medical technology market. Their platform provides specific information and intelligence to ensure that the world responds effectively and in real time to the dangers of infectious diseases.

Their software is primarily designed to locate, monitor, and predict the spread of an infectious disease. The BlueDot engine collects data on over 150 diseases and syndromes worldwide that are searched every 15 minutes, 24 hours a day[25]. This includes official data from organizations such as the Centers for Disease Control or the World Health Organization[26]. But the system also relies on less structured information[27].

On the 30th of December, 2019., the platform has collected a set of cases of "unusual pneumonia" that occurred around a market in Wuhan, China, and spotted a potential danger nine days before the world first time heard of the Coronavirus. “The new respiratory illness COVID-19 has since spread to 58 countries and infected more than 87,000 people globally with 104 deaths outside China”[28].

“WHO Director-General Tedros Adhanom Ghebreyesus said on 25th of February that COVID-19 absolutely has the potential to become a pandemic. Kamran Khan, the founder and CEO of BlueDot, who is also a professor of medicine and public health at the University of Toronto, told to CNBC in December that the virus will be spread large quantities”[29].

Artificial Intelligence and Machine Learning technologies became ground for company’s predictions of the outbreak and spread of the virus. These powerful tools include various

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[25] *Word on the Streets:: Tech for good in the fight against coronavirus*. (2020, 21. Mai). Word On The Streets. https://www.wordonthestreets.net/Articles/578049/Tech_for_good.aspx Accessed 09.11.2020.
[26] Murray and Nadel's Textbook of Respiratory Medicine. 2016 : 557–582.e22. Published online 2015 Apr 3. doi: 10.1016/B978-1-4557-3383-5.00033-6. Accessed 09.11.2020.

[27] Bowles, J. (2020, March 20). *How Canadian AI start-up BlueDot spotted Coronavirus before anyone else had a clue*. Diginomica. https://diginomica.com/how-canadian-ai-start-bluedot-spotted-coronavirus-anyone-else-had-clue Accessed 15.11.2020.

[28] M. (2020, March 3). *How this Canadian start-up spotted coronavirus before everyone else knew about it - CNBC*. CNBC. https://causes-of-high-fever.blogspot.com/2020/03/how-this-canadian-start-up-spotted.html Accessed 11.11.2020.
[29] Stieg, C. (2020, March 6). *How this Canadian start-up spotted coronavirus before everyone else knew about it.* CNBC. https://www.cnbc.com/2020/03/03/bluedot-used-artificial-intelligence-to-predict-coronavirus-spread.html Accessed 15.11.2020.

natural language processing algorithms and thus expand the sources of research information. More than 10,000 official and media sources, with over 60 languages, are processed daily. The data set includes information such as population density, global infectious disease warning, real-time climatic conditions, and insect and animal vectors[30].

"When an unusual event is detected, a computer uses airline ticket sales data from over 4,000 airports around the world to predict the spread of the disease, and then human experts in fields such as public health, medicine, and epidemiology are responsible for checking computer findings and generating reports for your customers"[31].

Based on natural language processing and machine learning, this platform finds information on various pathogens, such as time, location and other contextual data (number of cases and deaths)[32]. The main intention is to obtain organized, structured and useful data on the spatio-temporal pathogen on the basis of unstructured textual data, where the space and time and the name of the pathogen become known. Company uses anonymous location data from hundreds of millions of mobile phones to surveille public health response to COVID-19 works[33].

A strong portfolio of patents brought BlueDot to its peak and made it the current leader in AI in healthcare. Many aspects of the patent strategy can be imitated by others, seeking to develop or improve their technology, as well as for the early filing of patent applications and examination of the checking patent portfolio. "The claims in the Warning System for Infectious Diseases and Method Thereof patent cover a computer system for processing or modeling data in a global database of pathogen risk factors, a global database of pathogenic activities and a global database of transport. Claims do not limit the scope of protection to AI, moreover the computer system can use traditional data science methods of analyzing data or AI"[34].

Given that the health technology sector is expanding in terms of increasing cooperation with companies, it is crucial to protect their basic intellectual property. BlueDot's

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[30] Allam, Z., Dey, G., & Jones, D. S. (2020). Artificial intelligence (AI) provided early detection of the coronavirus (COVID-19) in China and will influence future Urban health policy internationally. *AI*, *1*(2), 156-165. DOI: https://doi.org/10.3390/ai1020009 Accessed 11.11.2020.

[31] Caulder, I., Kovarik, R., & Cowan, C. (2020, July 30). *AI in Focus: BlueDot and the Response to COVID-19*. Lexology. https://www.lexology.com/library/detail.aspx?g=a94f63b4-2829-4f62-97f7-43f2aecd12a6 Accessed 14.11.2020.

[32] Bowles, J. (2020b, March 20). *How Canadian AI start-up BlueDot spotted Coronavirus before anyone else had a clue*. Diginomica. https://diginomica.com/how-canadian-ai-start-bluedot-spotted-coronavirus-anyone-else-had-clue Accessed 15.11.2020.

[33] Caulder, I., Kovarik, R., & Cowan, C. (2020a, July). *AI in focus: BlueDot and the response to COVID-19*. Bereskin & Parr. https://www.bereskinparr.com/doc/ai-in-focus-bluedot-and-the-response-to-covid-19 Accessed 16.11.2020.

[34] Whitaker, B. (2020, May 7). *Outbreak Science: Using artificial intelligence to track the coronavirus pandemic - 60 Minutes*. CBS News. https://www.cbsnews.com/news/coronavirus-outbreak-computer-algorithm-artificial-intelligence/ Accessed 16.11.2020.

experience with patents, investments, and business growth illustrates the concrete benefits of early patent filing.[35]

2.1.2 Metabiota

Metabiota is a global company that cooperates with industry and governments around the world to fight against epidemics and protect global public health. Their platform offers a new way to understand, view, and analyze epidemics. “It provides detailed information for over 120 distinct pathogens including a profile, history, and up-to-date disease statistics”[36].

What Metabiota and BlueDot have in common is that both companies use natural language processing (NLP) algorithms to track health news and official reports in different languages around the world, and their forecasting tools relies on air travel data for risk assessment[37].

The modeling framework used by Metabiota consists of a stochastic population section model linked to human mobility networks. The first prediction results were obtained by simulating 200 Covid-19 outbreaks encompassing a series of plausible parameter values with initial conditions similar to the ones reported on the 26th of January, 2020. [38]

The first forecast predicted that the median of 85,000 cases will be registered by February 17th, which resulted with deviation of ~ 16% compared to 73,000 cases reported on that day. Following its publication, the rate of virus transmission in China proved to be significantly slower, so the model needed to be improved by including process slowdown intervention[39].

On February 3rd, 2020, was reported that around 127,000 cumulative cases worldwide was expected to be registered until March, and that showed as an accurate forecast[40]. A median of 127,000 cumulative cases within the 95% confidence window of 81,500 and 295,000 cases on 3rd March was projected[41].

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[35] *BlueDot for Healthcare | Outbreak SaaS for enterprise risk management*. (2020, September 15). BlueDot. https://bluedot.global/healthcare/ Accessed 10.11.2020.

[36] *Epidemic Tracker | Metabiota*. (2020). Metabiota. https://www.metabiota.com/epidemic-tracker Accessed 12.11.2020.

[37] Heaven, W. D. (2020, April 10). *AI could help with the next pandemic—but not with this one*. MIT Technology Review. https://www.technologyreview.com/2020/03/12/905352/ai-could-help-with-the-next-pandemicbut-not-with-this-one/ Accessed 15.11.2020.

[38] *Epidemic Tracker | Metabiota*. (2020b). Metabiota. https://www.metabiota.com/epidemic-tracker Accessed 12.11.2020.

[39] Ibid.

[40] Ibid.

[41] *Home | Metabiota*. (2020). Metabiota. https://metabiota.com/ Accessed 14.11.2020.

According to the February 2020 model, the countries expected to have a large number of people infected with the virus are China, Japan, Italy, Iran, Thailand, South Korea, the United States, Taiwan, Australia, and the Philippines[42] (Figure 2).

Figure 2: Rank of Number of New Cases by Country, February 25-March 3, 2020

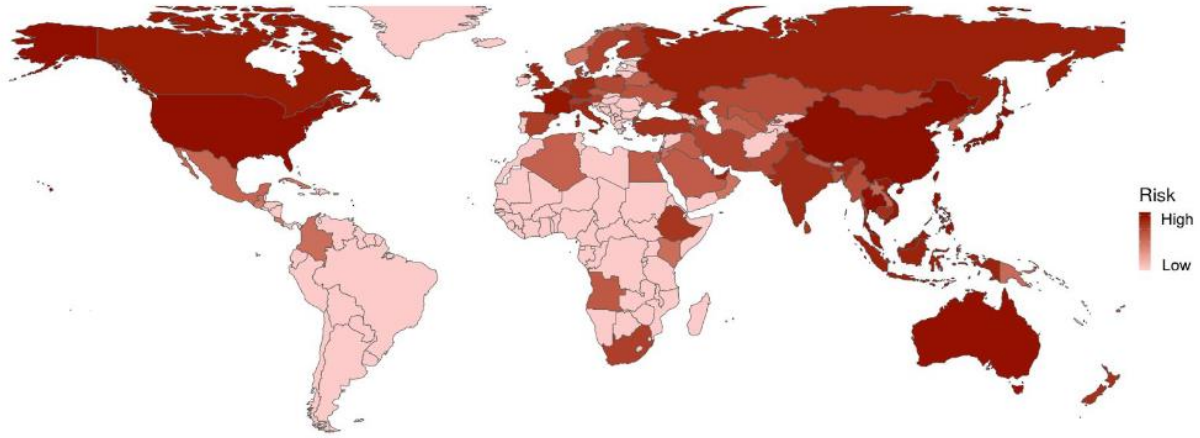

Figure 2[43]

Metabiota's latest public report, which predicted that there will be 127,000 cumulative cases worldwide on March 3rd, proved to be fairly accurate. It exceeded by about 30,000, but Mark Gallivan, director of the data science firm, claimed that was still within the margin of error. Besides, Gallivan also claimed that countries such as China, the United States, Italy, and Iran are likely to have a large number of new cases[44]. The prediction model assessed the geographical spread of the virus based on air travel and road networks to simulate population mobility.

[42]Metabiota: Metabiota Risk Report No. 3: February 25, 2020 Monitoring and risk analytics for the 2019 novel coronavirus (COVID-19) epidemic, 2020. Accessed 15.11.2020.
[43]Ibid.
[44] Heaven, W. D. (2020b, April 10). *AI could help with the next pandemic—but not with this one*. MIT Technology Review. https://www.technologyreview.com/2020/03/12/905352/ai-could-help-with-the-next-pandemicbut-not-with-this-one/ Accessed 15.11.2020.

2.2 Diagnosing COVID-19's Cases

Early detection by using Artificial Intelligence can be accomplished with X-ray, magnetic resonance imaging, and computed tomography (CT). Furthermore, diagnostic results can help make informed and rapid decisions.

"The early diagnosis and quarantine of COVID-19-positive cases are among the most effective solutions to combat the COVID-19 pandemic" [45]. Reverse transcription-polymerase chain reaction (RT-PCR) is used as the standard method for the classification of respiratory viruses. Since it requires specific materials, equipment, and instruments downside of this method lies in big cost and time-consuming. Also, it does not provide fast detection and tracking during the COVID-19 pandemic. Furthermore, many countries lack testing equipment due to insufficient budgets.[46]

The lack of diagnostic equipment has become one of the barriers to effective identification and management of infected individuals to combat further infections, and the need for highly sensitive diagnostic tools by healthcare professionals to achieve faster identification of potential COVID-19's cases is growing.[47]

"The use of AI methods in image processing, specifically for medical related images, is a low cost, fast, and simple way of identifying and diagnosing COVID-19"[48]. AI technology in healthcare is still new and still evolving in line with the medical field. Therefore, most estimates and operations are still performed by employees and depend on their interpretations, which are often time-consuming and do not have the comprehensiveness of data estimates.[49]

Fast decision making is one of the main characteristics of AI that can be effectively applied when it comes to establishing a diagnosis or recognizing symptoms. Increasing the transmission rate has created different common approaches among stakeholders to

[45] Alsharif, M.H.; Alsharif, Y.H.; Chaudhry, S.A.; Albreem, M.A.M.; Artificial intelligence technology for diagnosing COVID-19 cases: a review of substantial issues. European review for medical and pharmacological sciences. https://www.europeanreview.org/wp/wp-content/uploads/9226-9233-1.pdf Accessed 22.12.2020.
[46] Ibid.
[47] Metabiota: Metabiota Risk Report No. 3: February 25, 2020 Monitoring and risk analytics for the 2019 novel coronavirus (COVID-19) epidemic, 2020. Accessed 15.11.2020.
[48] Alsharif, M.H.; Alsharif, Y.H.; Chaudhry, S.A.; Albreem, M.A.M.; Artificial intelligence technology for diagnosing COVID-19 cases: a review of substantial issues. European review for medical and pharmacological sciences. https://www.europeanreview.org/wp/wp-content/uploads/9226-9233-1.pdf Accessed 22.12.2020.
[49] E. (2020, August 7). *Artificial Intelligence (AI) Provided Early Detection of the Coronavirus (COVID-19) in China and Will Influence Future Urban Health Policy Internationally*. Middle East Medical Portal. https://www.middleeastmedicalportal.com/artificial-intelligence-ai-provided-early-detection-of-the-coronavirus-covid-19-in-china-and-will-influence-future-urban-health-policy-internationally/ Accessed 11.11.2020.

develop innovative ways of reviewing, detecting, and diagnosing COVID-19 cases among people at a proportionate rate.[50]

Analysis of chest X-rays is one of the ways to identify the infection, which, thanks to artificial intelligence, healthcare professionals do not have to perform. Instead, a deep convolutional network model is used to classify X-ray images into normal, pneumonia, and COVID-19.[51]

2.2.1 CNN Model VGG16 for Classification and Detection

"VGG16 is a convolutional neural network model proposed by K. Simonyan and A. Zisserman from the University of Oxford in the paper "Very Deep Convolutional Networks for Large-Scale Image Recognition""[52].

The VGGR16 architecture is the basis of a platform for analyzing X-ray images with the goal of detecting coronavirus infection. This solution is proposed with goal for an initial detection of suspicious and critical cases and above all to minimize the burden on testing laboratories. "COVID-19 causes pneumonia, lungs inflammation and possibly attacks the respiratory tract, so it is essential to think about making chest X-ray images which will be useful to know, initially, whether the patient is a confirmed case or not".[53]

Platform works in a way that the user manually inserts the patient's information and downloads the radio image, and towards the end starts the test. The test takes 5 seconds and then a document will be generated containing all the information about the test and the X-ray image[54]. The platform calculates statistics and allows the user to view the number of confirmed, cured and dead cases. It also offers guidance and measures to better manage suspicious cases.

It is an intelligent and open platform that can quickly detect COVID-19 virus in a patient using chest X-rays and the VGG16 architecture. The platform consists of three parts:[55]

- Display of statistics concerning confirmed cases, new cases, cured cases and deaths

[50] Mei, X., Lee, HC., Diao, Ky. *et al.* Artificial intelligence–enabled rapid diagnosis of patients with COVID-19. *Nat Med* **26,** 1224–1228 (2020). https://doi.org/10.1038/s41591-020-0931-3 Accessed 7.11.2020.
[51] Sun, H., Yumou, Q., Han, Y., Yaxuan, H., Yuru, Z., Song, X. C.; Tracking and Predicting COVID-19 Epidemic in China Mainland. Preprint. Epidemiology, February 20, 2020. https://doi.org/10.1101/2020.02.17.20024257. Accessed 14.11.2020.
[52] Hassan, M. U. (2018, November 21). *VGG16 – Convolutional Network for Classification and Detection*. Neurohive. https://neurohive.io/en/popular-networks/vgg16/ Accessed 01.12.2020.
[53] Mohamed Tabaa, Hamza Fahmani, Mehdi El ouakifi, Hassna Bensag, Covid-19's Rapid diagnosis Open platform based on X-Ray Imaging and Deep Learning, Procedia Computer Science, Volume 177, 2020, Pages 618-623, ISSN 1877-0509, https://doi.org/10.1016/j.procs. 2020.10.088. Accessed 2.12.2020.
[54] Ibid.
[55] Ibid.

- Awareness messages for the radiology laboratories
- Test platform

It is important to mention that although platform gave excellent results, it is still not validated by the official medical authorities, and therefore, still not used in practice.

Dataset

For training, VGG16 uses images from ImageNet. ImageNet is a database containing over 15 million variable resolution images. Images were downloaded from the web and tagged using Amazon's Mechanical Turk crowd-sourcing tool.

Since the COVID-19's cases diagnostic platform is based on X-ray image analysis, the training database of this platform should contain as many images as possible to ensure correct decision making via the AI model. The database is required to contain a chest X-ray or CT image of actual COVID-19's cases. These can be COVID-19 cases for MERS, SARS and ARDS cases. The database currently has 100 images of confirmed COVID-19 cases and 100 images of common cases.

On Figure 3 is example of X-Ray images for the two cases: Normal and COVID-19.

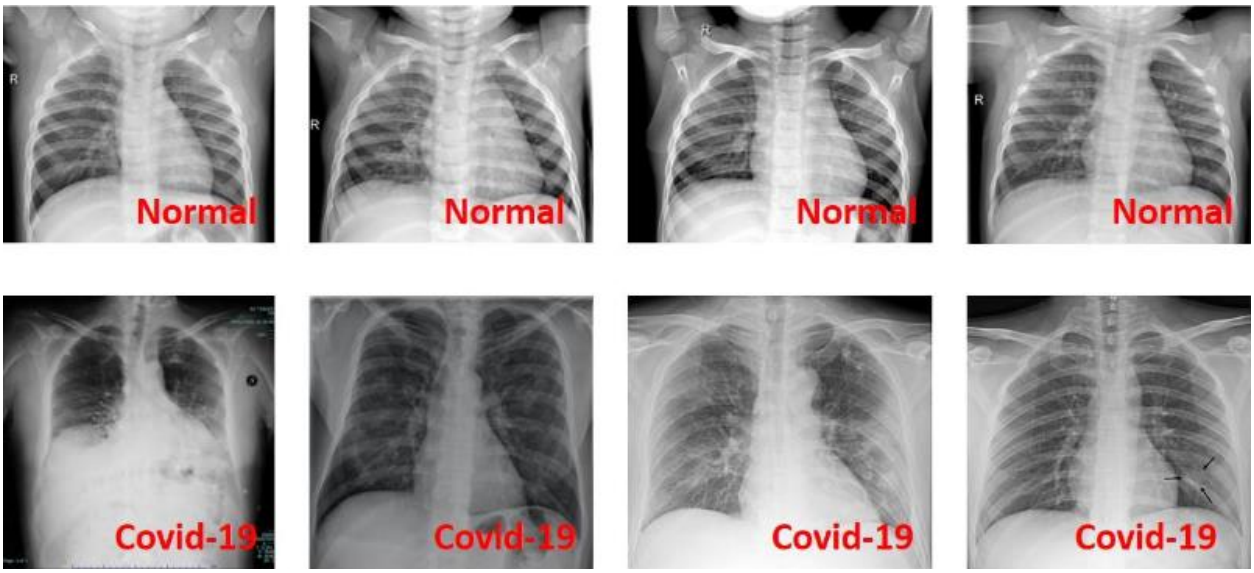

Figure 3[56]

[56] Mohamed Tabaa, Hamza Fahmani, Mehdi El ouakifi, Hassna Bensag, Covid-19's Rapid diagnosis Open platform based on X-Ray Imaging and Deep Learning, Procedia Computer Science, Volume 177, 2020, Pages 618-623, ISSN 1877-0509, https://doi.org/10.1016/j.procs.2020.10.088. Accessed 2.12.2020.

Figure 4 presents training loss and accuracy on COVID-19 Dataset.

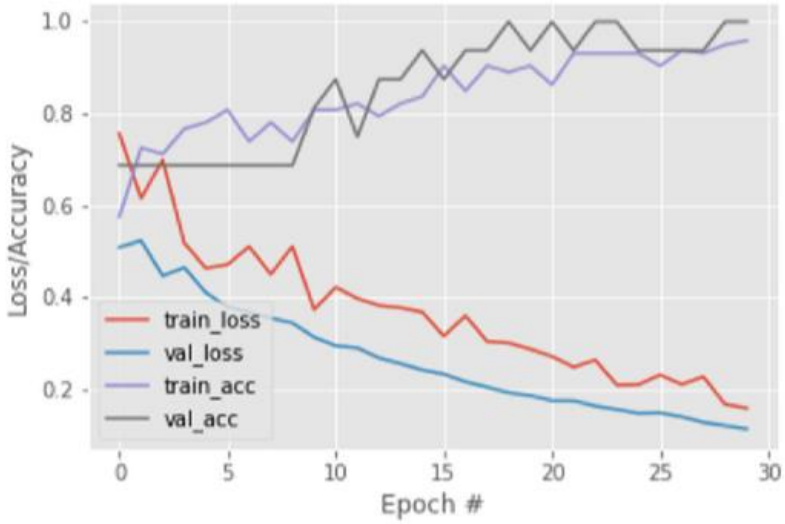

Figure 4[57]

VGG16 Model

The VGG16 architecture is the result of participation in the Large Scale Visual Recognition Challenge in 2014, where the model achieved 92.7% of imageNet tests. Intelligent architecture relies on 3×3 filter convolution layers with a pitch of 1, using the same padding and the same 2×2 filter max-pool layer with a pitch of 2. It follows the curvature and layout of the maximum pool layer throughout the architecture. This CNN network uses 138 million parameters. Number 16 in the name "VGG16" represents 16 layers that have different weights, as can be seen in Figure 5.[58]

The input to the cov1 layer is a fixed size of 224 x 224 RGB images. After the initial layer (cov1), the image goes through many convolutional layers, where filters are used with the receptive field 3×3. That is the smallest size to capture the notion. The convolution stride has fix size of 1 pixel. The spatial coating of the input of the convolution layer is such that the spatial resolution is retained after the convolution. The Spatial coating is carried out by five max-pooling layers, which follow some of the convolution layers (not all the layers are followed by max-pooling).[59]

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[57] Mohamed Tabaa, Hamza Fahmani, Mehdi El ouakifi, Hassna Bensag, Covid-19's Rapid diagnosis Open platform based on X-Ray Imaging and Deep Learning, Procedia Computer Science, Volume 177, 2020, Pages 618-623, ISSN 1877-0509, https://doi.org/10.1016/j.procs.2020.10.088. Accessed 2.12.2020.
[58] Ibid.
[59] Hassan, M. U. (2018, November 21). *VGG16 – Convolutional Network for Classification and Detection*. Neurohive. https://neurohive.io/en/popular-networks/vgg16/ Accessed 01.12.2020.

Three fully connected layers follow a series of convolutional layers, with the layer depth varying depending on the architecture. The first two FC layers have 4096 channels each, the third performs ILSVRC (Large Scale Visual Recognition Challenge) classification in 1000 directions and thus contains 1000 channels (one for each class). The final layer is a soft-max layer. The configuration of fully connected layers is the same in all networks.[60]

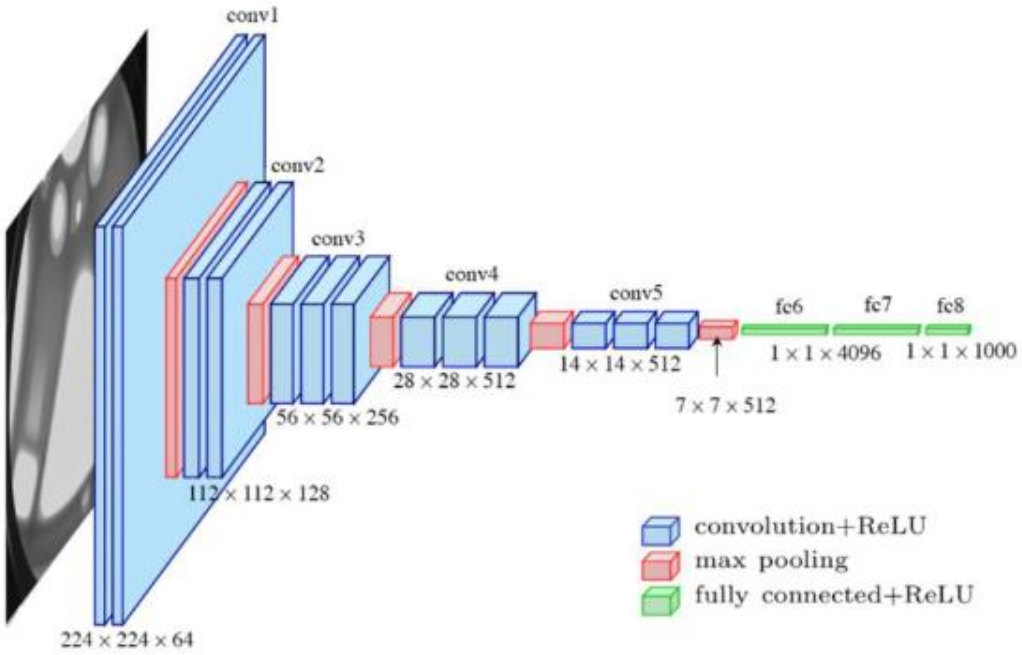

Figure 5[61]

Configurations

Configurations ConvNet are shown on Figure 6, where nets are referred to their names (A-E). All configurations follow the generic design present in the architecture and differ only in depth. Width of conv. layers (number of channels) is quite small, starting from 64 in the first layer, and then increasing by a factor of 2 after each layer of maximum aggregation, until it reaches 512.

[60] Ibid.
[61] Ibid.

ConvNet Configuration					
A	A-LRN	B	C	D	E
11 weight layers	11 weight layers	13 weight layers	16 weight layers	16 weight layers	19 weight layers
input (224 × 224 RGB image)					
conv3-64	conv3-64 **LRN**	conv3-64 **conv3-64**	conv3-64 conv3-64	conv3-64 conv3-64	conv3-64 conv3-64
maxpool					
conv3-128	conv3-128	conv3-128 **conv3-128**	conv3-128 conv3-128	conv3-128 conv3-128	conv3-128 conv3-128
maxpool					
conv3-256 conv3-256	conv3-256 conv3-256	conv3-256 conv3-256	conv3-256 conv3-256 **conv1-256**	conv3-256 conv3-256 **conv3-256**	conv3-256 conv3-256 conv3-256 **conv3-256**
maxpool					
conv3-512 conv3-512	conv3-512 conv3-512	conv3-512 conv3-512	conv3-512 conv3-512 **conv1-512**	conv3-512 conv3-512 **conv3-512**	conv3-512 conv3-512 conv3-512 **conv3-512**
maxpool					
conv3-512 conv3-512	conv3-512 conv3-512	conv3-512 conv3-512	conv3-512 conv3-512 **conv1-512**	conv3-512 conv3-512 **conv3-512**	conv3-512 conv3-512 conv3-512 **conv3-512**
maxpool					
FC-4096					
FC-4096					
FC-1000					
soft-max					

Figure 6[62]

Platform Drawbacks

Two biggest disadvantages of VGGNet are:

1. Requires a lot of time and effort to train the network.
2. The network architecture weights are quite large.
3. Setting up a VGG is a difficult job. By cause of its depth and number of fully-connected nodes, VGG16 is over 533MB.

Although VGG16 is used in many deep learning image classification problems, smaller network architectures, such as SqueezeNet and GoogLeNet, are usually favored.

[62] Hassan, M. U. (2018b, November 21). *VGG16 – Convolutional Network for Classification and Detection*. Neurohive. https://neurohive.io/en/popular-networks/vgg16/ Accessed 01.12.2020.

Model Success

VGG16 model achieves 92.7% top-5 test accuracy in ImageNet and it was one of the famous model submitted ILSVRC-2014 (Large Scale Visual Recognition Challenge 2014). At the ILSVRC-2012 and ILSVRC-2013 competitions, the model proved to be much more advanced compared to the previous generation models. When it comes to single network performance, this VGG16 architecture with 7.0% test error outperformed a single GoogLeNet by 0.9%.[63] (Figure 7)

Method	top-1 val. error (%)	top-5 val. error (%)	top-5 test error (%)
VGG (2 nets, multi-crop & dense eval.)	**23.7**	**6.8**	**6.8**
VGG (1 net, multi-crop & dense eval.)	24.4	7.1	7.0
VGG (ILSVRC submission, 7 nets, dense eval.)	24.7	7.5	7.3
GoogLeNet (Szegedy et al., 2014) (1 net)	-	7.9	
GoogLeNet (Szegedy et al., 2014) (7 nets)	-	**6.7**	
MSRA (He et al., 2014) (11 nets)	-	-	8.1
MSRA (He et al., 2014) (1 net)	27.9	9.1	9.1
Clarifai (Russakovsky et al., 2014) (multiple nets)	-	-	11.7
Clarifai (Russakovsky et al., 2014) (1 net)	-	-	12.5
Zeiler & Fergus (Zeiler & Fergus, 2013) (6 nets)	36.0	14.7	14.8
Zeiler & Fergus (Zeiler & Fergus, 2013) (1 net)	37.5	16.0	16.1
OverFeat (Sermanet et al., 2014) (7 nets)	34.0	13.2	13.6
OverFeat (Sermanet et al., 2014) (1 net)	35.7	14.2	-
Krizhevsky et al. (Krizhevsky et al., 2012) (5 nets)	38.1	16.4	16.4
Krizhevsky et al. (Krizhevsky et al., 2012) (1 net)	40.7	18.2	-

Figure 7[64]

It was demonstrated that the representation depth helps the classification accuracy, and that advanced performance on the ImageNet challenge dataset can be accomplished using a conventional ConvNet architecture with essentially boosted depth.

2.2.2 AI in Treatment of COVID-19's Patients

Numerous studies are currently being conducted around the world on the topic of personalizing drug choices using biomarkers for predictive imaging of treatment

[63] Hassan, M. U. (2018, November 21). *VGG16 – Convolutional Network for Classification and Detection*. Neurohive. https://neurohive.io/en/popular-networks/vgg16/ Accessed 01.12.2020
[64] Ibid.

responses. In the United States, the National Institutes of Health (NIH) is currently conducting a double-blind study of remdesivir vs. placebo in patients with COVID-19 with pneumonia and hypoxia. Both hydroxychloroquine and chloroquine have in vitro activity against the COVID-19 virus.[65] China has randomized controlled trials on tocilizumab (an IL-6 receptor blocker) for patients with COVID-19 pneumonia and elevated IL-6[66].

Artificial Intelligence can form complex models from broad data sources to identify tailored therapies for patients. To predict therapy and treatment options, Artificial Intelligence uses radionics to characterize the biological basis of various disease processes. Similarly, in the case of coronavirus, if one or more of these models can be prospectively validated, they could inform algorithms and treatment guidelines tailored to patients whose symptoms can range from mild symptoms to death. Chest imaging is only one part of this procedure. Sources of clinical data include history, vital signs, laboratory tests, and images, but also new modalities such as geospatial information and textual processing of the scientific literature.[67]

2.3 Monitoring the treatment

Artificial Intelligence has good potential to build an intelligent platform for automatic monitoring and prediction of the spread of this virus. A neural network can be developed to extract the visual features of this disease, and this would help in proper monitoring and treatment of the affected individuals[68]. Machine Learning principles can be conveniently used to implement effective therapeutic strategies against COVID-19. They could effectively speed up the assignment of pre-existing therapies by allowing the algorithm to discern whether commercially approved drugs can be used for a given patient[69]. There are currently many ideas and projects on this topic, but many of them have not yet been fully completed or approved to be implemented in practice with patients.

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[65] *Healthcare Workers*. (2020, February 11). Centers for Disease Control and Prevention. https://www.cdc.gov/coronavirus/2019-ncov/hcp/therapeutic-options.html Accessed 18.11.2020.

[66] Mehta, P., McAuley, D. F., Brown, M., Sanchez, E., Tattersall, R. S., Manson, J. S., & E.T.A.L. (2020). COVID-19: consider cytokine storm syndromes and immunosuppression. *The Lancet*, *395*(10229), 1033–1034. https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(20)30628-0/fulltext Accessed 18.11.2020.

[67] Kundu, S., Elhalawani, H., Gichoja, J. W., & Kahn, C. E. (2020, May 6). *How Might AI and Chest Imaging Help Unravel COVID-19's Mysteries?* RSNA. https://pubs.rsna.org/doi/full/10.1148/ryai.2020200053 Accessed 17.11.2020.

[68] Raju Vaishya, Mohd Javaid, Ibrahim Haleem Khan, Abid Haleem,Artificial Intelligence (AI) applications for COVID-19 pandemic, Diabetes & Metabolic Syndrome: Clinical Research & Reviews, Volume 14, Issue 4, 2020, https://www.sciencedirect.com/science/article/pii/S1871402120300771#bib1 Accessed 22.11.2020.

[69] Ibid.

2.3.1 European ENVISION project

On the 18th of November, 2020, the Bellvitge Institute for Biomedical Research (IDIBELL) has announced the European project ENVISION, which is developing an intelligent decision support system to improve the monitoring and treatment of patients with COVID-19 in intensive care units. The goal is to develop an AI tool that helps medical professionals make more accurate, faster, and more informed decisions in favor of a better prognosis for patients. All processes in the treatment of COVID patients must be optimized, and the combination of artificial intelligence with medical criteria will contribute to making the best decision for each patient in a faster way.

In collaboration with The Intensive Care Medicine Service of the Bellvitge University Hospital (HUB), the project should begin on December 1st, and the first serious results are expected on the 31st of July, 2022. The project includes 19 research centers from 13 European countries and is funded by the European Union's Horizon 2020 research and innovation program with a budget of € 4.9 million.[70]

The researchers will use an existing real-time data monitoring application to turn it into a complex intelligent system. The system is meant to support the follow-up and treatment of patients with COVID-19 in ICUs (Intensive Care Units). Data will be collected from healthcare monitoring instruments, physiological changes, crucial medical events, and medications administered during intensive care and then sent to the data analysis system. The data analysis system is directed by artificial intelligence with predictive modeling tools and smart alert functionality. The software will be tested by the ICUs of the 12 clinical centers participating in the investigation, and if it shows good results, it will be used in the future for the control and treatment of other ICU patients, and even for less serious patients.[71]

2.3.2 Internet of Medical Things (IoMT)

The Internet of Medical Things (IoMT) is a network through which medical devices will communicate and share health related data. IoMT in healthcare cooperation can improve the quality of life, provide better care services and can create more cost-effective systems[72]. The coronavirus pandemic and the sudden increase in the number of patients

[70] *Bellvitge will study the application of artificial intelligence in the treatment of Covid-19 in ICUs – Idibell*. (2020, November). Idibell. https://idibell.cat/en/2020/11/bellvitge-will-study-the-application-of-artificial-intelligence-in-the-treatment-of-covid-19-in-icus/ Accessed 22.11.2020.

[71] Ibid.

[72] Fadi Al-Turjman, Muhammad Hassan Nawaz, Umit Deniz Ulusar, Intelligence in the Internet of Medical Things era: A systematic review of current and future trends, Computer Communications, Volume 150, 2020 https://www.sciencedirect.com/science/article/abs/pii/S0140366419313337 Accessed 24.11.2020.

have led to reduced hospital and medical capacity, increasing health care and service costs, all together leading to a great need for advanced technology. During the pandemic, the main goal of the IoMT System became to provide relief to medical staff, ensure quarantine implementation and trace epidemic origins.[73]

Data, that the Internet of Medical Things uses, is collected with the help of sensors incorporated in mobile phones, drones, robots, as well as self-sampling COVID-19 tests. Afterwards, the collected data is sent to the central-cloud server for analysis. Analysis results would inform medical providers and government agencies in case of emergency, and offer them to better respond to the COVID-19 crisis. Also, drug providers could use these analyzes to give patients more precise medically-reliable instructions. Also, with the help of these online services, patients could receive more adequate care and at the same time reduce their exposure and further transmission of the virus. The IoMT could provide data to government agencies, such as local state health institutes and Centers for Disease Control and Prevention, to better allocate supplies, establish a lockdown estimate, and implement emergency strategies.[74]

Some big cities have already embraced the concept of new technology. The Shanghai Public Health Clinical Center uses body temperature sensors, along with transmitting data directly to a medical station to monitor patients with COVID-19 in real time, thus protecting the medical salt from high exposure. On the other hand, in Boston, public health uses a robot to communicate with patients, and the plan is soon to introduce sensors for precise measurement of breathing speed and temperature.

2.4 Contact tracing of the individuals

Despite caution, sufficient distance cannot be kept in all situations, which means that the virus can spread further. Keeping your distance is still the best way to protect yourself from infection, but there are situations in which closer local contact cannot be avoided. For example, a train ride, getting around by public transport, meetings at work or in professions where contact with people can only be avoided to a limited extent. In such situations, it is crucial to find a way to keep tracing contacts in order to protect yourself and those around you[75]. In order to determine the severity of the situation or the level of

[73] Fadi Al-Turjman, Muhammad Hassan Nawaz, Umit Deniz Ulusar, Intelligence in the Internet of Medical Things era: A systematic review of current and future trends, Computer Communications, Volume 150, 2020 https://www.sciencedirect.com/science/article/abs/pii/S0140366419313337 Accessed 24.11.2020.

[74] Tsikala Vafea, M., Atalla, E., Georgakas, J. *et al.* Emerging Technologies for Use in the Study, Diagnosis, and Treatment of Patients with COVID-19. *Cel. Mol. Bioeng.* **13,** 249–257 (2020). https://link.springer.com/article/10.1007/s12195-020-00629-w#Sec2 Accessed 25.11.2020.

[75] *FAQ "Stopp Corona"-App*. (2020). Stopp Corona. https://www.stoppcorona.at/faq_stopp_corona_app/ Accessed 26.11.2020.

infection, Artificial Intelligence can be used to detect, i.e. identify clusters, contact tracing and their control[76].

2.4.1 “Stopp Corona“ Austria’s tracing app

One of the main problems in preventing coronavirus is the speed with which the infection spreads. It takes about five days for the first symptoms of the infection to manifest, during which time an infected person unknowingly can infect many others and thus form a chain of infection. In order to prevent the chain of infection, it is necessary to devise the most efficient way of informing people about their contact with people who feel the symptoms of the virus.

According to the current state of knowledge, a corona infection can have occurred up to two days before symptoms first appeared[77]. That means if a person experiences symptoms that indicate a corona infection, other people may have been infected up to two days before the symptoms first appeared. Therefore, all contacts of the last two days will be informed anonymously.

This is exactly what the “Stopp Corona” contact tracing app, developed in Austria by Austrian Red Cross, does. The app is aimed at all people aged 14 and over, who want to document their encounters with other contacts in order to help break chains of infection more quickly. It is authorized by the Federal Ministry of Health and is the official app for tracing COVID-19 in Austria. The app can be downloaded via the Google Store or via the Apple Store, depending on the type of operating system the user has. For use in the Apple Store you need to have an operating system that is version 13.5 or later. The software update is mandatory because the app uses the new Exposure Notification API. In the first few weeks after the “Stopp Corona” App was launched, more than 600,000 of people downloaded it via Google PlayTM and the Apple Store®[78]. The Stopp Corona application already counts over 1.25 million users[79].

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[76] Raju Vaishya, Mohd Javaid, Ibrahim Haleem Khan, Abid Haleem, Artificial Intelligence (AI) applications for COVID-19 pandemic, Diabetes & Metabolic Syndrome: Clinical Research & Reviews, Volume 14, Issue 4, 2020, Pages 337-339, ISSN 1871-4021, https://doi.org/10.1016/j.dsx.2020.04.012. Accessed 23.11.2020.

[77] FAQ “Stopp Corona”-App. (2020). Stopp Corona. https://www.stoppcorona.at/faq_stopp_corona_app/ Accessed 26.11.2020.

[78] Ibid.

[79] https://futurezone.at/apps/stopp-corona-app-zeigt-kuenftig-was-im-hintergrund-passiert/401113971 Accessed 25.11.2020.

How does app work?

Personal encounters are saved anonymously on user's personal mobile phone by means of a "digital handshake". If user has agreed to the automatic handshake, the app documents all his/hers encounters with all people who are also using the app and who are in his/her area. This is done completely securely and anonymously. If people test positive for COVID-19, they use the app to alert those they digitally shook hands with. All contacts are then notified of the infection from the time user has been sick and for the last two days and are asked to isolate themselves if possible and to behave correctly if symptoms occur.[80]

Each user is saved anonymously under a specific ID. For each account, the application will store all the IDs with which the user has established a Bluetooth handshake. These IDs will be automatically deleted after 14 days, since 14 days from contact is considered to be the period in which the first symptoms will appear in case of infection.

Requirements for the automatic handshake:[81]

- an active Bluetooth setting
- an internet connection
- the app must be excluded from the manufacturer's battery optimization
- For iOS devices: at least iOS version 13.5
- For Android devices: at least version 6 with Bluetooth Low Energy (BLE)

If user gives a consent to the automatic handshake, establishing automatic handshake is always carried out automatically as soon as a device recognizes another via Bluetooth. This can take up to five minutes. Of course, the other person must also have the Stop Corona app and have activated the automatic function. Only then will the devices be networked.[82]

Application guide

The application has a simple User Interface (UI), which makes it accessible to users of all ages. It is important to note that the all attached Illustrations (Figures) in this section have been taken as screenshots of the app "Stopp Corona".

[80] FAQ "Stopp Corona"-App. (2020). Stopp Corona. https://www.stoppcorona.at/faq_stopp_corona_app/ Accessed 26.11.2020.

[81] Ibid.
[82] Ibid..

1. First steps:

Just after installation, the first time user logs in to the application, the he/she is asked for permission to use private data. This approval is required for further use of the application. In the next step, the application grants permission to send COVID-19 Exposure Notifications. Although this Exposure Notifications is optional and is not necessary for user to certainly use the app, without it the application will not be able to provide the user the maximum service and its purpose will not be fully established. After these two steps the user sees the Homepage of the app and can see an overview of the further services that the app offers. These two permission requirements are presented in Figures 8, 9 and 10.

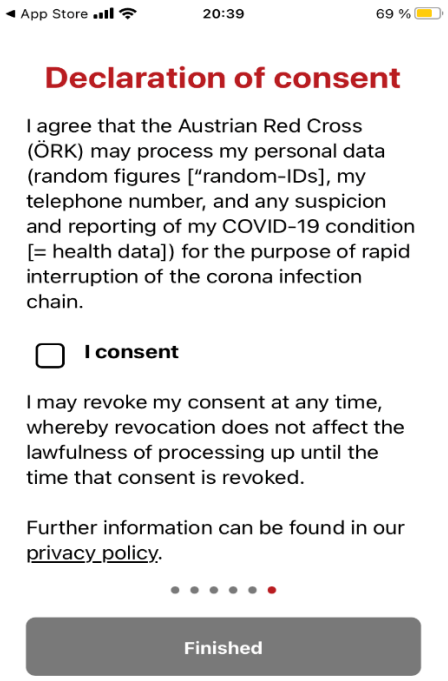

Figure 8

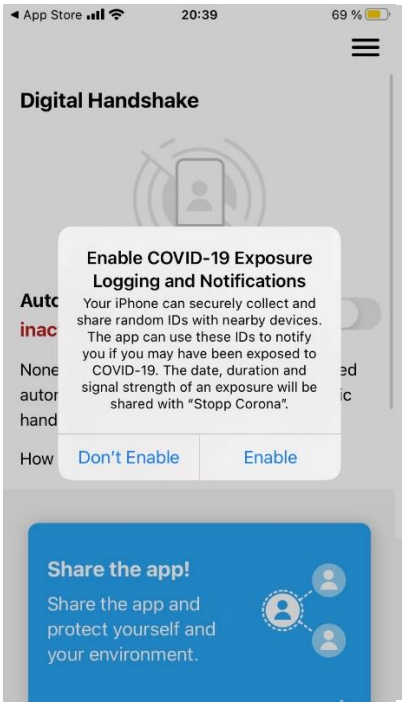

Figure 9

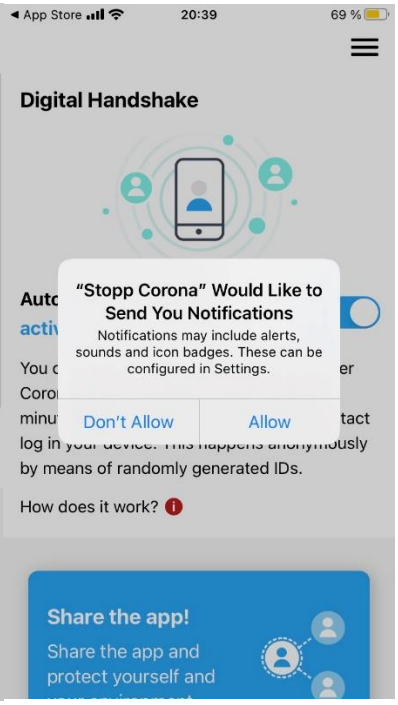

Figure 10

2. “Check Symptoms” service:

If the user suspects that he/she is infected, he/she can choose the "Check Symptoms" option. By selecting this option, the user is offered a survey of several questions to find out if he has symptoms of coronavirus. The survey consists of several questions, and the questions are shown in Figures 11, 12 and 13. The first question is: “How are you today?”,

And if the user answers with: “I have symptoms of illness”, he will get two additional questions in order to determine whether coronavirus symptoms are present.

After conducting a survey with the user, the system will send the user the result of the survey. Figure 14 shows the result if the user has no symptoms, while Figures 15 and 16 show the result of a survey with a user who has symptoms of coronavirus (Figure 15) or exists chance to be infected (Figure 16).

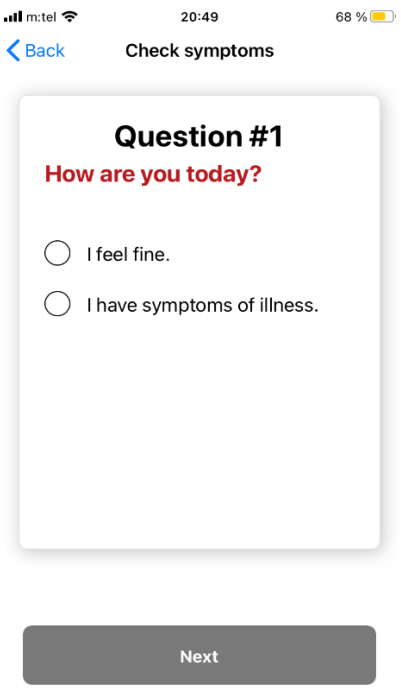

Figure 11

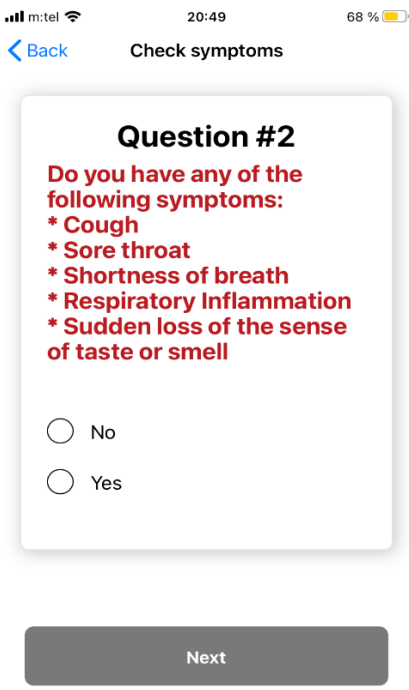

Figure 12

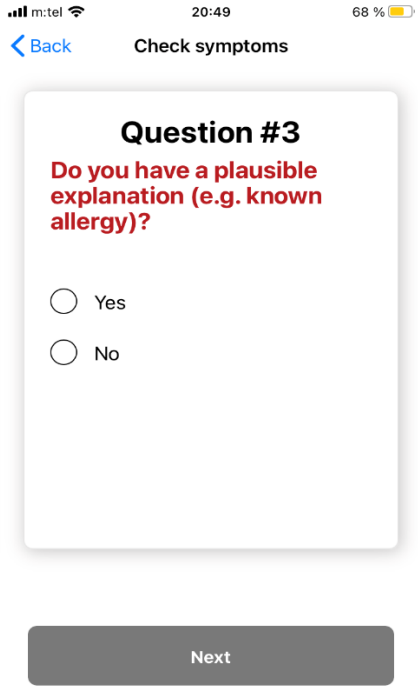

Figure 13

Figure 14

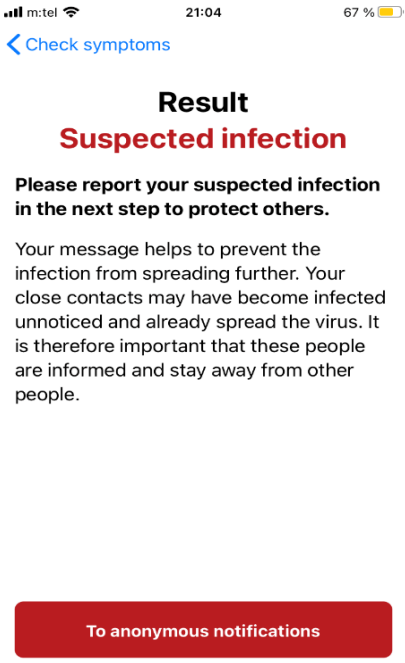

Figure 15

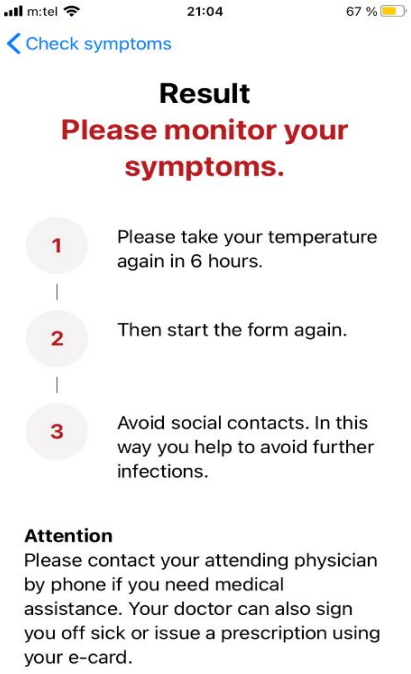

Figure 16

3. “Report medical confirmation” service:

If user gets the coronavirus, with choosing this option he/she can quickly send a warning in the app, what can be seen on Figure 17. Users contacts will be notified anonymously and can take appropriate action.

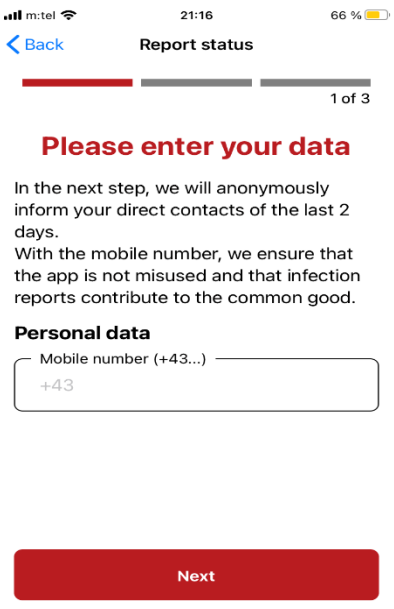

Figure 17

Exposure Notification API

API stands for application programming interface and represents a set of de definitions and protocols for building and integrating application software[83]. It is a software intermediary that allows two applications to talk to each other, and also provides layer of security[84].

Exposure Notification API is supported by a new privacy-safeguarding Bluetooth protocol and facilitates alerting users about possible exposure to someone they have recently been in contact with, who has afterwards been positively diagnosed as being infected with the virus. Bluetooth Low Energy wireless technology provides sensing the closeness of nearby smartphones and the data exchange mechanism. Wherever supported by the hardware and the operating system, Bluetooth controller will prevent excessive power drain.

To better understand the mechanism, the following terms and their explanations are given:

- Exposure Notification Service = "The Bluetooth Low Energy service for detecting device proximity"[85].

- Temporary Exposure Key = "A key that's generated every 24 hours for privacy consideration"[86].

- Diagnosis Key = "The subset of Temporary Exposure Keys uploaded when the device owner is diagnosed as positive for the coronavirus"[87].

- Rolling Proximity Identifier = "A privacy preserving identifier derived from the Temporary Exposure Key and sent in the broadcast of the Bluetooth payload. The

[83] *What is an API?* (2020). RedHat. https://www.redhat.com/en/topics/api/what-are-application-programming-interfaces Accessed 25.11.2020.

[84] What is an API? (Application Programming Interface). MuleSoft. https://www.mulesoft.com/resources/api/what-is-an-api Accessed 25.11.2020.

[85] *Exposure Notification Bluetooth Specification*. (2020, April). Apple. https://blog.google/documents/70/Exposure_Notification_-_Bluetooth_Specification_v1.2.2.pdf Accessed 25.11.2020.

[86] Ibid.
[87] Ibid.

identifier changes about every 15 minutes to prevent wireless tracking of the device"[88].

- Associated Encrypted Metadata (AEM) = "A privacy preserving encrypted metadata that shall be used to carry protocol versioning and transmit (Tx) power for better distance approximation. The Associated Encrypted Metadata changes about every 15 minutes, at the same cadence as the Rolling Proximity Identifier, to prevent wireless tracking of the device".[89]

Platforms running the Exposure Notification Service should be modeled to account for a large volume of broadcasters in public spaces and should constantly rotate their Random Non-resolvable address and Rolling Proximity Identifier. Discovered Exposure Notification Service advertisements shall be kept on the device and the scanning interval and window should have enough good coverage to detect nearby Exposure Notification Service advertisements within 5 minutes.

Data privacy

Red Cross holds data privacy for very important. The user does not need to provide any personal data by downloading and using the app. Users' contacts are saved on their end device and the Red Cross has no access to them so that no conclusions about user's encounters can be made. In case the user is registered as sick, the application asks for a mobile phone number to send a TAN confirmation. Also, in the event of illness, everyone in the contact chain will receive an anonymized report. Personal data, such as the name or mobile phone number of the sick person, will not be passed on.

Before the beginning of the installation process, the user needs to give consent for the processing of his/her data and if that does not happen the app cannot be used. The processing of the user's data by the app is based on consent by the user.

After the app is downloaded, data such as the user's email address, time of purchase of the app, and username will be saved and further used in the system. Apart from that the IP-Address, configuration settings of the user's phone as well as the time and date the user wanted to connect to the internet using the app are stored. That is all in compliance with the *GDPR Art.6 Par 1 lit f* where it states that the processing is lawful if it is necessary for the legitimate interests of the controller which is the case here.

[88] *Exposure Notification Bluetooth Specification*. (2020, April). Apple. https://blog.google/documents/70/Exposure_Notification_-_Bluetooth_Specification_v1.2.2.pdf Accessed 25.11.2020.
[89] Ibid.

Processing the collected data is in compliance with GDPR. It follows the Art.6 Lawfulness of Processing of the GDPR[90], where it states that the processing is according to law if the user of the app gives consent to the processing of his data for specific purposes[91]. The processing of the data is necessary "for the performance of a task carried out in the public interest"[92].

While app is working, in case user of the app is near another user of the app a digital handshake is established. That is done in accordance to *Art. 6 Par 1 lit a* and *Art. 9 Par 2 lit a* of the GDPR[93].

In case user is infected with COVID-19 he/she has the choice to report his/her illness to inform the all app users that have been in his/her close proximity. That is also done in accordance to *Art. 6 Par 1 lit a* and *Art. 9 Par 2 lit a* of the GDPR[94]. In accordance to *Art. 5 Par 1 lit b*. the user's data is at no point forwarded to a third party or used in ways that are not explicitly specified[95].

The application itself allows the user to directly access all legal information. All the user needs to access the data is to find the option menu in the upper right corner (on apple device), from where he can access the sections: "Functions", "Info" and "Legal". In the "Legal" section, the user can access Open Source Licenses as well as Data privacy information. (Figures 18 and 19)

Personal data represent any information related to an identified or identifiable natural person. Depending on user specific use of the functions of the app, the following data is processed: data collected when the app is downloaded, data that is processed after the app is installed, data required for the technical provision of the app, data processed in the digital handshake, data processed in the event of reporting sick, data that will be processed in the event of an all-clear notification, data processed when a sick report is revoked, data processed in the course of recommending the app and data that we process for statistical purposes.

The Data-privacy Tab allows the user to view the previously mentioned private information that the application uses and in adherence to which GDPR rule they are used. One such example shows Figure 19.

[90] Art. 6 General Data Protection Regulation (GDPR) Accessed 27.11.2020.
[91] Art.6 Par. 1 lit. a General Data Protection Regulation (GDPR) Accessed 27.11.2020.
[92] Art. 6 Par. 1 lit. e General Data Protection Regulation (GDPR) Accessed 27.11.2020.
[93] FAQ "Stopp Corona"-App. (2020). Stopp Corona. https://www.stoppcorona.at/faq_stopp_corona_app/ Accessed 26.11.2020.
[94] FAQ "Stopp Corona"-App. (2020). Stopp Corona. https://www.stoppcorona.at/faq_stopp_corona_app/ Accessed 26.11.2020.
[95] Ibid.

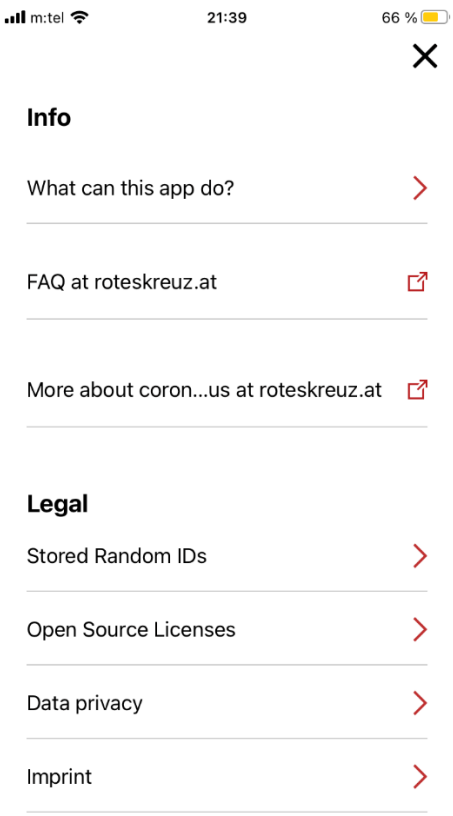

Figure 18

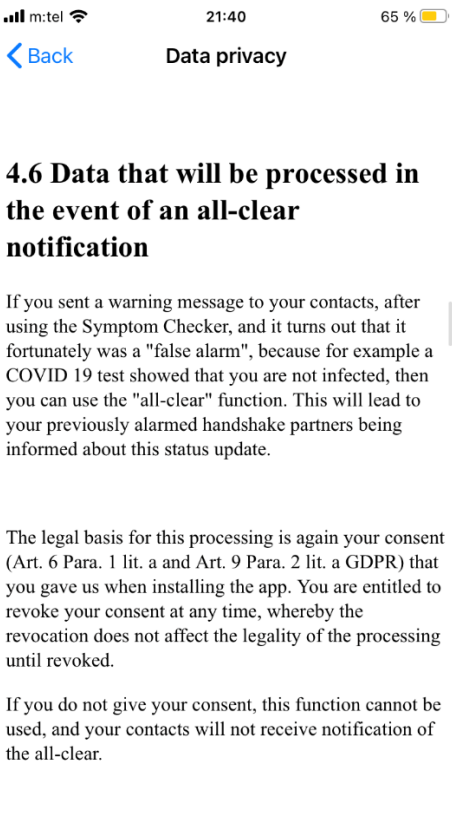

Figure 19

The report on the Stop Corona App by Epicenter Works, NOYB and SBA-Research gave an extremely positive result in terms of compliance with the requirements for the greatest possible data protection[96]. Taking into consideration how transparent the use of data by the app is and that everything aligns with the GDPR it can be said that the “Stopp Corona“ did not violate any laws and has not infringed on the user’s privacy and rights.

Code Transparency

To reassure all users, approval data protection commission of the Austrian Red Cross and the federal government approved to make application as open sourced the app for transparency. Since 24.04.2020, the code of the app is open and can be found at https://github.com/austrianredcross[97].

[96] https://www.stopp-corona.at/ Accessed 29.11.2020.

[97] Accenture. (2020, July 15). *“Stopp Corona” App*. https://www.accenture.com/us-en/case-studies/public-service/stopp-corona-app Accessed 28.11.2020.

3. Regulatory, safety, and privacy concerns of home monitoring technologies during COVID-19

The coronavirus pandemic has increased the degree of integration of artificial intelligence and technology into healthcare to reduce the exposure of both, healthcare workers and patients[98].

Home monitoring technology is an artifact used for surveillance without the direct supervision of a healthcare employee, such as in a patient's home. Among related health information, the device collects some private data from the user. An example of home monitoring technology is an application that monitors the user's heart rate. The data obtained by this technology can be forwarded to medical workers to analyze the data and decide on further treatment of the patient, and offer him/her to be indirectly supervised by a healthcare professional. On the other hand, the user (patient) has the right to reject any sharing of the collected data.

During the coronavirus pandemic, the number of home monitoring technologies on the market increased significantly, whereby some of the technologies are legally classified as medical devices, while others are not. This raised the question of how to balance the desperate need for the development of such software and at the same time ensure security and privacy.

3.1 Safety Concerns

According to Section (§) 201 (h) of the US Federal Food, Drug, and Cosmetic Act (FDCA), home monitoring technologies are categorized as medical devices, if they satisfy the following conditions:

- Artifact is intended for use in the diagnosis of a disease or other conditions, or in the treatment, alleviation, or prevention of disease[99].
- Artifact does not use chemical action inside or on the human body to reach goals[100].

[98] *How Hospitals Are Using AI to Battle Covid-19*. (2021, February 2). Harvard Business Review. https://hbr.org/2020/04/how-hospitals-are-using-ai-to-battle-covid-19 Accessed 04.01.2021.

[99] Gerke, S., Shachar, C., Chai, P.R. *et al.* Regulatory, safety, and privacy concerns of home monitoring technologies during COVID-19. *Nat Med* **26,** 1176–1182 (2020). https://doi.org/10.1038/s41591-020-0994-1 Accessed 03.01.2021.

[100] Ibid.

- Artifact does not depend on whether it is metabolized to reach its primary purpose[101].

The US Food and Drug Administration (FDA) has categorized all medical devices based on risk into three classes (Figure 20). Devices legally categorized as “medical devices” are marked in blue, while red ones represent “non-device software functions” and as such are not subject to FDA regulation[102]. The green-colored categories represent medical devices and usual premarket pathways for medical devices that were already available before the COVID-19 pandemic. Orange marks new regulatory pathways available for certain medical devices the COVID-19 pandemic.[103]

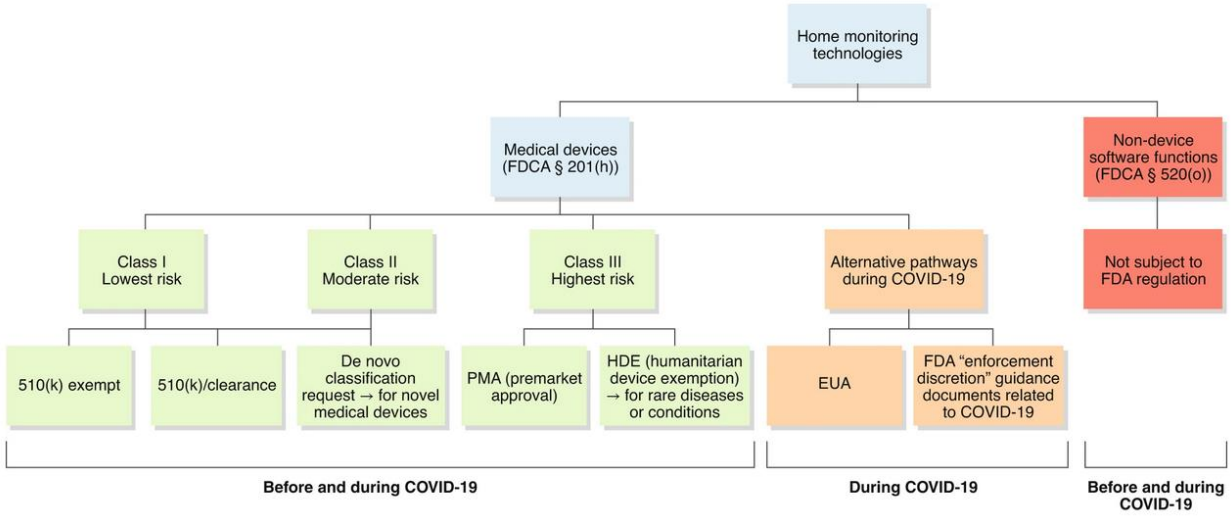

Figure 20[104]

The software can also be categorized as a medical device and is referred to as either “Software in a Medical Device” or “Software as a Medical Device”[105]. For example, in

[101] Gerke, S., Shachar, C., Chai, P.R. *et al.* Regulatory, safety, and privacy concerns of home monitoring technologies during COVID-19. *Nat Med* **26,** 1176–1182 (2020). https://doi.org/10.1038/s41591-020-0994-1 Accessed 03.01.2021.

[102] *Fig. 1: Regulatory pathways of home monitoring technologies (before and) during the COVID-19 pandemic. | Nature Medicine*. (2020). Nature. https://www.nature.com/articles/s41591-020-0994-1/figures/1?error=cookies_not_supported&code=0eaf9432-b416-471b-b907-cc9bf918e91b Accessed 06.01.2021.

[103] Ibid.

[104] Ibid.

[105] Center for Devices and Radiological Health. (2019, September 26). *Policy for Device Software Functions and Mobile Medical Applications*. U.S. Food and Drug Administration.

2018, Apple updated their software to implement a personal ECG and thus allow users to control their own heart rate[106]. This medical device is categorized as medium risk and belongs to class II, which means that it requires constant monitoring during operation, in order to provide security and correctness[107].

As already mentioned, home monitoring technologies that are not “Software in a Medical Device” or “Software as a Medical Device” are not regulated by FDA. Exceptions for specific software functions are regulated by FDCA § 520(o), introduced by the 21st Century Cures Act[108].

During the pandemics increased the demand and pressure to accelerate innovation also as appropriate regulations to control the risk. The FDA has stated that most of the newly established software cannot be categorized as a "medical device" and that many devices for contact monitoring during pandemics do fulfill the requirements for medical devices, hence cannot be regulated by FDA[109].

3.1.1. Emergency Use Authorizations for medical devices

The US Secretary of Health and Human Services (HHS) concluded on 4th February 2020 that there is a public-health emergency on the basis of the spread of SARS-CoV-2[110], what caused HHS secretary to issue three Emergency Use Authorization (EUA).

Declarations are related to certain types of medical devices:

- Devices used for in vitro diagnostics for the diagnosis or detection of SARS-CoV-2[111].

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https://www.fda.gov/regulatory-information/search-fda-guidance-documents/policy-device-software-functions-and-mobile-medical-applications Accessed 04.01.2021.

[106] Apple. (2021, January 22). *ECG app and irregular heart rhythm notification available today on Apple Watch*. Apple Newsroom. https://www.apple.com/newsroom/2018/12/ecg-app-and-irregular-heart-rhythm-notification-available-today-on-apple-watch/ Accessed 03.01.2021.

[107] FDA. Letter to Apple Inc. https://www.accessdata.fda.gov/cdrh_docs/pdf18/DEN180044.pdf (2018). Accessed 29.12.2021.

[108] *Fig. 1: Regulatory pathways of home monitoring technologies (before and) during the COVID-19 pandemic. | Nature Medicine*. (2020). Nature. https://www.nature.com/articles/s41591-020-0994-1/figures/1?error=cookies_not_supported&code=0eaf9432-b416-471b-b907-cc9bf918e91b Accessed 06.01.2021.

[109] Center for Devices and Radiological Health. (2020, March 26). *Digital Health Policies and Public Health Solutions for COVID-19*. U.S. Food and Drug Administration. https://www.fda.gov/medical-devices/coronavirus-covid-19-and-medical-devices/digital-health-policies-and-public-health-solutions-covid-19 Accessed 30.12.2021.

[110] *Determination of Public Health Emergency*. (2020, February 7). Federal Register. https://www.federalregister.gov/documents/2020/02/07/2020-02496/determination-of-public-health-emergency Accessed 30.12.2020.

[111] Ibid.

- Personal protective equipment for breathing[112].
- Alternative products used as medical devices, including home monitoring devices[113].

FDA has by now issued a few EUAs for home monitoring devices to address COVID-19.[114][115] One such authorization is issued for the VSMS patch, invented by G Medical Innovations, that offers remote patient monitoring of the QT interval of an ECG17. The patch is connected to a mobile phone and is used by the patient wearing it on the upper left chest for about two weeks. The collected data will be sent to the G Medical Innovations Center, where the analysis will be performed. The cardiography technician will form the clinical findings and send them to the doctor at the hospital. In 2017, this medical device received the CE mark in Europe, which is a prerequisite for placing the device on the market.[116]

Emergency Use Authorizations (EUA) for medical devices via the EUA pathway can lead to many risks[117]. "The FDA assesses these devices on the basis of Box 1 EUAs for medical devices under FDCA § 564"[118].

One of the requirements is a good basis in terms of explanation for medical device to be effective and contribute to treating, diagnosing, or preventing COVID-19. That implies that EUA does not guarantee that the product is reliable and efficient, it relies on reasonable assumptions. The third point of Box 1 is "Risk/benefit analysis", but it is challenging to determine the limit of acceptability of the device based on this analysis. On the other hand, when issuing the EUA, the FDA can abandon some risk-reducing requirements.[119]

In the case of the VSMS patch, FDA abandoned the good manufacturing practice requirements, but in the end, these requirements were fulfilled because of customer

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[112] *Emergency Use Declaration*. (2020, March 10). Federal Register. https://www.federalregister.gov/documents/2020/03/10/2020-04823/emergency-use-declaration Accessed 30.12.2020.
[113] *Emergency Use Authorization Declaration*. (2020, March 27). Federal Register. https://www.federalregister.gov/documents/2020/03/27/2020-06541/emergency-use-authorization-declaration Accessed 30.12.2020.

[114] Ibid.
[115] Center for Devices and Radiological Health. (2020, June 18). *Remote or Wearable Patient Monitoring Devices EUAs*. U.S. Food and Drug Administration. https://www.fda.gov/medical-devices/coronavirus-disease-2019-covid-19-emergency-use-authorizations-medical-devices/remote-or-wearable-patient-monitoring-devices-euas?utm_campaign=2020-06-18%20New%20EUA%20COVID-19%20page&utm_medium=email&utm_source=Eloqua Accessed 31.12.2020.
[116] FDA. Letter to G Medical Innovations Ltd. https://www.fda.gov/media/138105/download (2020). Accessed 02.01.2021.
[117] Gerke, S., Shachar, C., Chai, P.R. *et al.* Regulatory, safety, and privacy concerns of home monitoring technologies during COVID-19. *Nat Med* **26,** 1176–1182 (2020). https://doi.org/10.1038/s41591-020-0994-1 Accessed 03.01.2021.
[118] Ibid.
[119] ibid.

safety and to reduce the risks involved in the manufacture of devices[120][121]. The production process of EUA home surveillance devices should include as many safeguards as possible to ensure that the products are safe and effective in combating COVID-19[122].

As there is no 100% security of correctness, Emergency Use Authorizations for medical devices can cause serious damage and consequences in some cases. In case the medical device fails and does not recognize a life-dangerous cardiac arrhythmia in a patient, the patient may suffer fatal consequences.[123]

Due to such problems, there are questions about who will be responsible in case of such disasters. In some cases, the Public Readiness and Emergency Preparedness (PREP) Act may provide liability immunity to a manufacturer of a EUA medical device[124][125]. On the other hand, manufacturers should be aware that the FDA's nonbinding guidance documents for industry and FDA staff on enforcement discretion for certain medical devices related to COVID-19 (Box 2) do not bring such devices within the scope of the PREP Act21, and thus should not rely on immunity.[126]

3.1.2. Fraudulent Home Monitoring Technology

For fraudulent companies, the pandemic and the high demand for new technologies to facilitate the current situation in public health may seem like an opportunity to market defective medical devices and earn money. The FDA has warned consumers of the

[120] Gerke, S., Shachar, C., Chai, P.R. *et al.* Regulatory, safety, and privacy concerns of home monitoring technologies during COVID-19. *Nat Med* **26,** 1176–1182 (2020). https://doi.org/10.1038/s41591-020-0994-1 Accessed 03.01.2021.
[121] FDA. Letter to G Medical Innovations Ltd. https://www.fda.gov/media/138105/download (2020). Accessed 02.01.2021.
[122] Gerke, S., Shachar, C., Chai, P.R. *et al.* Regulatory, safety, and privacy concerns of home monitoring technologies during COVID-19. *Nat Med* **26,** 1176–1182 (2020). https://doi.org/10.1038/s41591-020-0994-1 Accessed 03.01.2021.
[123] *Declaration Under the Public Readiness and Emergency Preparedness Act for Medical Countermeasures Against COVID-19*. (2020b, March 17). Federal Register. https://www.federalregister.gov/documents/2020/03/17/2020-05484/declaration-under-the-public-readiness-and-emergency-preparedness-act-for-medical-countermeasures Accessed 04.01.2021.

[124]Ibid.

[125] HHS. Advisory opinion on the Public Readiness and Emergency Preparedness Act and the March 10, 2020 Declaration under the Act April 17, 2020, as modified on May 19, 2020. https://www.hhs.gov/sites/default/files/prep-act-advisory-opinion-hhs-ogc.pdf (2020). Accessed 05.01.2021.
[126] Spivack, P.S. & Lyons, E.M. Liability immunity under the PREP Act for COVID-19 countermeasures: what manufacturers need to know. https://www.hoganlovells.com/~/media/hogan-lovells/pdf/2020 pdfs/2020_03_23_liability_immunity_under_the_prep_act-for_covid_19_countermeasures.pdf (2020). Accessed 03.01.2021.

dangers of counterfeit products that claim to cure and suppress the coronavirus. The most common examples of such products are unauthorized vaccines and home tests.[127]

Consumers should be protected from such medical artifacts, and for the beginning, the US Federal Trade Commission warns all consumers to ignore all add-ons and other advertisements for home tests and vaccinations[128]. State attorneys should constantly monitor the market and, if necessary, file consumer protection claims. Doctors can also contribute by raising the awareness of danger and informing the patients[129].

3.2. Privacy concerns

Home monitoring technology can facilitate organization and reduce public health overload during a pandemic. To reach their peak and give the maximum contribution, it is necessary to cooperate with patients, in this case, device users. However, these technologies use users' private sensitive data and thus cause user distrust. If people do not trust technology companies as creators of home surveillance technologies, they will not accept to use them. To gain trust, it is necessary to provide users with privacy and security.

3.2.1. Privacy laws in the USA and Europe

Security of European citizens on how their data are collected, used, and protected online is protected by General Data Protection Regulation (GDPR) 2016/679 and by the EU member states laws, that implemented the ePrivacy Directive (2002/58/EC). GDPR binds companies to strict rules about using and securing the personal data they collect from people.[130]

According to Article 9(1) of GDPR, processing of personal data that reveals certain information, including genetic data and data concerning health is prohibited[131]. However, Article 9 (2) contains exceptions to this general ban, and one of them is a case when

[127] Office of the Commissioner. (2021b, January 4). *Beware of Fraudulent Coronavirus Tests, Vaccines and Treatments*. U.S. Food and Drug Administration. https://www.fda.gov/consumers/consumer-updates/beware-fraudulent-coronavirus-tests-vaccines-and-treatments?utm_campaign=CU%20Roundup%20040320&utm_medium=email&utm_source=Eloqua Accessed 06.01.2021.
[128] *Coronavirus Advice for Consumers*. (2021b, January 27). Federal Trade Commission. https://www.ftc.gov/coronavirus/scams-consumer-advice Accessed 05.01.2021.
[129] Ibid.
[130] Wolford, B. (2019, February 13). *Does the GDPR apply to companies outside of the EU?* GDPR.Eu. https://gdpr.eu/companies-outside-of-europe/ Accessed 05.01.2021.
[131] General Data Protection Regulation (GDPR), Article 9(1) https://gdpr.eu/article-9-processing-special-categories-of-personal-data-prohibited/ Accessed 05.01.2021.

processing is necessary for preventive or occupational medicine, for the assessment of the working capacity of the employee, medical diagnosis, and other health purposes[132]. "The ePrivacy Directive that has been transposed into the national law of the EU member states also provides safeguards for electronic communication data, such as location data from mobile phones"[133][134].

EU GDPR was introduced on 14th April 2016 and it is the largest piece of data regulation ever passed by the European Union. Its significance lies in the fact that it secures the protection of European data subjects' rights and defines what companies that process personal data must do to assure these rights. Most companies are processing some private data regularly, and no matter if they are European companies or not, if they process data relating to the EU citizens, they must comply with GDPR. Territorial Scope is regulated by Article 3 of GDPR[135].

For example, if an American company uses the private data of Europeans, its developers must design the technology following GDPR principles. If GDPR is not complied with, the company will suffer serious consequences, most often in the form of a large fine and damaged reputation.[136] "GDPR allows for massive penalties of up €20 million or, if higher, as much as four percent of global revenue"[137].

The GDPR also regulates the manner and conditions of personal data processing. Principles relating to the processing of personal data are contained in Article 5, also as in Recital 39. In April 2020, the European Commission announced an EU toolbox for the use of contact-tracing and warning apps, which will provide the EU Member States with requirements and guidelines for the use of such applications. The toolbox was developed by EU Member States with the support of the Commission.[138]

Some of these requirements are: that contact tracking applications are installed voluntarily, without pressure on society; that they are fully compliant with EU data protection and privacy laws; apps use anonymous data for processing; the goal of the

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[132] General Data Protection Regulation (GDPR), Article 9(2) https://gdpr.eu/article-9-processing-special-categories-of-personal-data-prohibited/ Accessed 05.01.2021.
[133] Gerke, S., Shachar, C., Chai, P.R. *et al.* Regulatory, safety, and privacy concerns of home monitoring technologies during COVID-19. *Nat Med* **26,** 1176–1182 (2020). https://doi.org/10.1038/s41591-020-0994-1 Accessed 03.01.2021.
[134] *Statement by the EDPB Chair on the processing of personal data in the context of the COVID-19 outbreak*. (2020, March 16). European Data Protection Board - European Data Protection Board. https://edpb.europa.eu/news/news/2020/statement-edpb-chair-processing-personal-data-context-covid-19-outbreak_en Accessed 04.01.2021.
[135] General Data Protection Regulation (GDPR), Article 3 https://gdpr.eu/article-9-processing-special-categories-of-personal-data-prohibited/ Accessed 05.01.2021.
[136] ibid.
[137] ibid.
[138] European Commission. Coronavirus: An EU approach for efficient contact tracing apps to support gradual lifting of confinement measures.
https://ec.europa.eu/commission/presscorner/detail/en/ip_20_670 (2020). Accessed 08.01.2021.

app is to take advantage of the latest technological tools to improve privacy, etc.[139] Although this toolbox specifically refers to the search for contacts in the EU, the aim is to expand to the US.[140] "Public health authorities should also ensure that they involve the most vulnerable groups to benefit from new home surveillance technologies"[141].

On the other hand, privacy regulations in the U.S. only partially regulate home monitoring technologies. “The Health Insurance Portability and Accountability Act (HIPAA) sets the standard for the patient’s sensitive data protection. Companies that work with protected health information must have a physical, network, and process security measures in place and follow them to ensure HIPAA Compliance” [142].

“Covered entities (anyone providing treatment, payment, and operations in healthcare) and business associates (anyone who has access to patient information and provides support in treatment, payment, or operations) must meet HIPAA Compliance”[143].

The HIPAA Privacy Rule regulates the use and disclosure of protected health information (Code of Federal Regulations ((CFR): 45 CFR § 160.103)[144]. However, HIPAA-e5 does not regulate most technology companies, so information on how companies collect and for what purposes they further use the data is not controlled. In any case, American citizens must be informed that their privacy may not be protected, and the need for the United States to establish a federal law similar to the EU GDPR has never been greater.[145]

HIPAA also protects health information on home surveillance from the Electronic Health Record (EHR), that can be individually disclosed. There are exceptions for entities to use or disclose protected health information, such as public health activities (45 CFR § 164.512 (b)) and health surveillance activities (45 CFR § 165.512 (d))[146][147]. In compliance

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[139] European Commission. Coronavirus: An EU approach for efficient contact tracing apps to support gradual lifting of confinement measures. https://ec.europa.eu/commission/presscorner/detail/en/ip_20_670 (2020). Accessed 08.01.2021.
[140] Ibid.
[141] *Fig. 1: Regulatory pathways of home monitoring technologies (before and) during the COVID-19 pandemic. | Nature Medicine*. (2020). Nature. https://www.nature.com/articles/s41591-020-0994-1/figures/1?error=cookies_not_supported&code=2b3bab1a-6da5-41d5-80c8-232341251780 Accessed 06.01.2021.
[142] *What is HIPAA Compliance?* (2020, December 2). Digital Guardian. https://digitalguardian.com/blog/what-hipaa-compliance Accessed 09.01.2021.
[143] Ibid.
[144] *Fig. 1: Regulatory pathways of home monitoring technologies (before and) during the COVID-19 pandemic. | Nature Medicine*. (2020). Nature. https://www.nature.com/articles/s41591-020-0994-1/figures/1?error=cookies_not_supported&code=2b3bab1a-6da5-41d5-80c8-232341251780 Accessed 06.01.2021.
[145] Ibid.
[146] Regulatory, safety, and privacy concerns of home monitoring technologies during COVID-19 https://www.nature.com/articles/s41591-020-0994-1/figures/1 Accessed 06.01.2021.
[147] *Enforcement Discretion Under HIPAA To Allow Uses and Disclosures of Protected Health Information by Business Associates for Public Health and Health Oversight Activities in Response to COVID-19*. (2020, April 7). Federal Register. https://www.federalregister.gov/documents/2020/04/07/2020-

with them, actions such as sending patient status data to public health authorities for the purpose of preventing the COVID-19 virus are not problematic.

For business associates who use or disclose protected health information to contribute to public health (according to 45 CFR § 164.512 (b)) or health surveillance (according to 45 CFR § 165.512) d)) during a coronavirus pandemic, the Office for Civil Rights at HHS announced, in April 2020, that the business associate must notify the affected entity within 10 calendar days after detection or use[148]. Of course, business associates are authorized for such actions only if so is permitted in their business associate agreement (BAA) with the covered entity[149].

The GDPR has also inspired some US states to introduce similar privacy laws and among them the California Consumer Privacy Act of 2018, that was put into effect on 1st January 2020[150].“California Consumer Privacy Act (CCPA) is a state-wide data privacy law that regulates how businesses all over the world are allowed to handle the personal information (PI) of California residents”[151]. According to the CCPA, citizens may require a company to delete their personal information (California Civil Code § 1798.105)[152].

Every citizen of the US, following the example of the EU GDPR, should be given the "right to be forgotten". This means that, according to Article 17 of the GDPR, a citizen has the right to request the deletion of his data. “To avoid undermining data analysis efforts and to keep the governance of these technologies similar to the CCPA, the right to be forgotten should be limited to personal information and should not be extended to de-identified or aggregate consumer information (California Civil Code § 1798.140(o))”[153].

Beside many benefits, home monitoring technology potentially encroaches on people's privacy. To fulfill privacy expectations, technology companies, health care providers, and public health employees need to work to the highest ethical standards, especially when existing privacy regulations do not apply. Data for processing should, with the approval of the user, be used exclusively in anonymous form with the introduction of safeguards

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07268/enforcement-discretion-under-hipaa-to-allow-uses-and-disclosures-of-protected-health-information-by Accessed 09.01.2021.

[148] Ibid.

[149] Ibid.

[150] *Fig. 1: Regulatory pathways of home monitoring technologies (before and) during the COVID-19 pandemic. | Nature Medicine*. (2020b). Nature. https://www.nature.com/articles/s41591-020-0994-1/figures/1?error=cookies_not_supported&code=02ae2981-0ab8-4ce9-8e78-a50a36845b52 Accessed 06.01.2021.

[151] “What is CCPA?” https://www.cookiebot.com/en/what-is-ccpa/ Accessed 09.01.2021.

[152] *Fig. 1: Regulatory pathways of home monitoring technologies (before and) during the COVID-19 pandemic. | Nature Medicine*. (2020b). Nature. https://www.nature.com/articles/s41591-020-0994-1/figures/1?error=cookies_not_supported&code=02ae2981-0ab8-4ce9-8e78-a50a36845b52 Accessed 06.01.2021.

[153] Ibid.

for the risk of re-identification. The technology should offer the patient/user the ability to "turn on" and "turn off", and to collect data only while the user is "on".[154]

The use of home surveillance data should be transparent. Therefore, it should be clearly stated which data and how the data will be used, such that every individual can decide whether agrees to the application of new technologies. Also, commercial use of the data should be prohibited, unless the use is previously planned and announced, and if the user will not be disabled to use the home monitoring device in case of rejecting commercial use of private data.

Until the United States introduces new federal law that protects all health data, the data collected by home monitoring devices, that can be individually identified regardless of anonymous form, should be stored in patients' medical records or be covered by BAAs, where the data will receive HIPAA's protections. Alternative way is to store data in the users' device or smartphone instead of on remote servers. By preventing easy access to the data, invasion of privacy will get bounded.[155]

4. Legal Aspects of Mass Surveillance

4.1. Mass Surveillance, Introduction

Mass surveillance is conducted to identify danger, as well as to investigate a known threat. By systematically monitoring people's lives, mass surveillance enables the potential for unchecked state power and control over individuals. The name itself comes from the French word which in translation means "looking upon", and the term includes not only visual observation but also the analysis of all behavior, speech, and actions. The monitoring includes monitoring cameras, GPS tracking, and online monitoring.[156]

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[154] Gerke, S., Shachar, C., Chai, P.R. *et al.* Regulatory, safety, and privacy concerns of home monitoring technologies during COVID-19. *Nat Med* **26,** 1176–1182 (2020). https://doi.org/10.1038/s41591-020-0994-1 Accessed 03.01.2021.

[155] *Fig. 1: Regulatory pathways of home monitoring technologies (before and) during the COVID-19 pandemic. | Nature Medicine*. (2020b). Nature. https://www.nature.com/articles/s41591-020-0994-1/figures/1?error=cookies_not_supported&code=02ae2981-0ab8-4ce9-8e78-a50a36845b52 Accessed 06.01.2021.

[156] *The Ethics (or not) of Massive Government Surveillance*. Stanford. https://cs.stanford.edu/people/eroberts/cs181/projects/ethics-of-surveillance/ethics.html Accessed 16.12.2020.

The main difference between “mass” and “targeted” surveillance is that strategic or mass surveillance is not necessarily caused by suspicion of a particular person or more of them, while targeted surveillance or in other words “wiretapping” consists of a covert collection of conversations, telecommunications, and metadata by technical means.[157] Surveillance is often done secretly and at the behest of some authority[158].

Mass surveillance has equally often been criticized for violating privacy rights, limiting civil and political rights and freedoms, and being illegal under some legal or constitutional systems. In addition to making a significant contribution to the security of operations, mass surveillance can also represent a risk to individual rights, and therefore the Member States do not have unlimited power in this area. Mass surveillance is granted only if necessary. Given the risk of violations of the fundamental rights to privacy and freedom of expression enshrined in the Convention, Member States must take into account the development of legal safeguards to ensure respect for citizens and human rights when formulating methods and strategies for mass surveillance.[159]

One of the reasons for conducting mass surveillance may be fighting against terrorism, which requires governments to respond effectively and take good countermeasures, as well as constant mass surveillance of communications. According to the case-law of the European Court of Human Rights, interpreting the mass surveillance of a terrorist threat as a violation of privacy would stand up to the government's efforts to combat terrorism. If domestic legislation approves monitoring techniques, it is crucial to provide adequate safeguards to minimize risks to freedom of expression and the right to privacy. The standards relating to targeted supervision set out in the Court's case-law must therefore be adapted and applied to strategic supervision.[160]

4.2. Mass Surveillance in Age of COVID-19

The coronavirus pandemic has brought many threats to the citizens and nations safety, which made many governments (E.g. China, USA, Australia, Germany, Russia, etc.) start tracking the movement and behavior of all residents by installing many mass surveillance system points in all the towns, villages, streets, and public spaces to track and monitor suspects and detect suspicious patterns[161].

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[157] Council of Europe, Mass Surveillance; https://rm.coe.int/factsheet-on-mass-surveillance-july2018-docx/16808c168e Accessed 15.12.2020.
[158] *The Ethics (or not) of Massive Government Surveillance*. Stanford. https://cs.stanford.edu/people/eroberts/cs181/projects/ethics-of-surveillance/ethics.html Accessed 16.12.2020.
[159] Council of Europe, Mass Surveillance; https://rm.coe.int/factsheet-on-mass-surveillance-july2018-docx/16808c168e Accessed 15.12.2020.
[160] Ibid.
[161] https://ieeexplore.ieee.org/abstract/document/9136589 Accessed 20.12.2020.

The mass surveillance system can identify, locate, and disclose the identity of certain individuals for safety or health reasons. The tracking function can be used to monitor the behavior of people who have been confirmed to be infected with coronavirus, all who have been in contact with them, as well as for detecting locations recently accessed by the COVID-19 infected.[162].

The chapter "AI in Contact Tracing of the Individuals" described "Stopp Corona" Austria's tracing app, one of many applications for surveillance of infection and prevention of the so-called "chain of infection", also as a guide on how to use it. There are currently at least 53 contact tracing apps in the world across at least 29 countries[163].

- China's tracking app is created to identify and isolate people who might be spreading the illness[164]. Each user is assigned a red, yellow, or green color. Color represents an assessment of a user's risk to public places. Namely, the methodology of color assigning is not transparent and reportedly application shares collected data with police, and has been suspected to provide new forms of automated social control that could persist long after the pandemic[165].

- In South Korea, the tracking app uses much more user private data than it is necessary. The application is claimed to store data such as card payment history, time of entry and departure of public facilities, etc.[166]

- In the United States, North and South Dakota released a tracking app that collects the locations of citizens using cell towers, GPS, and Wi-Fi and stores those data on a centralized, private server. The U.S. government is already eavesdropping on massive cell phone data to monitor public health in the fight against COVID-19. These efforts include monitoring the presence and movement of people in specific areas of geographical interest. Under the new legislation, Congress has allocated more than $500,000,000 to monitor public health data and modernize analytics[167]. Google analyzed and tracked people's movements to generate COVID-19 Community Mobility Reports for each province in the United States. The application offers a graphical representation of the movement of residents, where

[162] https://ieeexplore.ieee.org/abstract/document/9136589 Accessed 20.12.2020.
[163] See Samuel Woodhams, *COVID-19 Digital Rights Tracker*, Top10VPN (Apr. 28, 2020), https://www.top10vpn.com/research/investigations/covid-19-digital-rights-tracker/ Accessed 19.12.2020.
[164] Zhong, R. (2020, May 26). *China's Coronavirus Tracking Apps Stir Privacy Fears as They Linger*. The New York Times. https://www.nytimes.com/2020/05/26/technology/china-coronavirus-surveillance.html Accessed 20.12.2020.
[165]Thompson, D. (2020, August 19). *Contact Tracing Could Free America From Quarantine*. The Atlantic. https://www.theatlantic.com/ideas/archive/2020/04/contact-tracing-could-free-america-from-its-quarantine-nightmare/609577/ Accessed 20.12.2020.

[166] *Apps and Covid-19 | Privacy International*. Privacyinternational.Org. https://privacyinternational.org/examples/apps-and-covid-19 Accessed 23.12.2020.
[167] Coronavirus Aid, Relief, and Economic Security (CARES) Act, Pub. L. No. 116–136, 134 Stat. 281, 554 (2020). Accessed 20.12.2020.

each user is shown as a single point. In this way, critical zones, as well as coronavirus, spread clusters can be identified. These analyzes by Google and others also allow the government and others to understand how well the public has respected social distancing at the individual, county, state, and national levels.[168]

Despite the public health benefits touted by proponents, it is not clear that digital contact tracing can achieve its lavish claims, nor is it evident that it can do so without imposing disproportionate privacy harms. The following will discuss whether and under what circumstances the United States should accept the use of epidemiological surveillance programs, including the use of cell phone location data for contact search purposes.

4.3. Fourth Amendment Frameworks

As previously described, United States tracking app uses mobile phone location to conduct individual contact searches, analysis and forecasting of virus spread, and determining whether it follows the law in terms of intruding on people's private lives, relies on the Fourth Amendment.

It's necessary to address two Fourth Amendment thresholds:

- Does the program entails state action?
- Does the conduct at issue constitutes a "search" or a "seizure"?

In the United States, rights to protect privacy from threats of government oversight are enshrined in the Fourth Amendment, which guarantees that "The right of the people to be secure in their persons, houses, papers, and effects against unreasonable searches and seizures shall not be violated . . . ."[169].

"The Fourth Amendment (Amendment IV) to the United States Constitution prohibits unreasonable searches and seizures and requires any search warrant to be judicially sanctioned and supported by probable cause"[170].

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[168] Coronavirus Aid, Relief, and Economic Security (CARES) Act, Pub. L. No. 116–136, 134 Stat. 281, 554 (2020). Accessed 20.12.2020.
[169] U.S. Const., Amend. IV. Accessed 22.12.2020.
[170] Fourth Amendment to the United States Constitution. (2018, March 1). In *Simple English Wikipedia, the free encyclopedia*. https://simple.wikipedia.org/wiki/Fourth_Amendment_to_the_United_States_Constitution Accessed 02.01.2021.

“The Fourth Amendment only protects against searches and seizures conducted by the government or pursuant to governmental direction. Surveillance and investigatory actions taken by strictly private persons, such as private investigators, suspicious spouses, or nosey neighbors, aren't governed by the Fourth Amendment”[171].

The Fourth Amendment regulates governments and their agents, but does not regulate the behavior of individuals or entities. In the case of the Coronavirus Monitoring regime, private entities, such as mobile network providers and technology companies with access to location data through applications installed on users' devices, are responsible for collecting contact data.

However, regardless of being run as private entities, under established doctrine, a private party may be subject to Fourth Amendment regulation to the extent it behaves like an agent of the state. “Whether a private party should be deemed an agent or instrument of the Government for Fourth Amendment purposes necessarily turns on the degree of the Government’s participation in the private party’s activities, a question that can only be resolved in light of all the circumstances”[172].

Mobile telephony service providers and technology companies that collect contact information and similar surveillance programs can be interpreted as government agents because most of these entities are subject to government requirements for access to information.[173] Also, pandemic monitoring programs and tools require constant access to historical data for analysis, data for monitoring of targeted individuals, and real-time data for monitoring the activities of individuals and groups.

According to the court's decision, the Fourth Amendment regulates the law's approach to enforcing historical cell site location data collected and stored by cellphone service providers. Since mobile phones are the most used gadgets nowadays, location data of mobile phones, whether in the form of cell site location or GPS tracking, has shown as most important part of tracing and proximity surveillance proposals.

“On Friday, June 22, the Supreme Court issued its much-anticipated opinion in *Carpenter v. United States*, holding that a warrant is required for police to access cell site location information from a cell phone company - the detailed geolocation information generated by a cellphone’s communication with cell towers”[174].

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[171] F. (2019, February 5). *When the Fourth Amendment Applies*. Findlaw. https://www.findlaw.com/criminal/criminal-rights/when-the-fourth-amendment-applies.html Accessed 02.01.2021.
[172] Skinner v. Ry. Labor Execs. Ass’n, 489 U.S. 602, 614–615 (1989) Accessed 23.12.2020.
[173] David Gray & Danielle Citron, The Right to Quantitative Privacy, 98 Minn. L. Rev. 62, 133–37 (2013). Accessed 23.12.2020.
[174] *Summary: The Supreme Court Rules in Carpenter v. United States*. (2019, October 31). Lawfare. https://www.lawfareblog.com/summary-supreme-court-rules-carpenter-v-united-states Accessed 29.12.2020.

When it comes to second Fourth Amendment threshold, should be cleared what is considered under “search” or a “seizure”.

- Search – Represents violation of subjectively expressed expectations of privacy that society accepts as reasonable[175], and physical intrusion into areas protected by the constitution for the purpose of gathering information[176]. In case that government agents actively search data on mobile phones or other devices in order to collect location data or access photographs and other evidence of social contacts, their handling may be considered as physically intruding upon a constitutionally protected “effect” for the purpose of data collection[177]. Also if location and data, collected by mobile network providers and technology companies, are used and stored by government agents, then this is interpreted as an intrusion into reasonable expectations of privacy[178].

- Seizures – Represent a material violation of property or freedom. Depending on the technology used, epidemiological surveillance programs plausibly could constitute seizures of “effects.” If the government requires citizens to download some application on mobile phone or other electronic devices, then that “interference” might well amount to a seizure of effects[179]. This applies in the case that government agents hack devices to install tracking software[180]. In the case that the aim of the surveillance system was to use personal devices to restrict the freedom of users, for example, by using geo-fencing or other proximity monitoring to conduct physical quarantine, then this would constitute seizure of persons[181].

Since the epidemiological surveillance programs used during the pandemic are aimed at helping public health rather than meeting the objectives of traditional law enforcement, they are likely to fall under special needs doctrine, whether location monitoring, individual monitoring, or the use of aggregate data. Public health is authorized by the court as a legitimate basis for special needs, where it’s expected that the programs and used tools will contribute to public health and serve the legitimate public interest.

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[175] See Katz v. United States, 389 U.S. 347 (1967). Accessed 24.12.2020.
[176] See Florida v. Jardines, 569 U.S. 1 (2013); United States v. Jones, 565 U.S. 400 (2012). Accessed 25.12.2020.
[177] Natalie Ram, David Gray, Mass surveillance in the age of COVID-19, *Journal of Law and the Biosciences*, Volume 7, Issue 1, January-June 2020, lsaa023, https://doi.org/10.1093/jlb/lsaa023 Accessed 20.12.2020.
[178] United States v. Karo, 468 U.S. 705, 716–18 (1984). Accessed 25.12.2020.
[179] Natalie Ram, David Gray, Mass surveillance in the age of COVID-19, *Journal of Law and the Biosciences*, Volume 7, Issue 1, January-June 2020, lsaa023, https://doi.org/10.1093/jlb/lsaa023 Accessed 25.12.2020.
[180] *Cf.* United States v. Horton, 863 F-3d 1041, 1046–1047 (8th Cir. 2017) Accessed 27.12.2020.
[181] 19-292 TORRES V. MADRID. (2019, December). https://www.supremecourt.gov/docket/docketfiles/html/qp/19-00292qp.pdf Accessed 25.12.2020.

Special needs investigations generally do not require a warrant, and in these non-criminal contexts, the Court has approved a range of regulatory approaches that serve legitimate public policy interests. That has ensured the right of people to protect themselves from threats of unreasonable searches and seizures. Executive agencies and legislatures are of great importance in this case.[182]

Courts tend to give political branches broad freedom to develop and implement administrative and programmatic structures for regulation of the use of searches in order to contribute goals such as public health, as long as goals meet the following criteria:

1. goals are narrowly tailored
2. goals have good ground to succeed
3. goals manage an acceptable balance between privacy interests and public policy goals
4. goals restrict the discretion of government agents that conduct the searches

Currently, there is no doubt that a mass surveillance program during a pandemic has a significant public health interest. Proper interventions could save thousands, if not hundreds of thousands of lives, and reduce social, cultural, and economic damage[183]. In any case, the Fourth Amendment still requires some form of constitutionally sufficient future restriction on searches and the discretionary authority of search agents[184].

4.4. The Case of Israel – Israel's controversial Shin Bet security service surveillance program

The coronavirus and its rapid spread have led many states to use mass surveillance to try to suppress the epidemic. One of these countries is Israel, whose government on March 16, 2020 approved two urgent regulations that allow mass monitoring of the location of citizens with the aim of preventing a pandemic of COVID-19[185].

[182] 19-292 TORRES V. MADRID. (2019, December). https://www.supremecourt.gov/docket/docketfiles/html/qp/19-00292qp.pdf Accessed 25.12.2020..
[183] Natalie Ram, David Gray, Mass surveillance in the age of COVID-19, *Journal of Law and the Biosciences*, Volume 7, Issue 1, January-June 2020, lsaa023, https://doi.org/10.1093/jlb/lsaa023 Accessed 20.12.2020.
[184] Ibid.
[185] Amit, M., Kimhi, H., Bader, T. *et al.* Mass-surveillance technologies to fight coronavirus spread: the case of Israel. *Nat Med* 26**,** 1167–1169 (2020). https://doi.org/10.1038/s41591-020-0927-z. Accessed 29.12.2020.

The new regulations referred to:[186]

- Implementation of new rules of social isolation
- Monitoring the locations of patients infected with the virus

Israel Security Agency (ISA), better known by the acronym Shabak or the Shin Bet[187], has a primary role in preventing terrorism and espionage, but at the time of the pandemic, ISA was given the duty to conduct a "digital epidemiological investigation" to find potential contacts of infected individuals.

Due to many difficulties with previous contact tracing methods, the government has introduced a controversial Shin Bet security service surveillance program, which will use primarily cellphone data to identify people exposed to the COVID-19 virus and stop their contact with other people to prevent further spread of the virus[188].

The advanced capabilities of the digital surveillance agency have been redirected to comprehensive epidemiological research and digital identification of people who have come in contact with infected ones[189]. This decision was made as a consequence of the great need to conduct hundreds of investigations in a short period, to ensure the quarantine of potentially infected but asymptomatic people, and to prevent further infection[190]. Although ISA has not shown optimism for using counter-terrorism technologies for other purposes, the government has remained firm in its decision, arguing that it is the fastest way to stop the virus[191].

After the approval of regulations for permitting digital contact tracing, ISA began using the mobile phone location for identifying and quarantining citizens who had been in contact with infected ones[192].

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[186] Amit, M., Kimhi, H., Bader, T. *et al.* Mass-surveillance technologies to fight coronavirus spread: the case of Israel. *Nat Med* 26**,** 1167–1169 (2020). https://doi.org/10.1038/s41591-020-0927-z. Accessed 29.12.2020.
[187] Shin Bet. (2021, January 7). In *Wikipedia*. https://en.wikipedia.org/wiki/Shin_Bet Accessed 02.01.2021.
[188] Sokol, S., & Staff, T. (2021, July 27). *Health Ministry launches revamped COVID-19 tracking app*. The Times of Israel. https://www.timesofisrael.com/health-ministry-launches-revamped-covid-19-tracking-app/ Accessed 03.01.2021.
[189] Amit, M., Kimhi, H., Bader, T. *et al.* Mass-surveillance technologies to fight coronavirus spread: the case of Israel. *Nat Med* 26**,** 1167–1169 (2020). https://doi.org/10.1038/s41591-020-0927-z. Accessed 29.12.2020.
[190] Ibid.
[191] Sokol, S., & Staff, T. (2021, July 27). *Health Ministry launches revamped COVID-19 tracking app*. The Times of Israel. https://www.timesofisrael.com/health-ministry-launches-revamped-covid-19-tracking-app/ Accessed 03.01.2021.
[192] Amit, M., Kimhi, H., Bader, T. *et al.* Mass-surveillance technologies to fight coronavirus spread: the case of Israel. *Nat Med* **26,** 1167–1169 (2020). https://doi.org/10.1038/s41591-020-0927-z Accessed 29.12.2020.

Figure 21 Israel Security Agency logo[193]

Seven days after the newly designed regime was launched, the Israeli Ministry of Health, after analyzing the data, announced that using traditional methods of epidemiological investigation revealed only 33% of known potential spreaders, the other 67% is due to the digital surveillance program. However, a month after the mass surveillance program began, many human rights organizations and journalists filed complaints alleging violations of human rights to privacy.[194]

As a consequence, the Supreme Court of the State of Israel debated the need for a middle ground solution to protect against violations of fundamental human rights. During this discussion, representatives of the Ministry of Health stated that out of 12,501 confirmed COVID-19 cases in Israel, 4,611 (36.8%) cases were detected by cell phone tracking.[195]

The end decision of The Supreme Court was that primary legislation will be required before global contact-tracing technology can be further used during the transition period as part of the 'exit strategy'[196]. Pursuant to the Supreme Court ruling, the Israeli parliament approved a three-week extension of emergency regulations on May 5, 2020, including a digital search for contacts by ISA, thus giving the Israeli government enough

[193] Shin Bet. (2021, January 7). In *Wikipedia*. https://en.wikipedia.org/wiki/Shin_Bet Accessed 02.01.2021.
[194] Amit, M., Kimhi, H., Bader, T. *et al.* Mass-surveillance technologies to fight coronavirus spread: the case of Israel. *Nat Med* **26,** 1167–1169 (2020). https://doi.org/10.1038/s41591-020-0927-z Accessed 29.12.2020.
[195] Worldometer. Coronavirus/Israel https://www.worldometers.info/coronavirus/country/israel/ Accessed 02.01.2021.
[196] Lis, J. (2020, May 5). *Knesset panel extends Shin Bet coronavirus tracking by another three weeks*. Haaretz.Com. https://www.haaretz.com/israel-news/.premium-knesset-panel-extends-shin-bet-coronavirus-tracking-by-another-three-weeks-1.8821398 Accessed 03.01.2021.

time to pass the primary law needed to monitor mobile phones to control proliferation SARS-CoV-28[197].

The case of Israel is one of many that raises the fundamental question of how to balance the need for a non-voluntary program of mass surveillance in emergencies with the risk of permanent damage to civil liberties regularly. In addition to public health experts, technology giants such as Google and Facebook are also involved in problem-solving. The use of data from mobile phones, as they provide information about the movement of people in real-time, has given excellent results, but also caused concern about the exchange of personal data. In order to make an ethnically correct decision, the government and the public will need to weigh the value of privacy against the possibility that data collection could save millions of lives.

Although EU privacy law and the General Data Protection Regulation (GDPR) do not prevent tracking for public health purposes, officials say privacy rights must be protected as much as possible[198]. Countries with strict data privacy laws, such as Germany and Italy, have addressed this issue by asking telecommunications companies to share anonymous, aggregated information they have already collected. Also, mobile phone location data is transmitted in an aggregated, anonymized format. Regardless of the fact that users are not identified, anonymous data can be used to see where and when people gather and risk the spread of the infection.

Another alternative solution, implemented by Israel, among others, is that a contact search application that requires a transparent display to the user of how his private data will be used, stored and shared, and requires user approval for further use.

Six days after ISA launched mandatory coronavirus surveillance, the Israeli Ministry of Health has launched a very similar voluntary service, an open source application that allows citizens to choose to report the locations of their mobile phones[199]. The application works on a principle similar to the "Stop Corona" Austrian application, monitors the user's movements and sends a notification if the user is in direct contact with an infected person. However, this application had a lot of technical shortcomings. For example, in scenario where a wall was between the user and the infected person, and therefore virus transmission would not be possible, the user would be notified that he was potentially infected and should go to quarantine, because the application only takes into account the distance of two people.

“However, some users expressed skepticism regarding the app’s utility after receiving false positives and questioned the ministry’s claim that it would allow them to

[197] Amit, M., Kimhi, H., Bader, T. *et al.* Mass-surveillance technologies to fight coronavirus spread: the case of Israel. *Nat Med* 26**,** 1167–1169 (2020). https://doi.org/10.1038/s41591-020-0927-z . Accessed 29.12.2020.
[198] *How can I change my BBC cookie settings?* (2019, October 18). BC News. https://www.bbc.co.uk/usingthebbc/cookies/how-can-i-change-my-bbc-cookie-settings/ Accessed 04.01.2021.
[199] Ibid.

stop the spread of the disease and protect those closest to us"[200]. Deficiencies in determining the distance between the two users were also noted. In the first seven days, the application was downloaded by more than a million citizens, but in a very short period, it lost 30% of its users. This application, which includes voluntary submission of data and completely anonymous data, gives priority to the preservation of civil rights, but to be successful, many people must use it.

Short-term data from Israel on the effectiveness of the digital surveillance system and the high rate of voluntary participation in disease surveillance have shown that mass digital surveillance is feasible. Because this strategy can compromise privacy and civil liberties, policymakers should be very careful about making decisions about using these AI tools, adhering to the principles in Box 1 in order to minimize restrictions, expedite a return to a normal state, and reduce the impact on economies, while saving lives.[201]

4.4.1. Box 1 Principles for Maintaining Privacy and Civil Liberties with Cellphone Tracking

- Time: The mass surveillance program should be limited in time and carried out in certain periods, not continuously. Mass surveillance and contact-seeking applications will be most important in the period of entering the crisis (sudden increase in the number of infected, new measures, and the danger of closing public facilities) or in the period of stabilization and a gradual return to "normal" life. In these cases, the isolation of potentially infected people could prevent the closure of schools, companies, and public services.[202]
- Operator: Civilian operators such as the telecommunication and software industries should be advised of, and preferably operate the mass contact-tracing systems. Legislation to prevent a 'slippery slope' and the illegitimate use of military technologies against citizens is needed.[203]
- Data: Data collection, use, storage, and sharing should be transparent. The type of data should be scientifically justified. Data should be anonymous, and epidemiologists should define time limits for data storage, after which the data will be deleted[204].

[200] Sokol, S., & Staff, T. (2021, July 27). *Health Ministry launches revamped COVID-19 tracking app*. The Times of Israel. https://www.timesofisrael.com/health-ministry-launches-revamped-covid-19-tracking-app/ Accessed 03.01.2021.
[201] Amit, M., Kimhi, H., Bader, T. *et al.* Mass-surveillance technologies to fight coronavirus spread: the case of Israel. *Nat Med* 26**,** 1167–1169 (2020). https://doi.org/10.1038/s41591-020-0927-z . Accessed 29.12.2020.
[202] Ibid.
[203] Ibid.
[204] Ibid.

- Access: Access to the database should be constantly monitored, with as few people as possible being authorized to access. Each authorized person should be security checked and sign a non-disclosure agreement.[205]
- Participation: Citizen participation in the digital monitoring program should be voluntary. The government should tend to encourage voluntary participation by ensuring transparency and protection of individual privacy, and citizens to allow using their data.[206]
- Supervision: If the funds and technologies intended for anti-terrorist operations are used for mass surveillance, it is necessary to establish an independent committee of professionals who will monitor the program daily. The board should consist of a privacy lawyer, an ethicist, an epidemiologist, a digital privacy expert, and a public representative.[207]

Conclusion

The coronavirus pandemic has caused many concerns for the health of the world's population, as well as sustaining the economic development of countries. The public health system and its employees suffer a special overload. The wave of technological innovation and the development of artificial intelligence have made a great contribution to the fight against the pandemic. Machine learning tools enable monitoring of virus spread, identification of high-risk patients, as well as prediction of mortality risk based on patient data. Metabiota and BlueDot were among the first companies to recognize the virus and give accurate predictions of risky countries. These companies made a great contribution to the monitoring and forecasting of COVID-19.

Machine learning has a good predisposition to reduce the treatment process and improve the health conditions of the infected ones. When it comes to recognizing the symptoms of a virus, AI performs test analyzes and pattern recognition with the greatest possible precision.

Home surveillance technologies have significant potential to reduce personal contact between people and thus exposure to COVID-19. On the other hand, the rapid development of new products also presents challenges ranging from security and accountability to privacy. Mass surveillance plays a major role when it comes to monitoring human contact and assessing the risk of infection, but there is speculation that some countries have misused the collected data by using it for illicit purposes. Therefore,

[205]Amit, M., Kimhi, H., Bader, T. *et al.* Mass-surveillance technologies to fight coronavirus spread: the case of Israel. *Nat Med* 26**,** 1167–1169 (2020). https://doi.org/10.1038/s41591-020-0927-z . Accessed 29.12.2020.
[206] Ibid.
[207] Ibid

user data may only be used if the users allow it, and to gain the user's trust, it is desirable that the data to be used, as well as the purposes to be used, be transparent. When designing software for citizen surveillance purposes, developers must consider ethical and moral aspects. The use of private data and human rights are regulated by law, and by violating these laws, companies, i.e. software producers, risk reputational damage and large fines.

New technologies can be used effectively to enable the medical community to respond quickly to the increased demands and burden of COVID-19. The technologies have been used in the study, diagnosis, and treatment of COVID-19. Recent advances have shown that collaboration between medical researchers and engineers is critical to developing faster and cheaper ways to deal with a pandemic. In the context of the rapid spread of disease around the world, open access to knowledge, tools, and technology is crucial for a timely response. Open access to knowledge, tools, and technology is key to progress, and researchers and engineers must continue to work together and share expertise to solve in this time of crisis.

Table of Figures

Abbreviation

AEM = Associated Encrypted Metadata

AI = Artificial Intelligence

ARDS = Acute Respiratory Distress Syndrome

CFR = Code of Federal Regulations

CRP = C-reactive protein

CT = Computed Tomography

ECG = Personal Electrocardiogram

EUA = Emergency Use Authorization

FDA = Food and Drug Administration

FDCA = Federal Food, Drug, and Cosmetic Act

GDPR = General Data Protection Regulation

HHS = Health and Human Services

HPI = The Health Insurance Portability and Accountability Act

HUB = Hospital University Bellvitge

ICUs = Intensive Care Units

ILSVRC = International Large Scale Visual Recognition Challenge

IoMT = Internet of Medical Things

ICTs = Information and Communication Technologies

MERS-CoV = Middle East Respiratory Syndrome Coronavirus

ML = Machine learning

NIH = National Institutes of Health

NLP = Natural Language Processing

PREP = Public Readiness and Emergency Preparedness

RT-PCR = Reverse transcription polymerase chain reaction

UI = User Interface

SARS-CoV = SARS Coronavirus

SMSI = Social media search indexes

TFEU = Treaty on the Functioning of the EU

WHO = World Health Organization (WHO)

Bibliography

Books, scientific journals and legislative sources

Singhal, T. A Review of Coronavirus Disease-2019 (COVID-19). *Indian J Pediatr* **87,** 281–286 (2020). https://doi.org/10.1007/s12098-020-03263-6 Accessed 20.01.2021.

Kumar D, Malviya R, Kumar Sharma P. Corona Virus: A Review of COVID-19. EJMO. 2020; 4(1): 8-25 https://ejmo.org/10.14744/ejmo.2020.51418/ Accessed 20.01.2021

Max Roser, Hannah Ritchie, Esteban Ortiz-Ospina and Joe Hasell (2020) - "Coronavirus Pandemic (COVID-19)". *Published online at OurWorldInData.org.* https://ourworldindata.org/coronavirus Accessed 23.01.2021.

Article 26 Consolidated version of the Treaty on the Functioning of the European Union Accessed 20.01.2021.

Raju Vaishya, Mohd Javaid, Ibrahim Haleem Khan, Abid Haleem, Artificial Intelligence (AI) applications for COVID-19 pandemic, Diabetes & Metabolic Syndrome: Clinical Research & Reviews, Volume 14, Issue 4, 2020, Pages 337-339, ISSN 1871-4021, https://www.sciencedirect.com/science/article/pii/S1871402120300771#bib1 Accessed 10.12.2020.

Bragazzi, N. L., Dai, H., Damiani, G., Behzadifar, M., Martini, M., & Wu, J. (2020). How Big Data and Artificial Intelligence Can Help Better Manage the COVID-19 Pandemic. *International Journal of Environmental Research and Public Health*, *17*(9), 3176. https://doi.org/10.3390/ijerph17093176 Accessed 11.12.2020.

Sun, K., Chen, J., & Viboud, C. Early epidemiological analysis of the coronavirus disease 2019 outbreak based on crowdsourced data: A population-level observational study. Lancet Digit. Health 2020. https://www.thelancet.com/journals/landig/article/PIIS2589-7500(20)30026-1/fulltext#seccestitle80 Accessed 20.12.2020.

Qin, L., Sun, Q., Wang, Y., Wu, K.F., Chen, M., Shia, B.C., & Wu, S.Y. Prediction of Number of Cases of 2019 Novel Coronavirus (COVID-19) Using Social Media Search

Index. Int. J. Environ. Res. Public Health 2020, 17, 2365. https://www.mdpi.com/1660-4601/17/7/2365 Accessed 19.12.2020.

Allam, Z., Dey, G., & Jones, D. (2020). Artificial Intelligence (AI) Provided Early Detection of the Coronavirus (COVID-19) in China and Will Influence Future Urban Health Policy Internationally. *AI*, *1*(2), 156–165. doi:10.3390/ai1020009 Accessed 07.11.2020.

Murray and Nadel's Textbook of Respiratory Medicine. 2016 : 557–582.e22. Published online 2015 Apr 3. doi: 10.1016/B978-1-4557-3383-5.00033-6. Accessed 09.11.2020.

Alsharif, M.H.; Alsharif, Y.H.; Chaudhry, S.A.; Albreem, M.A.M.; Artificial intelligence technology for diagnosing COVID-19 cases: a review of substantial issues. European review for medical and pharmacological sciences. https://www.europeanreview.org/wp/wp-content/uploads/9226-9233-1.pdf Accessed 22.12.2020.

Mei, X., Lee, HC., Diao, Ky. *et al.* Artificial intelligence–enabled rapid diagnosis of patients with COVID-19. *Nat Med* **26,** 1224–1228 (2020). https://doi.org/10.1038/s41591-020-0931-3 Accessed 7.11.2020.

Sun, H., Yumou, Q., Han, Y., Yaxuan, H., Yuru, Z., Song, X. C.; Tracking and Predicting COVID-19 Epidemic in China Mainland. Preprint. Epidemiology, February 20, 2020. https://doi.org/10.1101/2020.02.17.20024257. Accessed 14.11.2020.

Hassan, M. U. (2018, November 21). *VGG16 – Convolutional Network for Classification and Detection*. Neurohive. https://neurohive.io/en/popular-networks/vgg16/ Accessed 01.12.2020.

Mohamed Tabaa, Hamza Fahmani, Mehdi El ouakifi, Hassna Bensag, Covid-19's Rapid diagnosis Open platform based on X-Ray Imaging and Deep Learning, Procedia Computer Science, Volume 177,
2020, Pages 618-623, ISSN 1877-0509, https://doi.org/10.1016/j.procs.2020.10.088. Accessed 2.12.2020.

Mehta, P., McAuley, D. F., Brown, M., Sanchez, E., Tattersall, R. S., Manson, J. S., & E.T.A.L. (2020). COVID-19: consider cytokine storm syndromes and immunosuppression. *The Lancet*, *395*(10229), 1033–1034. https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(20)30628-0/fulltext Accessed 18.11.2020.

Raju Vaishya, Mohd Javaid, Ibrahim Haleem Khan, Abid Haleem,Artificial Intelligence (AI) applications for COVID-19 pandemic, Diabetes & Metabolic Syndrome: Clinical Research & Reviews, Volume 14, Issue 4, 2020, https://www.sciencedirect.com/science/article/pii/S1871402120300771#bib1 Accessed 22.11.2020.

Fadi Al-Turjman, Muhammad Hassan Nawaz, Umit Deniz Ulusar, Intelligence in the Internet of Medical Things era: A systematic review of current and future trends, Computer Communications, Volume 150, 2020 https://www.sciencedirect.com/science/article/abs/pii/S0140366419313337 Accessed 24.11.2020.

Tsikala Vafea, M., Atalla, E., Georgakas, J. *et al.* Emerging Technologies for Use in the Study, Diagnosis, and Treatment of Patients with COVID-19. *Cel. Mol. Bioeng.* **13,** 249–257 (2020). https://link.springer.com/article/10.1007/s12195-020-00629-w#Sec2 Accessed 25.11.2020.

Art. 6 General Data Protection Regulation (GDPR) Accessed 27.11.2020.

Art.6 Par. 1 lit. a General Data Protection Regulation (GDPR) Accessed 27.11.2020.

Art. 6 Par. 1 lit. e General Data Protection Regulation (GDPR) Accessed 27.11.2020.

Gerke, S., Shachar, C., Chai, P.R. *et al.* Regulatory, safety, and privacy concerns of home monitoring technologies during COVID-19. *Nat Med* **26,** 1176–1182 (2020). https://doi.org/10.1038/s41591-020-0994-1 Accessed 03.01.2021.

Determination of Public Health Emergency. (2020, February 7). Federal Register. https://www.federalregister.gov/documents/2020/02/07/2020-02496/determination-of-public-health-emergency Accessed 30.12.2020.

Emergency Use Declaration. (2020, March 10). Federal Register. https://www.federalregister.gov/documents/2020/03/10/2020-04823/emergency-use-declaration Accessed 30.12.2020.

Declaration Under the Public Readiness and Emergency Preparedness Act for Medical Countermeasures Against COVID-19. (2020b, March 17). Federal Register. https://www.federalregister.gov/documents/2020/03/17/2020-05484/declaration-under-the-public-readiness-and-emergency-preparedness-act-for-medical-countermeasures Accessed 04.01.2021.

General Data Protection Regulation (GDPR), Article 9(1) https://gdpr.eu/article-9-processing-special-categories-of-personal-data-prohibited/ Accessed 05.01.2021.

General Data Protection Regulation (GDPR), Article 9(2) https://gdpr.eu/article-9-processing-special-categories-of-personal-data-prohibited/ Accessed 05.01.2021.

General Data Protection Regulation (GDPR), Article 3 https://gdpr.eu/article-9-processing-special-categories-of-personal-data-prohibited/ Accessed 05.01.2021.

Enforcement Discretion Under HIPAA To Allow Uses and Disclosures of Protected Health Information by Business Associates for Public Health and Health Oversight Activities in Response to COVID-19. (2020, April 7). Federal Register.

https://www.federalregister.gov/documents/2020/04/07/2020-07268/enforcement-discretion-under-hipaa-to-allow-uses-and-disclosures-of-protected-health-information-by Accessed 09.01.2021.

Coronavirus Aid, Relief, and Economic Security (CARES) Act, Pub. L. No. 116–136, 134 Stat. 281, 554 (2020). Accessed 20.12.2020.

U.S. Const., Amend. IV. Accessed 22.12.2020.

Skinner v. Ry. Labor Execs. Ass'n, 489 U.S. 602, 614–615 (1989) Accessed 23.12.2020.

David Gray & Danielle Citron, The Right to Quantitative Privacy, 98 Minn. L. Rev. 62, 133–37 (2013). Accessed 23.12.2020.

Katz v. United States, 389 U.S. 347 (1967). Accessed 24.12.2020.

Florida v. Jardines, 569 U.S. 1 (2013); United States v. Jones, 565 U.S. 400 (2012). Accessed 25.12.2020.

Natalie Ram, David Gray, Mass surveillance in the age of COVID-19, *Journal of Law and the Biosciences*, Volume 7, Issue 1, January-June 2020, lsaa023, https://doi.org/10.1093/jlb/lsaa023 Accessed 20.12.2020.

United States v. Karo, 468 U.S. 705, 716–18 (1984). Accessed 25.12.2020.

Natalie Ram, David Gray, Mass surveillance in the age of COVID-19, *Journal of Law and the Biosciences*, Volume 7, Issue 1, January-June 2020, lsaa023, https://doi.org/10.1093/jlb/lsaa023 Accessed 25.12.2020.

Cf. United States v. Horton, 863 F-3d 1041, 1046–1047 (8th Cir. 2017) Accessed 27.12.2020.

19-292 TORRES V. MADRID. (2019, December). https://www.supremecourt.gov/docket/docketfiles/html/qp/19-00292qp.pdf Accessed 25.12.2020.

Amit, M., Kimhi, H., Bader, T. *et al.* Mass-surveillance technologies to fight coronavirus spread: the case of Israel. *Nat Med* 26**,** 1167–1169 (2020). https://doi.org/10.1038/s41591-020-0927-z. Accessed 29.12.2020.

Websites and other resources

Coronavirus is not the flu. It's worse. (2020, April 1). [Video]. YouTube. https://www.youtube.com/watch?v=FVIGhz3uwuQ Accessed 23.01.2020.

Fredericks B (13 March 2020). "WHO says Europe is new epicenter of coronavirus pandemic" https://nypost.com/2020/03/13/who-says-europe-is-new-epicenter-of-coronavirus-pandemic/ *Accessed 22.01.2021.*

Henley, Jon (18 March 2020). "More than 250m in lockdown in EU as Belgium and Germany adopt measures". https://www.theguardian.com/world/2020/mar/18/coronavirus-lockdown-eu-belgium-germany-adopt-measures Accessed 20.01.2021.

World Health Organization (WHO), "Severe Acute Respiratory Syndrome (SARS)" https://www.who.int/ith/diseases/sars/en/ Accessed 10.11.2020.

Monitoring and risk analytics for the 2019 novel coronavirus(COVID-19) epidemic, Metabiota Risk Report No. 3, 25.02.2020, https://metabiota.com/sites/default/files/inline-files/Metabiota_Risk_Report_No.3-25Feb2020-COVID-2019_0.pdf Accessed 8.11.2020.

Tang, V., (October 15, 2020), How BlueDot Leverages Data Integration to Predict COVID-19 Spread, Safe Software, https://www.safe.com/blog/2020/10/bluedot-leverages-data-integration-predict-covid-19-spread/ Accessed 07.11.2020

Word on the Streets:: Tech for good in the fight against coronavirus. (2020, 21. Mai). Word On The Streets. https://www.wordonthestreets.net/Articles/578049/Tech_for_good.aspx Accessed 09.11.2020.

Bowles, J. (2020, March 20). *How Canadian AI start-up BlueDot spotted Coronavirus before anyone else had a clue*. Diginomica. https://diginomica.com/how-canadian-ai-start-bluedot-spotted-coronavirus-anyone-else-had-clue Accessed 15.11.2020.

M. (2020, March 3). *How this Canadian start-up spotted coronavirus before everyone else knew about it - CNBC*. CNBC. https://causes-of-high-fever.blogspot.com/2020/03/how-this-canadian-start-up-spotted.html Accessed 11.11.2020.

Stieg, C. (2020, March 6). *How this Canadian start-up spotted coronavirus before everyone else knew about it.* CNBC. https://www.cnbc.com/2020/03/03/bluedot-used-artificial-intelligence-to-predict-coronavirus-spread.html Accessed 15.11.2020.

Caulder, I., Kovarik, R., & Cowan, C. (2020, July 30). *AI in Focus: BlueDot and the Response to COVID-19*. Lexology. https://www.lexology.com/library/detail.aspx?g=a94f63b4-2829-4f62-97f7-43f2aecd12a6 Accessed 14.11.2020.

Bowles, J. (2020b, March 20). *How Canadian AI start-up BlueDot spotted Coronavirus before anyone else had a clue*. Diginomica. https://diginomica.com/how-canadian-ai-start-bluedot-spotted-coronavirus-anyone-else-had-clue Accessed 15.11.2020.

Whitaker, B. (2020, May 7). *Outbreak Science: Using artificial intelligence to track the coronavirus pandemic - 60 Minutes*. CBS News. https://www.cbsnews.com/news/coronavirus-outbreak-computer-algorithm-artificial-intelligence/ Accessed 16.11.2020.

BlueDot for Healthcare | Outbreak SaaS for enterprise risk management. (2020, September 15). BlueDot. https://bluedot.global/healthcare/ Accessed 10.11.2020.

Epidemic Tracker | Metabiota. (2020). Metabiota. https://www.metabiota.com/epidemic-tracker Accessed 12.11.2020.

Heaven, W. D. (2020, April 10). *AI could help with the next pandemic—but not with this one*. MIT Technology Review. https://www.technologyreview.com/2020/03/12/905352/ai-could-help-with-the-next-pandemicbut-not-with-this-one/ Accessed 15.11.2020.

Epidemic Tracker | Metabiota. (2020b). Metabiota. https://www.metabiota.com/epidemic-tracker Accessed 12.11.2020.

Home | Metabiota. (2020). Metabiota. https://metabiota.com/ Accessed 14.11.2020.

Metabiota: Metabiota Risk Report No. 3: February 25, 2020 Monitoring and risk analytics for the 2019 novel coronavirus (COVID-19) epidemic, 2020. Accessed 15.11.2020.

Heaven, W. D. (2020b, April 10). *AI could help with the next pandemic—but not with this one*. MIT Technology Review. https://www.technologyreview.com/2020/03/12/905352/ai-could-help-with-the-next-pandemicbut-not-with-this-one/ Accessed 15.11.2020.

Metabiota: Metabiota Risk Report No. 3: February 25, 2020 Monitoring and risk analytics for the 2019 novel coronavirus (COVID-19) epidemic, 2020. Accessed 15.11.2020.

E. (2020, August 7). *Artificial Intelligence (AI) Provided Early Detection of the Coronavirus (COVID-19) in China and Will Influence Future Urban Health Policy Internationally*. Middle East Medical Portal. https://www.middleeastmedicalportal.com/artificial-intelligence-ai-provided-early-detection-of-the-coronavirus-covid-19-in-china-and-will-influence-future-urban-health-policy-internationally/ Accessed 11.11.2020.

Healthcare Workers. (2020, February 11). Centers for Disease Control and Prevention. https://www.cdc.gov/coronavirus/2019-ncov/hcp/therapeutic-options.html Accessed 18.11.2020.

Kundu, S., Elhalawani, H., Gichoja, J. W., & Kahn, C. E. (2020, May 6). *How Might AI and Chest Imaging Help Unravel COVID-19's Mysteries?* RSNA. https://pubs.rsna.org/doi/full/10.1148/ryai.2020200053 Accessed 17.11.2020.

Bellvitge will study the application of artificial intelligence in the treatment of Covid-19 in ICUs – Idibell. (2020, November). Idibell. https://idibell.cat/en/2020/11/bellvitge-will-study-the-application-of-artificial-intelligence-in-the-treatment-of-covid-19-in-icus/ Accessed 22.11.2020.

FAQ "Stopp Corona"-App. (2020). Stopp Corona. https://www.stoppcorona.at/faq_stopp_corona_app/ Accessed 26.11.2020.

https://futurezone.at/apps/stopp-corona-app-zeigt-kuenftig-was-im-hintergrund-passiert/401113971 Accessed 25.11.2020.

What is an API? (2020). RedHat. https://www.redhat.com/en/topics/api/what-are-application-programming-interfaces Accessed 25.11.2020.

What is an API? (Application Programming Interface). MuleSoft. https://www.mulesoft.com/resources/api/what-is-an-api Accessed 25.11.2020.

https://covid19-static.cdn-apple.com/applications/covid19/current/static/contact-tracing/pdf/ExposureNotification-BluetoothSpecificationv1.2.pdf Accessed 25.11.2020.

Accenture. (2020, July 15). *"Stopp Corona" App*. https://www.accenture.com/us-en/case-studies/public-service/stopp-corona-app Accessed 28.11.2020.

How Hospitals Are Using AI to Battle Covid-19. (2021, February 2). Harvard Business Review. https://hbr.org/2020/04/how-hospitals-are-using-ai-to-battle-covid-19 Accessed 04.01.2021.

Fig. 1: Regulatory pathways of home monitoring technologies (before and) during the COVID-19 pandemic. | Nature Medicine. (2020). Nature. https://www.nature.com/articles/s41591-020-0994-1/figures/1?error=cookies_not_supported&code=0eaf9432-b416-471b-b907-cc9bf918e91b Accessed 06.01.2021.

Center for Devices and Radiological Health. (2019, September 26). *Policy for Device Software Functions and Mobile Medical Applications*. U.S. Food and Drug Administration. https://www.fda.gov/regulatory-information/search-fda-guidance-documents/policy-device-software-functions-and-mobile-medical-applications Accessed 04.01.2021.

Apple. (2021, January 22). *ECG app and irregular heart rhythm notification available today on Apple Watch*. Apple Newsroom. https://www.apple.com/newsroom/2018/12/ecg-app-and-irregular-heart-rhythm-notification-available-today-on-apple-watch/ Accessed 03.01.2021.

FDA. Letter to Apple Inc. https://www.accessdata.fda.gov/cdrh_docs/pdf18/DEN180044.pdf (2018). Accessed 29.12.2021.

Center for Devices and Radiological Health. (2020, March 26). *Digital Health Policies and Public Health Solutions for COVID-19*. U.S. Food and Drug Administration. https://www.fda.gov/medical-devices/coronavirus-covid-19-and-medical-devices/digital-health-policies-and-public-health-solutions-covid-19 Accessed 30.12.2021.

HHS. Advisory opinion on the Public Readiness and Emergency Preparedness Act and the March 10, 2020 Declaration under the Act April 17, 2020, as modified on May 19, 2020. https://www.hhs.gov/sites/default/files/prep-act-advisory-opinion-hhs-ogc.pdf (2020). Accessed 05.01.2021.

Spivack, P.S. & Lyons, E.M. Liability immunity under the PREP Act for COVID-19 countermeasures: what manufacturers need to know. https://www.hoganlovells.com/~/media/hogan-lovells/pdf/2020 pdfs/2020_03_23_liability_immunity_under_the_prep_act-for_covid_19_countermeasures.pdf (2020). Accessed 03.01.2021.

Office of the Commissioner. (2021b, January 4). *Beware of Fraudulent Coronavirus Tests, Vaccines and Treatments*. U.S. Food and Drug Administration. https://www.fda.gov/consumers/consumer-updates/beware-fraudulent-coronavirus-tests-vaccines-and treatments?utm_campaign=CU%20Roundup%20040320&utm_medium=email&utm_source=Eloqua Accessed 06.01.2021.

Coronavirus Advice for Consumers. (2021b, January 27). Federal Trade Commission. https://www.ftc.gov/coronavirus/scams-consumer-advice Accessed 05.01.2021.

Wolford, B. (2019, February 13). *Does the GDPR apply to companies outside of the EU?* GDPR.Eu. https://gdpr.eu/companies-outside-of-europe/ Accessed 05.01.2021.

Statement by the EDPB Chair on the processing of personal data in the context of the COVID-19 outbreak. (2020, March 16). European Data Protection Board - European Data Protection Board. https://edpb.europa.eu/news/news/2020/statement-edpb-chair-processing-personal-data-context-covid-19-outbreak_en Accessed 04.01.2021.

European Commission. Coronavirus: An EU approach for efficient contact tracing apps to support gradual lifting of confinement measures. https://ec.europa.eu/commission/presscorner/detail/en/ip_20_670 (2020). Accessed 08.01.2021.

Fig. 1: Regulatory pathways of home monitoring technologies (before and) during the COVID-19 pandemic. | Nature Medicine. (2020). Nature. https://www.nature.com/articles/s41591-020-0994-

1/figures/1?error=cookies_not_supported&code=2b3bab1a-6da5-41d5-80c8-232341251780 Accessed 06.01.2021.

What is HIPAA Compliance? (2020, December 2). Digital Guardian. https://digitalguardian.com/blog/what-hipaa-compliance Accessed 09.01.2021.

Regulatory, safety, and privacy concerns of home monitoring technologies during COVID-19 https://www.nature.com/articles/s41591-020-0994-1/figures/1 Accessed 06.01.2021.

"What is CCPA?" https://www.cookiebot.com/en/what-is-ccpa/ Accessed 09.01.2021.

The Ethics (or not) of Massive Government Surveillance. Stanford. https://cs.stanford.edu/people/eroberts/cs181/projects/ethics-of-surveillance/ethics.html Accessed 16.12.2020.

Council of Europe, Mass Surveillance; https://rm.coe.int/factsheet-on-mass-surveillance-july2018-docx/16808c168e Accessed 15.12.2020.

See Samuel Woodhams, *COVID-19 Digital Rights Tracker*, Top10VPN (Apr. 28, 2020), https://www.top10vpn.com/research/investigations/covid-19-digital-rights-tracker/ Accessed 19.12.2020.

Zhong, R. (2020, May 26). *China's Coronavirus Tracking Apps Stir Privacy Fears as They Linger*. The New York Times. https://www.nytimes.com/2020/05/26/technology/china-coronavirus-surveillance.html Accessed 20.12.2020.

Thompson, D. (2020, August 19). *Contact Tracing Could Free America From Quarantine*. The Atlantic. https://www.theatlantic.com/ideas/archive/2020/04/contact-tracing-could-free-america-from-its-quarantine-nightmare/609577/ Accessed 20.12.2020.

Apps and Covid-19 | Privacy International. Privacyinternational.Org. https://privacyinternational.org/examples/apps-and-covid-19 Accessed 23.12.2020.

Fourth Amendment to the United States Constitution. (2018, March 1). In *Simple English Wikipedia, the free encyclopedia*. https://simple.wikipedia.org/wiki/Fourth_Amendment_to_the_United_States_Constitution Accessed 02.01.2021.

F. (2019, February 5). *When the Fourth Amendment Applies*. Findlaw. https://www.findlaw.com/criminal/criminal-rights/when-the-fourth-amendment-applies.html Accessed 02.01.2021.

Summary: The Supreme Court Rules in Carpenter v. United States. (2019, October 31). Lawfare. https://www.lawfareblog.com/summary-supreme-court-rules-carpenter-v-united-states Accessed 29.12.2020

Shin Bet. (2021, January 7). In *Wikipedia*. https://en.wikipedia.org/wiki/Shin_Bet Accessed 02.01.2021.

Sokol, S., & Staff, T. (2021, July 27). *Health Ministry launches revamped COVID-19 tracking app*. The Times of Israel. https://www.timesofisrael.com/health-ministry-launches-revamped-covid-19-tracking-app/ Accessed 03.01.2021.

Worldometer. Coronavirus/Israel https://www.worldometers.info/coronavirus/country/israel/ Accessed 02.01.2021.

Lis, J. (2020, May 5). *Knesset panel extends Shin Bet coronavirus tracking by another three weeks*. Haaretz.Com. https://www.haaretz.com/israel-news/.premium-knesset-panel-extends-shin-bet-coronavirus-tracking-by-another-three-weeks-1.8821398 Accessed 03.01.2021.

How can I change my BBC cookie settings? (2019, October 18). BC News. https://www.bbc.co.uk/usingthebbc/cookies/how-can-i-change-my-bbc-cookie-settings/ Accessed 04.01.2021.