



Northern Periphery and  
Arctic Programme  
2014-2020



EUROPEAN UNION  
Investing in your future  
European Regional Development Fund

# TechSols

Impact on COVID-19 from Technology Solutions in NPA Regions  
Final report · March 2021

## 1. Introduction

In December 2019 there was an outbreak of the SARS-CoV-2 virus which originated in the Hubei province of China (Esakandari *et al.*, 2020). In the months since the outbreak the virus has spread globally. At the time of writing there have been 128 million cases and 2.8 million deaths in total. This includes 4.34 million confirmed cases and almost 117,000 deaths in the UK (WHO, 2020). Suspected cases of Covid-19 are diagnosed using real-time polymerase chain reaction (qPCR) applied to a sample obtained after a nasal swab is performed (Pascarella *et al.*, 2020). Aside from clinical testing, one of the major indicators of infection is the presence of several symptoms. The most notable are cough, fever, and fatigue which often present within 7 days of exposure to the viral pathogen (Esakandari *et al.*, 2020).

Over the past 12 months, technology has played a vital role in all aspects of Covid-19 management. This includes the adaptation of existing technology and creation of new products because of innovation. Such technologies can range from medical devices to artificial intelligence and data analytics (Wang and Tang, 2020). These technologies have been used for a range of purposes including clinical diagnosis, disease tracking, predicting patient outcomes and the development and validation of treatment options (Kumar, Gupta and Srivastava, 2020). The impact of successful technology integration into Covid-19 management is demonstrated by using countries such as South Korea as an example. During the initial outbreak, South Korea had a death rate of only 0.5 per 100000. This was in stark contrast to other regions such as the USA which had a death rate ten times higher despite being better prepared for a pandemic and having greater hospital resources. It is thought that the improved implementation of contact tracing apps, and quarantine measures using digital applications contributed greatly to South Korea's success in reducing the impact of Covid-19 (Whitelaw *et al.*, 2020). Similar success has also been observed in other countries, notably Taiwan which remained relatively unaffected by the Covid-19 crisis. This was mainly due to countries open source culture and the idea of 'open data'. Health information communication using smart cards enabled effective rationing of face masks while APIs were developed to provide public information regarding testing and mask

supply within defined geographical regions (Wired, 2020). Digital coordination thereby enabled a rapid and effective response to any outbreaks that occurred and helped manage resources at a local and national level.

The TechSolns project aims to assess the impact that technology has had during the Covid-19 pandemic across the Northern Periphery and Arctic (NPA) region programme partner countries. This includes a range of technology solutions that aim to address the physical/mental, economic, and social challenges that have occurred during the pandemic, especially for the most vulnerable individuals. The findings of this report will provide an overview of the efficacy and cost-effectiveness of such technologies which can guide governments and policymakers. Improvements in technology development and better implementation at a population level will provide economic, social, and health benefits.

## **2. Methods**

To identify eligible companies and technology to include in this report, a threefold approach was used. Firstly, we conducted a scoping review of technology solutions in response to COVID-19 in the Northern Periphery and Arctic Area using a web search. The key terms used to identify the solutions included 'COVID-19', 'technology', 'AI', and the name of each country in the NPA region. We also scraped twitter for information by searching for hashtags such as 'techforce19', 'NHSX', and 'covid19tech'. Additionally, we checked reputable news websites for articles on covid-19 technology solutions, regularly visiting reputable new sources such as BBC, The Guardian, and The Telegraph for news items.

Secondly, we attended multiple innovation webinars to learn about technology solutions to the pandemic and gather relevant companies / contacts from these.

Finally, we utilised the existing networks of start-up companies, government agencies, academics, healthcare providers, health and tech entrepreneurs, and health charities from the Partners and Associate Partners on the project and identified suitable case studies from these contacts.

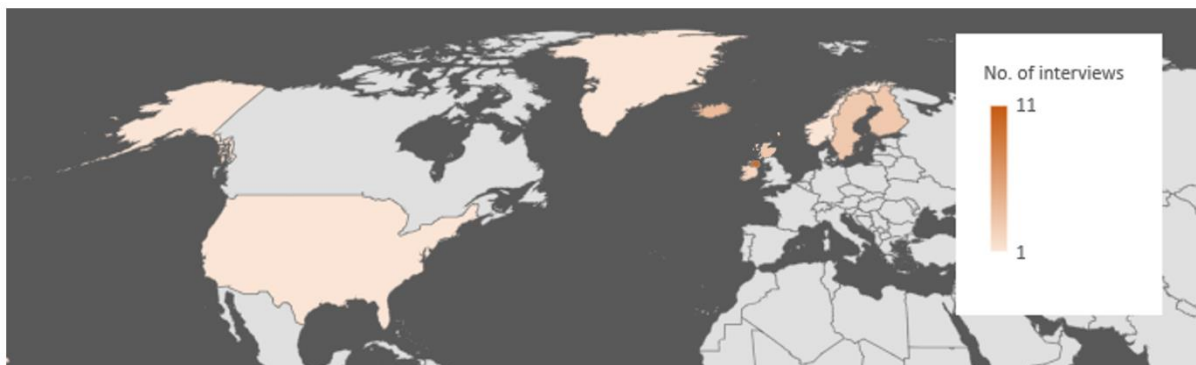
We collated all this information and identified the key companies which had strived with COVID-19 innovation. Each of these companies were then invited to attend a scheduled interview, and those that agreed were asked a series of 11 questions which provided an overview of the company including current expertise, target markets, and how these have changed due to the Covid-19 pandemic. Interviews were conducted online and the responses to each of the questions were recorded and used

to create a summary of findings for each company. We present a brief overview and analysis of the interviews below. Please reference the appendix for the full interviews of each company.

### 3. Results

In total, we interviewed 35 companies over the 9 partner countries of the Northern Periphery and Arctic Area Programme, namely Northern Ireland, Ireland, Scotland, Faroe Islands, Iceland, Greenland, Norway, Finland and Sweden. Additionally, we spoke to a connected health company in Maine, New England. While the USA is not part of the NPA programme, it has been noted that the similarities between Maine and NPA partner countries are striking; Maine is one of the U.S.'s most rural states. The state covers 30,843 square miles with 545,287 people living in rural areas. Maine is also the "oldest" state in the country, with 21% of Mainers being 65 years old or older; while the average age is 44.9 years. It was therefore deemed appropriate to include a case study from this region.

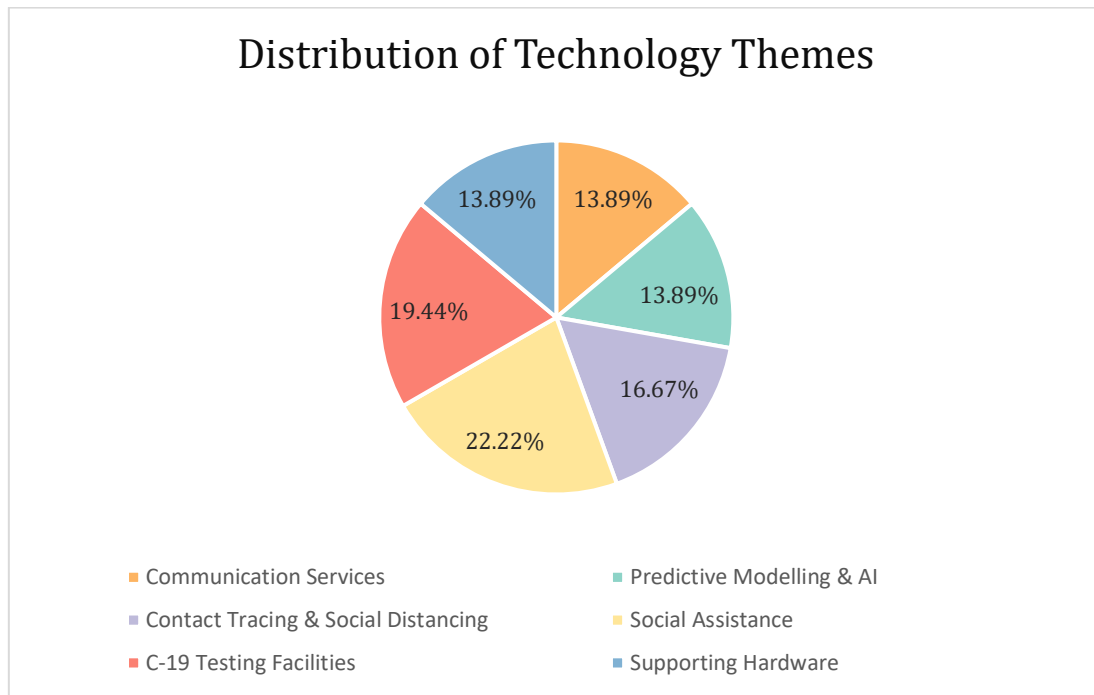
Although we have not been able to interview and include as a case study every technology solution and innovation which has occurred within the NPA region, to the best of our knowledge we have accurately sampled the technology solutions developed in each country and we believe this report provides a fair representation of the key innovations which occurred and were developed within the NPA area. The number of interviews performed in these regions has been highlighted in Figure 1.



*Figure 1: Distribution of technology solution interviews over the NPA region*

Reviewing the technologies which are included in this report, we can categorise the products and services that the 35 interviewed companies offer into 6 recurring themes of business. These are 1) Communication Services 2) Predictive Modelling & AI Technologies 3) Contact Tracing Systems 4) Social Assistance 5) COVID-19 Testing Facilities 6) Supporting Hardware. Figure 2 shows the

percentages that each of the categories makes up when compared to the total number of interviews. The chart shows an approximately even number of interviews were performed from each of the categories, with social assistance technologies proving the most popular theme.



*Figure 2: Distribution of interviewed companies technology themes*

**Social Assistance** made up **22.22%** of interviewed companies. These companies each provided software which would help with daily living during COVID-19. Elemental Software (NI) provided a platform which enabled social prescribing. This service assisted users in finding the certain services within their community, for example, it could be used to organise grocery collection and pharmacy deliveries The Medicines Optimisation Innovation Centre (NI) developed a service which could supply emergency prescriptions and offer virtual clinics. Interactive Health Limited (Scotland) have produced an app which encourages individuals to make informed health choices and includes advice regarding a variety of physical and mental health problems. Curest AB (Sweden) developed software to ensure physical therapy still continues remotely using Virtual Reality, whereas Kara Connect (Iceland) provided a telehealth platform for health professionals, child protection services, clinics and school counselling services enabling these services to be delivered online. Boneprox AB (Sweden) developed an educational platform to allow for the remote training of Dentists during the pandemic. Var

Healthcare (Norway) added specific COVID-19 procedures to their digital nursing reference handbook, whereas Helseboka (Norway) added vaccine scheduling to their already established health record app.

**COVID-19 Testing Facilities** made up **19.44%** of interviewed companies. These companies each provided a technology solution to aid in the testing for detection of COVID-19. Ulster University (NI) and BioNavis (Finland) both worked on antibody testing, with Ulster University using it to determine the population exposure to COVID-19 while BioNavis developed an anti-pathogen antibody assay allowing for fast and effective COVID-19 testing. Similarly, Biomensio (Finland) adapted their biosensor technology and extended it for use as a COVID diagnosis tool. Thetis (Faroe), a private veterinary and environmental agency and Heilsufrøðiliga Starvsstovan (Faroe), the public faroese food and veterinary authority, both converted parts of their labs normally used for food export testing to process COVID-19 tests. Origo (Iceland) developed software to screen and track the progress of your COVID-19 test, while iSTOC (Finland) adapted their Cloud-based medical diagnosis platform to enable it to screen large numbers of Covid-19 test results which can be communicated to health officials.

**Contact Tracing & Social Distancing** made up **16.67%** of interviewed companies. These companies each provided an app which would help ensure social distancing and/or services for tracking those who had been in contact with an infected person. HSCNI (NI) and Big Motive (NI) worked together on the STOPCOVIDNI app, the national contact tracing app for Northern Ireland. This application is based on the DP3T concept utilising the Bluetooth API from Apple and Google. Solita (Finland) produced a similar national app for Finland. The Icelandic Directorate of Health (Iceland) also produced a contact tracing app, which used GPS technology instead of Bluetooth. Wyld Networks (Scotland) on the other hand produced an app using their own mesh networks to produce heatmaps which would indicate areas in care homes where the 2m minimum distance has been infringed, while CENSIS (Scotland) produced and tested various social distancing apps based on Bluetooth RSSI.

**Communication Services, Predictive modelling & AI Technologies and Supporting Hardware** each made up **13.89%** of interviewed company's technologies.

**Communication Services.** These companies either offered software, hardware, or both to facilitate virtual communication. Kraydel Ltd (NI) and Ethel (NI) both produced their own bespoke elder friendly video calling device and the software for this, while Nemila (Faroe), Memaxi (Iceland), and the Icelandic Directorate of Health (Iceland), each produced video calling software to run on pre-existing tablets / phones / computers.

**Predictive modelling & AI Technologies.** These companies offered a solution using Artificial Intelligence in response to COVID-19. Liopa (NI) produced an AI powered lip-reading application for use with tracheotomy patients, while Axial 3D (NI) used AI to produce 3D models of organs, providing a tool to assist with surgery by allowing doctors to practice procedures in advance. Tapa Healthcare (Ireland), SHAPES (NI), and Sencio (USA) each provide an AI powered health monitoring tool which provide early warnings for various illnesses including COVID-19.

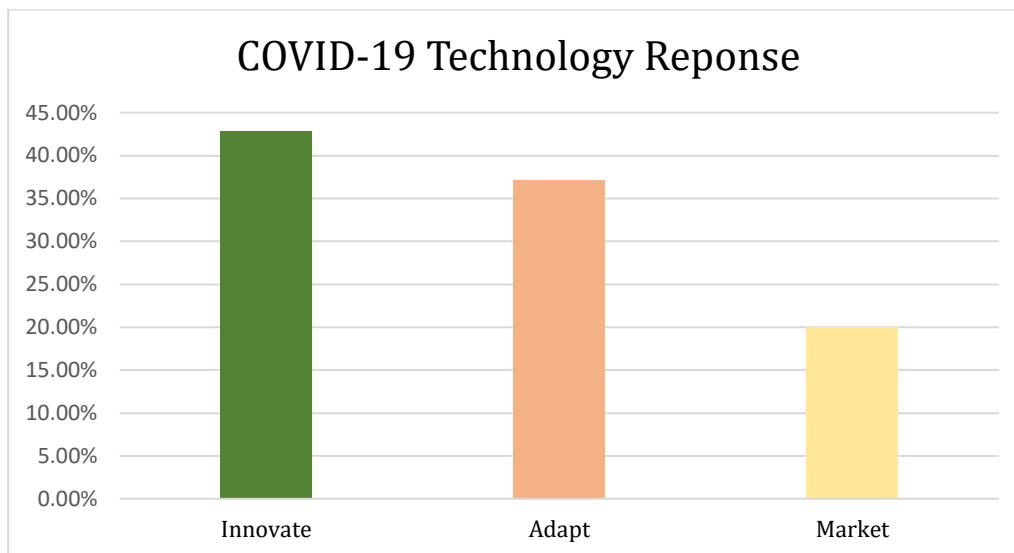
**Supporting Hardware.** These companies each provided a hardware solution to combat various challenges brought by COVID-19. Trimedika (NI) produced a non-contact thermometer, while Innovate Greenland (Greenland) used 3D printers to make face visors for medical staff. BioPixS (Ireland) produced phantoms which mimic human tissue and blood, allowing for the testing and validation of various COVID-19 technologies. Cuviva AB (Sweden) provided health monitoring software which uses connected sensors to monitor patients in their homes. Lainisalo (Finland) manufactured an anti-viral coating which would eliminate COVID-19 virus particles.

The study demonstrates a wide range of technology innovations throughout several regions. Many of these innovations include software platforms that conduct a variety of functions ranging from predicting changes in patient's health and monitoring vital signs to contact tracing and products that provide reduced workload and improved workflow for healthcare workers. Many of these technological solutions have had considerable success, demonstrated by the fact that many of these companies have experienced continued growth and expanded to include new markets resulting in increased revenue. The companies discussed as part of the current project therefore provide evidence of cost-effective digital solutions that address many of the health, economic and social challenges faced by vulnerable groups during the Covid-19 pandemic.

It is worth noting that not all of the agencies / companies interviewed fell into one specific category. For instance, The Icelandic Directorate of Health covered both contact tracing and video calling services.

As part of the interviews, we asked each company to identify the technology response they provided as either Innovative, Adaptive, or Marketed. These categories were formulated given the following definitions. A product was considered innovative if the business were previously offering an unrelated technology / service, but were able to use their background expertise to innovate and offer a new product / service to aid in the coronavirus crisis. Adaption on the other hand was if the company had a pre-existing product / service which was added to / adjusted in order to make it suitable for the

market demands COVID-19 brought. Finally, a product / service was considered marketed if the company had a pre-existing technology solution which fit the needs of the COVID market and were able to increase sales because of the pandemic. Figure 3 shows the distribution of the categories of technology response over the 35 interviewed companies.



*Figure 3: Company Technology Response to COVID-19*

Figure 3 shows that 43% of sampled companies innovated in some way. This was the most common type of technology response to COVID-19. This result was to be expected as the pandemic brought about many new and unique problems which had not historically been an issue or considered before, and thus required the innovation of new solutions to aid in the response. For example, before the pandemic, contact tracing applications were completely unheard of, while 2020 saw 49 countries develop one of these apps for their citizens. On the other hand, 37% of sampled companies adapted their product to fit the needs of the pandemic market. Examples of product adaptation can be seen in companies like Elemental software who adapted their social prescribing application to include neighbourhood arranged grocery and prescription pickup and a self-referral system and Sensico who added a COVID-19 warning system into their AI powered health monitoring software to detect and monitor both onset and worsening of COVID-19 symptoms. Finally, 20% of the solutions identified in this report were pre-existing products which found their demand increasing after the pandemic started. Trimedika, for example, had been manufacturing non-contact thermometers since 2014 for the healthcare market and found demand for their device increase exponentially after the onset of COVID-19. Ethel are another good example of a marketed technology solution, who were already producing a device and software to facilitate simple video calling between elders and their families

but were able to expand to the care home market once social distancing and visiting restrictions were introduced into these facilities.

## 4. Discussion

Our results show that there has been widespread technological innovation within the NPA region as a response to COVID-19. Technology adaption, innovation, and uptake in these regions is perhaps unsurprising given periphery countries track record of adaption and flexibility in response to crisis, which is often the case due to the close-knit community and closely aligned interests which often exist in these relatively small countries. Below we discuss in more detail the technology innovations which occurred within our identified themes, and the synergies which exist between these technology solutions from supporting research carried out by the rest of the COVID-19 Response Group (CORE).

### **Communication Services and Social Assistance**

From our results, it is clear that a major theme of technology solutions emerging from the COVID-19 pandemic were focused on addressing the social problems that had formed. This is evidenced by *social assistance* and *communication services* technologies making up 36% of the interviewed companies.

In synergy with CORE Theme F, *Analysing Emerging Themes*, it was found that during the first wave of COVID-19 (March-June '20), residents of care homes were the most affected cohort. For example, the Northern Ireland Statistics and Research Agency (NISRA) reported 716 deaths linked to COVID-19 up to and including 22nd May. Of these 728 deaths, over half of them (53.1%) had been residents of care homes. A similar situation existed in Finland with the Finnish Institute for Health and Welfare (THL) reporting 44% of COVID-19 deaths occurring in 24h care homes up to and including 8<sup>th</sup> July. As a response, both Northern Ireland and Finland placed a ban on all care home visitations. Increased anxiety and loneliness was reported amongst the elderly leading to an initiative supported by HSCNI to facilitate or increase virtual visits through technology solutions. HSCNI has helped alleviate these feelings of social isolation by implementing virtual visits in care homes. Companies such as Kraydel, Ethel, Nemila, and Memaxi have provided technologies that enable social connectedness. The importance of maintaining social distancing has meant that many vulnerable groups have also experienced difficulties accessing required services such as supermarkets and pharmacies. Companies such as Elemental Software have helped to connect individuals with local services which they require most. The theme of maintaining social connections during a pandemic has also been observed within



a health and care setting. Given that the elderly population represent some of the most vulnerable individuals, preventing the spread of infection to this group is of great importance. Adapting video conferencing technology to address a growing concern over social isolation is another example of how technology can alleviate problems that have recently arisen due to the pandemic.

The importance of addressing such problems is highlighted by the results of a study conducted by Taquet *et al.* (2020) which found that individuals who contracted Covid-19 were twice as likely to suffer from a mental illness such as anxiety, depression, or insomnia than those who suffer from other isolating conditions such as flu or fractures. Additionally, those with an existing mental illness were 65% more likely to contract Covid-19 (Taquet *et al.* 2020). Partner research on the *Impact from COVID-19 isolation on mental health in NPA regions - Remind*, similarly found that mental distress during the pandemic has significantly increased. For example, in the UK an increase from 18.9% to 27.3% has been reported. To combat this, social prescribing platforms such as that provided by Elemental Software connect patients to services that provide physical and mental health benefits. This can reduce the likelihood of future declines in health which cuts down on the number of GP appointments. Resources can therefore be allocated more effectively to deal with the pandemic and other health emergencies.

Communication and Social Assistance technologies such as Kara Connect, Curest AB, and Helseboka can also support remote consultations from Doctors. From our partner research on the *Communities' response and resilience to coronavirus 19* we have learnt that 58 – 87% of users of the health care system (dependant on the NPA region) were willing to use remote services, with the telephone being the most popular communication method. However, while these telehealth methods provide a scalable and potentially safer method of utilising primary care facilities, a large cohort of almost 50% feel they lack the skills or tools required to effectively access telehealth systems. Common problems included lack of ICT skills and no access to an internet connection.

In times when the pandemic is under control, it is likely that the adoption of telehealthcare systems will continue to grow and be extended to other areas of primary care. However, several areas still require improvement, including education of those unfamiliar with e-medicine systems for both patients and professionals.

### **Predictive modelling and AI**

Many of the companies interviewed marketed products for use by the healthcare service and its workers. This included digital platforms such as READS developed by Tapa Healthcare (Ireland) which

integrates with EHRs to predict patient outcomes. Powered by AI, 3D anatomical models produced by Axial3D for use by consultants enabled planning and discussion of surgery to continue remotely during the pandemic. This meant that teams of consultants and surgeons could proceed with the planning phase of important surgical operations. Such examples provide insight into how the products offered by these companies have helped improve workflow in a hospital setting. Improved planning and better patient management have resulted in reduced workload and enabled many hospital procedures to proceed despite the interruption caused by Covid-19. One problem that has arisen within hospitals over the past 12 months is the increased burden on intensive care units (ICUs) due to the severe respiratory problems experienced by some patients, especially the most vulnerable individuals. As a result, many patients require a tracheostomy to be performed which can leave them incapable of speech. Liopa is just one example of how health technology innovation can provide adaptive solutions to new problems. By combining lip reading technology and artificial intelligence (AI), patients can communicate more effectively with clinicians. This reduces communication problems and stress for both patients and staff. Overall, there has been increased pressure on healthcare services. Improved workflow is essential to enable more appropriate allocation of clinician time and healthcare resources. Alternatively, software such as SENSCIO take it one step further and put the power in the patients hands, allowing them to monitor their own health and wellbeing by providing an AI powered health monitoring application which helps predict the onset of illnesses including COVID-19.

### **Supporting Hardware**

Technological hardware solutions also played their part in response to the COVID-19 crisis. Direct innovation occurred in companies like Lainisalo, a Finnish paint manufacturer who produced an anti-viral coating, known as COVIDSAFE, which could destroy COVID-19 particles. This coating contains copper, a known virucidal, and is capable of destroying COVID-19 particles within four hours. They hope that with continued development this mixture could assist in future pandemics. Another interesting hardware development which emerged in the early stages of the pandemic was the use of non-commercial 3D printers. With PPE shortages becoming a worldwide problem, people such as Dr Aaron McConville<sup>†</sup>, a lecturer at Ulster University, had been producing thousands of 3D printed face shields to be used by NHS staff. Similarly, Greenland, a country which has mostly avoided the COVID-19 pandemic, also had individuals printing face shields for healthcare staff. However, supporting technological hardware did not necessarily have to be a novel idea in order for the solution to be successful. For example, Trimedika produces a non-contact infrared thermometer which aids in reducing the spread of infection while measuring vital stats, and noticed a huge increase in demand

for their product as hospitals started to pivot to this technology exclusively. Demands were also noticed from businesses, hospitality, and schools who each wanted to conduct temperature screening on arrival at their premise. Infrared thermometers like this have been available on the market for some time, however due to the pandemic the devices were brought into the limelight.

In Ireland there is continued support for technological innovation as shown by the introduction of the Enterprise Ireland Covid-19 products scheme which provides funding for research and development (R&D) into solutions including medical devices, software, and vaccine development (Enterprise Ireland, 2020). Funding is vital to enable innovation. An example is the work undertaken by Aquila Bioscience in Ireland. Development of pathogen capturing technology (PCT) and its application to hand wipes can remove 99.99% of the SARS-COV 2 virus from the surface of the skin (Irish Advantage, 2020). Funded by the European Space Agency (ESA), PMD solutions will develop a wearable sensor that monitors respiratory function to detect health problems such as shortness of breath and breathing difficulties. This enables clinicians and carers to detect potential adverse events up to 12 hours before the event occurs. Skytek, also funded by the ESA, aim to develop a platform that will work in conjunction with the computerised infection disease reporting (CIDR) system which will monitor case numbers and create alerts if an outbreak is suspected to occur. Intended users include hospitals, pharmacies and nursing homes who will be able to react proactively to manage or even prevent an outbreak of cases. In addition to the many changes that have occurred within GP practices, there has also been considerable integration of technology into pharmacies across Northern Ireland.

However, there are noticeable side-effects to the rapid development of hardware and software solutions for the pandemic. Incomplete and not fit for purpose technology solutions emerged daily and in some cases had a knock-on-effect in the trust in new technology from the national health procurement departments, as was noted by *Biomensio*. However, a solution developed to help testing the functionality of a new device emerged from a company called BioPixS located in the Republic of Ireland. They produced imaging phantoms, which are objects which have been specifically designed to mimic bodily organs for testing and validation of devices without requiring actual human tissue. This technology allows companies to test and verify their COVID-19 device without having to complete lengthy ethical processes to test their devices on actual humans.

### **Contact tracing and Social Distancing**

The use of digital technology was found to not just be confined to use within a hospital setting but can be implemented at a population level. Accessibility has been a major focus during the pandemic and

includes both digital and informational accessibility. Contact tracing and Social distancing apps have been a major development within the field of public health technology in the NPA region and indeed worldwide. In fact, 49 countries have developed their own bespoke track and trace app so that people can receive alerts if they have been in contact with someone who later tests positive for COVID-19, which in turn should help stop the spread of the virus. This includes 6 of the 9 countries within the NPA, namely STOPCOVIDNI (NI), COVID Tracker Ireland (Ireland), Protect Scotland (Scotland), Smittestopp (Norway), Rakning C-19 (Iceland), and Koronavilkku (Finland). Contact tracing apps became vastly more popular with the public once Apple and Google launched their Decentralized Privacy-Preserving Proximity Tracing protocol which used anonymous Bluetooth instead of GPS for contact tracing. 5 of the 6 apps mentioned above use this protocol, with Rakning C-19 being the only app to still use the original GPS concept for track and trace. Any app using the Apple and Google decentralized protocol are also inter-compatible, meaning that your native countries track and trace app will receive alerts and function as normal if travelling in another country utilising the same protocol. Interestingly, The Norwegian Data Protection Authority banned the original version of Smittestopp which utilised GPS tracking, stating that perceived benefits do not outweigh data privacy risks. Smittestopp was then redesigned using the DP3T protocol.

Each of these apps were designed to be used by all individuals, including groups such as the elderly. Digital design companies such as Big Motive (NI) were involved in the development process of STOPCOVIDNI and ensured that the user experience enabled the technology to be useable by those individuals who may not be familiar with such technology. The design patterns which they developed were used by many other countries when developing their own national app, including Scotland's Protect Scotland.

A particular highlight from the contact tracing national apps was the development of the Iceland COVID-19 track and trace application, Rakning C-19. While many countries worked for months developing their contact tracing app, Iceland completed theirs in just 10 days by volunteers. An open question is answering if this rapid development is just a matter of scale? With Iceland having a smaller population does it simplify the implementation, or is there an increased trust in public institutions?

A major concern as the pandemic and lockdown progressed was how to re-open non-essential businesses and allow a safer path for employees to return to work. This consideration led some companies to develop applications which promoted social distancing. A prominent example of this was with Wyld Networks (Scotland), who originally produced a mesh network application which produced a Bluetooth network to extend Wi-Fi coverage into areas which would normally be out of

reach. They innovated upon this technology to produce a heat map of areas where social distancing regulations were being infringed. Similarly, CENSIS (Scotland) also tested and produced social distancing applications based on Bluetooth RSSI.

When considering increased technology use and innovation during the pandemic the issue of privacy and data security has arisen. Although such concerns have always existed, the widespread use of the national contact tracing apps have brought such concerns into the public domain. Uptake of these technologies can be as little as 2-25% across a range of European countries with data privacy being cited as a major concern. However, in cases where benefits of a new technology are unknown and certain risks exist, adaptive governance can be applied. Features of governance include continued public engagement during the development and implementation phase of and considering the technical, legal, and ethical aspects of the technology being developed (Blasimme and Vayena, 2020). Aside from privacy issues, socioeconomic factors can influence technology uptake. Contact tracing apps require access to smartphones and the knowledge to download and use the apps. Lower income groups may not benefit from such technology while users such as the elderly may be incapable of making use of it. Some efforts have been made by technology companies such as Apple whereby 'Exposure Notifications Express' has been integrated into iOS 13.7 onwards. Nevertheless, such issues influence the success of technology regardless of how effective the technology is at achieving its intended purpose (Technology Review, 2020).

### **C-19 testing**

One of the most critical innovations as a response to the pandemic was providing the technology and facilities to test for the Sars-COV-2 virus in the human body. At the IT level, innovation from Origo Iceland was spoken of worldwide when they developed software to track the tests of every international passenger arriving at the airport, ensuring the virus was controlled within the country while allowing them to reopen for tourism. The tracking software has been so successful that the Directorate of Health wants to use the same system for the tracking of cancer patients' treatments, demonstrating that pandemic innovation does not have to be a one-off development and rather that it can be adapted and help drive change in other sectors. iSTOC Finland demonstrated how existing technology could be adapted when they altered their Cloud-based medical diagnosis platform to enable it to screen large numbers of Covid-19 test results which can be communicated to health officials. Innovation such as this was mandatory so that health ministers could properly understand the virus, how it is being transmitted, and develop public policies and responses accordingly.

COVID-19 testing was only possible with the relevant biomedical equipment and technology. Companies like BioNavis quickly developed antibody assays to allow for the accurate testing of COVID-19. Biomensio on the other hand adapted their biosensor technology and extended it for use as a quick COVID diagnosis tool. Biomensio see this technology being of particular interest to the tourist industry and to larger employers who may wish to do a health screening on all employees before entering a building, both of whom rely on quick results from a test. NUI Galway are working on a similar time-sensitive testing solution. Here, they have developed a handheld Covid-19 test by utilising antibodies attached to nanoparticles so that a response is produced when a sample of the virus is introduced enabling a result to be obtained in as little as 10 minutes (NUI Galway, 2020).

Even at a lab level, adaption was observed to allow for the processing of COVID-19 tests. For example, Thetis (Faroe), a private veterinary and environmental agency and Heilsufrøðiliga Starvsstovan (Faroe), the public Faroese food and veterinary authority, both converted parts of their labs normally used for food export testing to process C-19 tests. There is synergy to be found while examining the Technology solutions which focused on C-19 testing facilities and the research conducted on *Economic Impact* by Theme E. *Economic Impact* considered the financial effects that C-19 had on health care systems within periphery areas and discussed if these areas had the correct characteristics to support flexible adaptation in response to crises. When we consider the adaptations made by Heilsufrøðiliga Starvsstovan, it raises questions of the differing regulatory controls between countries and how they impact upon an entities ability to adapt. For instance, if Heilsufrøðiliga Starvsstovan had of been within a larger country, could it have adapted to C-19 testing? And what impact would permitting or restricting these adaptations have had upon the Faroe Islands response to C-19?

### **Mathematical modelling**

Although not covered in any of our interviews, modelling, including both mathematical and epidemiological models, have played a key role during the pandemic and often informs the development and use of other technologies – many of which feature in this report. Coordinating vaccinations is one area where modelling has been applied. Given the initial limited availability and logistical difficulties associated with a vaccination programme mathematical modelling has been used to identify those who should receive the vaccine first. These models consider factors that influence transmission and infection including age, socioeconomic factors, and health risks to determine optimal vaccine application using available resources and time (Technology Review, 2020). Epidemiological models have also been used to monitor the impact of population mobility on regional cases. A study by Chang *et al.* (2020) used mobility network models applied to Chicago. It found that 10% of locations

in the city accounted for 85% of infections. The impact of lockdown on the number of cases was also modelled. However, it was predicted that limited occupancy of locations to 20% would reduce the infection rate by 80%. Such models have been used to inform reopening strategies and provides an alternative way in which technology can inform decisions during the current pandemic (Chang *et al.* 2020).

### **Lessons Learned**

During each of the interviews, the representative was asked to comment on any lessons learned during their work in the pandemic. This information is important as it can allow companies and public agencies to more effectively adapt to any future pandemic or phenomenon which significantly changes the way the public interacts with these services.

A common theme in these lessons was the reaction of typical health services. Many health systems globally have a conservative outlook, which can both delay and increase workload. For example, the Icelandic directorate of health allowed the general population to book COVID-19 tests without the intervention or supervision of a doctor. This isn't typical, as normally tests would need a referral, but in doing this they found it resulted in a much more efficient system. This decreased workload for doctors and fears that the system would be abused by patients turned out to be unfounded.

The increased spotlight and investment opportunities available to companies also allowed them to dramatically increase their productivity, innovation and made them more aware of their gaps in knowledge. For example, Liopa from Northern Ireland, who provided a system of automated lip-reading, found a completely new market in providing this lip-reading service at a distance to those who had communication difficulties as a result of COVID-19.

While increased funding helped some companies make a real impact, others noticed that many individuals were trying to pitch and push underdeveloped ideas which were unlikely to succeed in an attempt to get 'a piece of the pie'. CENSIS noted that the filtering of new technology was therefore an important stage of the development process, and generally found that the more mature ideas – the ones which had been well planned and based on existing expertise – were the ones more likely to be invested in. Trimedika were in agreement with this who said that while innovation and adaption was important in a pandemic, for them staying focused on their originally researched market and plan was what was going to bring them the most success.

## 5. Conclusions and Recommendations

The original concept behind the TechSolns theme of the NPA CORE project was to investigate how companies and public agencies had innovated, adapted or re-marketed their technological products/services to fulfil the new market created by the COVID-19 global pandemic. 35 companies and agencies were interviewed over the NPA region using a standardised list of 11 questions. These questions ranged from basic information gathering, such as company size and location, to how their company evolved and the lessons they learned during the pandemic. While conducting the interviews, six clear sectors of companies emerged: Communication Services, Predictive Modelling, Contact Tracing, Social Assistance, COVID-19 testing and Supportive Hardware. Of these six categories, social assistance-based companies were the most interviewed. 45% of the companies innovated a new product/service, while 32% adapted an existing product/service and 23% re-marketed their product/service. Interestingly, innovation made up the vast majority of the interviews, which is likely the case due to increased opportunities for funding and the re-prioritisation of the most important and time sensitive tasks.

Throughout the interviews, it was found that many of the companies who had innovated had taken their previous expertise and tried to apply it to assisting in the pandemic. For instance, BioPixS, a company who produce anthropomorphic phantoms, produced variants which could assist in the validation of COVID-19 related medical tools. This concurrent innovation towards a singular goal by multiple companies across a wide spectrum of expertise areas could result in changes to project management structure to become more reactive to change. The additional innovation will also open new future business opportunities and potentially large steps forward in medical understanding.

Looking beyond the pandemic, it is important to keep in mind the uncertainty the future holds for individuals, public agencies and technology companies. To gain insight into how future preparation could be achieved, each of the interviewed was asking if they had any important lessons they learned during the pandemic and how this would ultimately affect their outlook and future goals. Many of the companies interviewed found that they had an accelerated uptake of their products during the pandemic. Examples include Elemental software in Northern Ireland who expanded their userbase by 100%, and Helseboka in Norway who had the number of users increase ten-fold.

An inevitable effect of the pandemic has been the scrutiny of the public healthcare systems. Some countries appeared to be able to handle crisis better than others — an example being the Icelandic health service. After accounting for their small size relative to the rest of Europe, their proportional



number of cases was markedly smaller. As the pandemic subsides, it is less important to consider the failings of other countries but rather why and specifically how others managed to control it better. By capturing this information, it should be possible to scale these strategies to fit other countries and in the case of another similar global crisis, apply them with increased efficacy.

Cost efficiency is another important factor going forward, the core aspect of many of the companies interviewed in this manuscript aimed to increase efficiency within aspects of a healthcare system. This is not only brought upon by the pandemic, but also with the elderly becoming an increasingly larger percentage of the overall population. In general, those who are older are more susceptible to illness and this comes with an increased cost burden on health systems. An extraordinary amount of research is now dedicated to early diagnosis and cost reduction in health care systems. One example of such research comes from the NPA funded SENDoc project where one of the deliverables was the creation of a prospective falls likelihood model for the elderly, allowing earlier pre-emptive therapy to commence, home modifications made etc. Of the companies interviewed within this manuscript, Tapa Healthcare employed early warning scores for proactive insights into a patient's health. Many others interviewed provided communication services such as Kraydel, who are not only providing a system to allow people in isolation to communicate but are also innovating further by providing wearable hardware which can automatically pick up vital signs. Technology such as this has the potential to reduce the need for doctor visits, bringing associated cost savings, especially in remote areas where access to a doctor may be much more difficult. It is worth noting that in order for technology uptake to be successful within the elderly population, the system needs to be user friendly and simple to use. Many of the interviewed companies have already focused on this aspect including Memaxi, STOPCOVIDNI, Kraydel, and Ethel — to name a few — who have all designed their systems with elderly users in mind.

With the COVID-19 vaccination program now active in many countries, the idea of a vaccine passport is under consideration. While detracted by some as discriminative towards those who do not want to be vaccinated, the implementation of such a system could enable increased health data exchange between countries. This increase in data exchange could result in easier handling of pandemics in the future and could be advantageous for those within medical research.

Many of the companies featured in this report found success by leveraging their pre-existing market knowledge, however they may not represent the entities who completely pivoted their direction who may not have been as successful. We therefore recommend that companies use due diligence before changing their current business direction or focus. Businesses should not forgo their primary trade to focus on crisis innovation; rather this should come secondary.

The report has shown that similar technology innovations occurred between many of the NPA countries. Going forward, countries could more efficiently combat a crisis if interdisciplinary, multi-national teams worked on technology together rather than multiple countries producing the same product.

## 6. Bibliography

Basimme, A. and Vayena, E. (2020) 'What's next for COVID-19 apps? Governance and oversight', *Science*, 370(6518), pp760-762. doi: 10.1126/science.abd9006.

Chang, S., Pierson, E., Wei Koh, P., Gerardin, J., Redbird, B., Grusky, D. and Leskovec, J. (2020) 'Mobility network models of COVID-19 explain inequities and inform reopening', *Nature*, [Online]. Available at <https://www.nature.com/articles/s41586-020-2923-3> [Accessed 26 Nov. 2020].

Enterprise Ireland. (2020) 'Covid-19 Products Scheme'. [Online] Available at <https://www.enterpriseireland.com/en/funding-supports/covid-19-products-scheme#Covid19> [Accessed 24 Nov. 2020].

Esakandari, H. *et al.* (2020) 'A comprehensive review of COVID-19 characteristics', 2, pp. 1–10.

Healthcare and Care at Distance. (2020) 'Webinar series: Technology use for Covid-19 response'. [Online] Available at <https://www.healthcareatdistance.com/vopd-webinar-series> [Accessed 14 Dec 2020]

Irish Advantage. (2020) 'Aquila Bioscience: Making Clean Work of Covid-19'. [Online] Available at <https://irishadvantage.com/Aquila-Bioscience-covid-19/> [Accessed 24 Nov. 2020].

Kumar, A., Gupta, P. K. and Srivastava, A. (2020) 'A review of modern technologies for tackling COVID-19 pandemic', *Diabetes and Metabolic Syndrome: Clinical Research and Reviews*, 14(4), pp. 569–573. doi: 10.1016/j.dsx.2020.05.008.

Medicines Optimisation Innovation Centre. (2020) 'Rapid review of pharmacy services changed in response to Covid-19 in Northern Ireland'

NUI Galway. (2020) 'NUI Galway Receive Grant to Develop Handheld Device for Rapid Covid-19 Testing'. [Online] Available at <https://www.nuigalway.ie/about-us/news-and-events/news-archive/2020/november/nui-galway-receive-grant-to-develop-handheld-device-for-rapid-covid-19-testing.html> [Accessed 24. Nov 2020]

Pascarella, G. *et al.* (2020) 'COVID-19 diagnosis and management: a comprehensive review', *Journal of Internal Medicine*, 288(2), pp. 192–206. doi: 10.1111/joim.13091.

Taquet, M, Luciano, S, Geddes, J.R, and Harrison, P.J. (2020) Bidirectional associations between COVID-19 and psychiatric disorder: retrospective cohort studies of 62354 Covid 19 cases in the USA', *Lancet Psychiatry*, [Online] Available at [https://www.thelancet.com/journals/lanpsy/article/PIIS2215-0366\(20\)30462-4/fulltext](https://www.thelancet.com/journals/lanpsy/article/PIIS2215-0366(20)30462-4/fulltext) [Accessed 26 Nov. 2020].

Technology Review. (2020) 'Who Should Get a Covid-19 Vaccine First?'. [Online] Available at <https://www.technologyreview.com/2020/11/20/1012313/who-should-get-a-covid-19-vaccine-first> [Accessed 25 Nov. 2020].

Technology Review. (2020) 'Do digital contact tracing apps work? Here's what you need to know.' [Online] Available at <https://www.technologyreview.com/2020/11/20/1012325/do-digital-contact-tracing-apps-work-heres-what-you-need-to-know> [Accessed 27 Nov. 2020].

Ulster University (2020) 'Ulster University launches new study exploring COVID-19 exposure and immunity in NI'. [Online] Available at <https://www.ulster.ac.uk/news/2020/june/ulster-university-launches-new-study->

exploring-covid-19-exposure-and-immunity-in-ni [Accessed 08 Dec. 2020].

Wang, Z. and Tang, K. (2020) 'Combating COVID-19: health equity matters', *Nature Medicine*, 26(4), p. 458. doi: 10.1038/s41591-020-0823-6.

Whitelaw, S. *et al.* (2020) 'Applications of digital technology in COVID-19 pandemic planning and response', *The Lancet Digital Health*, 2(8), pp. e435–e440. doi: 10.1016/S2589-7500(20)30142-4.

# Appendix

## 1. Northern Ireland

### 1.1. Kraydel Ltd.

Kraydel is a Belfast-based company that focuses on the research, development and commercialisation of technology aimed at providing remote connectivity and health monitoring. Its main product, known as Konnect, consists of a hub that provides video communication by connection to a television and Wi-Fi network. It is designed with several built-in sensors to monitor sound and motion as well as environmental conditions such as temperature. Bluetooth also enables the device to connect wirelessly to other smart devices including smoke alarms and doorbells thereby providing a detailed overview of the health, wellbeing, and security of the individual. This information is collated using secure cloud-based storage so that friends, family members and carers of the individual can access the information remotely and in real-time.

Given its capabilities, Konnect was originally marketed for elderly individuals with the purpose of providing domiciliary. Covid-19 has resulted in Konnect undergoing several modifications enabling adaptation to a rapidly changing healthcare landscape. The device now can now also connect to medical monitoring devices such as thermometers and pulse oximeters to provide information on body temperature and blood oxygen levels. Combined with the ability to initiate video calls and set up notifications this has made Konnect ideal for remotely monitoring those with suspected or confirmed Covid-19 infections and for providing health and care vulnerable individuals such as the elderly. Further extensions to the devices functionality are planned in the future, including the ability to monitor sounds such as coughing and sneezing which could be used as possible early indicators of the onset of Covid-19 and to assess symptom severity as the disease progresses.

### 1.2. Liopa

Liopa is a spinout company from the Centre for Secure Information Technologies (CSIT) at Queens University, Belfast and was established in 2015. Liopa specialises in the development of a visual speech recognition (VSR) platform called LipRead which uses a camera to capture video input of lip movements and uses deep neural network (DNN) processes to analyse lip movements and perceive what has been spoken.

The main target audience of LipRead is patients who have undergone a tracheotomy. Normally, staff are required to lip read manually, which can be difficult and stressful for both patients and staff.

LipRead helps ease the process. The application can also provide benefit to stroke patients who have difficulty communicating.

Liopa has marketed their existing product to meet the needs of patients during the Covid-19 crisis. Many Covid-19 patients who require ventilator care often need to receive a tracheotomy. LipRead can help facilitate communication during rehabilitation. Covid-19 has therefore helped to accelerate testing and maturity of the product, especially following an Innovate UK award which was received earlier in the year.

### **1.3. Axial 3D**

Axial3D is a tech start-up company based in Belfast and is led by CEO Roger Johnston. It currently consists of 40 employees who are in Belfast with a further 6 who are based in the US. The primary purpose of the company is to automate the production of 3D models using basic 2D images obtained from CT and MRI scans. These models can either be 3D printed or generated digitally for use on a computer. The target market consists mainly of clinical consultants who utilise the models for planning surgery. In 50% of cases, plans developed prior to surgery change when undertaking procedures in the operating theatre. The provision of 3D models enables better planning. As a result, surgeons spend on average 62 minutes less in the operating theatre. Reduced operating times also lead to a 17% reduction in bedtime due to fewer infection post-surgery. Overall, the models developed by Axial3D have seen use in over 15 countries globally, with the main market being split between UK and USA.

During the Covid-19 pandemic, Axial3D have marketed their 3D models to consultants who have had to undertake many of their daily consultation appointments remotely. 3D models are generated digitally and can be incorporated as part of online meetings. The company has also utilised its printing facilities to create face shields, ventilator parts, swabs and touchless door handles for use in medical buildings and by medical personnel. Operating during a pandemic has led to accelerated product development and innovation and promoted the uptake of remote learning and working. The current crisis has also led to greater acceptance of innovation from technology companies amongst NHS trusts and hospitals.

### **1.4. Elemental software**

Elemental Software is based in Derry/Londonderry and currently employs 33 people. Jennifer Neff is co-founder and CEO of the company since it was launched in 2013. Their focus is the provision of a social prescribing platform that is used by a range of individuals and organisations. Users range from

GPs within NHS trusts to housing organisations, prisons, community organisations, and social care sectors. Individuals who require a social prescription are assessed to determine their needs. Based on this information providers, such as a GP, can recommend access to a range of community and social programmes that may be of benefit to the patient. The providers can achieve this through access to a directory containing all local programmes that are available within a geographical location. The end goal is the overall improvement of an individual's health and well-being. Enabling preventative interventions and provision of required services at an early stage can avoid a decline in a patient's physical or mental health, thereby reducing the possibility of future GP appointments, improving the livelihoods of the individuals as well as providing community benefits.

Elemental Software has responded to Covid-19 by adapting its existing social prescribing platform. The system can now enable prioritisation of certain groups including those cohorts of people who are vulnerable and shielding. It also provides a COVID-19 database of services which connects users with the services they need most, ranging from grocery collection and library services to pharmacy delivery services. Self-referral has also been incorporated into the system enabling users to browse available services and select those which meet their needs. Overall COVID-19 has resulted in rapid development and growth within Elemental Software. The company has seen a 100% increase in users and a 66% rise in revenue. The turnaround time for the implementation of new services and features has also reduced dramatically due to greater productivity and investment.

## **1.5. HSCNI**

Health and Social Care Northern Ireland (HSCNI) is a publicly funded healthcare system which currently serves the whole of the Northern Ireland region. HSCNI has many responsibilities in developing and maintaining digital systems that are required as part of the healthcare system. In 2015 an e-health strategy was developed which has led to several digital innovations. NI will become the first region in the UK to provide fully integrated health and social care records through the 'encompass' programme. The software is to be provided by the US-based firm Epic and will enable reduced dependence on paper records and the collation of patient health information in one digital location. In recent years there has also been a drive to promote telecare including greater use of virtual consultations.

In response to the Covid-19 pandemic HSCNI has designed and implemented the StopCOVID NI contact tracing app which informs users if they have been in close contact with an infected individual. The increased implementation of telecare has led to a greater number of virtual consultations. COVID-19 has also facilitated greater digital accessibility amongst both healthcare professionals and patients.

Care homes have incorporated digital technologies for many purposes such as virtual visits and inspections. The current pandemic has resulted in accelerated uptake of technology across the healthcare sector and a rise in public awareness regarding the usefulness of health data and how it can be used to inform public health decisions. The experience gained from developing and implementing digital solutions in such a short timeframe has increased preparedness for future outbreaks. It has also highlighted the need for healthcare systems to be flexible. The ability to leverage regional resources to meet the demands of the healthcare system and using health data to inform decisions are some of the ways in which HSCNI has learned to adapt to the current crisis.

### **1.6. Big Motive**

Big Motive is a small design agency based in Belfast and currently employs 10 people. Originally providing a service to the private sector, Big Motive specialise in service design, user experience and brand identity solutions for websites and applications. They have provided products for companies including BBC, Liberty IT and Coca-Cola.

In recent years there has been a growing interest to provide a shift in focus from the private to public sector and the onset of the Covid-19 pandemic facilitated this move. Big motive was able to market their existing service to the healthcare sector through involvement with several projects. Firstly, they facilitated the design of a contact-tracing app known as STOP-COVID NI in collaboration with NearForm, Expleo, and the public health agency. The app can notify users if they have been in close contact with another individual who has received a positive test result. This is implemented in user friendly manner while maintaining privacy and security. The STOP-COVID-NI app was the first contact tracing app in the world to be suitable for under 16's, allowing for the safe return of schoolchildren to in person classes. This app achieved the rating of 11+ by designing a bespoke interface and notification system depending on what age you selected upon registration, providing less intimidating and thus more child friendly notifications which tell them to show the application to their parent or guardian if they have been in contact with someone with COVID-19.

The company has also worked on a symptom checker app for use in Northern Ireland, providing users with information on symptoms, how to get tested and what to do in the event of infection. There are plans to work on similar projects in the future during the rollout of the Covid-19 vaccination programme.

### **1.7. Ethel**

Ethel is a connected care solutions company based in Lisburn, NI, currently employing 5 people, and was founded by Deepak Samson and John Compton who were both previously employed by the NHS.

The company provides a product called the Ethel Smarthub, a simple to use touchscreen device providing a 'digital concierge service' for users who have no experience with technology. The device provides reminders for medication, video call functionality, remote physiotherapy capabilities, 'how to' videos for people with dementia, as well as prompting for user check-in on the device after providing reminders for tasks due. If the user fails to check-in, automatic alerts are sent to the care team that they need to call to the users home to ensure they are okay. The original target market for the Ethel Smarthub was for socially isolated people who mostly happened to be elderly, and allowed for the seamless integration of paid care from the health service and unpaid care from family.

Not long into the pandemic, Ethel were quickly approached by multiple people saying that their device would be perfect for use in a nursing home / care home - due to limited family visits being allowed. Ethel were able to add some enhancements to their product and have now successfully broke into the vast nursing / care home market. In fact, the South Eastern Health Trust in County Down is now using Ethel devices to conduct video calls with elderly patients. It is also being used by brain injury clients to keep in touch with therapists in the UK who cannot travel at present.

Since COVID, the company is now working towards adding a digitised NEWS2 (national early warning score 2) service to the device and are working on techniques to monitor pulse and respiration using only the camera. Self-reporting on NEWS2 would allow for the earlier discharge of patients thus reducing the current strain on hospital beds.

### **1.8. Medicines Optimisation Innovation Centre**

A report by the Medicines Optimisation Innovation Centre (MOIC) has highlighted several key areas where technology has played a crucial role in recent months. Such innovations include the development of a service for the supply of emergency prescriptions if the local GP practice were to close. Virtual clinics were also established and utilised in a similar manner to online services that were being offered at GP practices. Many logistical and operational changes also occurred within a short period of time which required training and information provision to pharmacy staff. This was made possible by remote learning which enabled staff to adapt to changes in a safe environment (MOIC, 2020).

### **1.9. SHAPES**



Involving 14 European countries, SHAPES forms part of the HORIZON 2020 project and is to be conducted over a 3-year period. Its purpose is to create a digital platform capable of integrating a variety of solutions that ultimately improve the health and wellbeing of elderly individuals and enable independent living. It works by combining data analytics and artificial intelligence and applying these technologies to health and lifestyle information, generating personalised solutions for each individual user.

#### **1.10. Ulster University**

Technology innovation is also apparent at many universities. Ulster University is currently undertaking the Protective/risk factors antibody response, DNA, genomics (PANDEMIC) study to determine population exposure to the Covid-19 virus within Northern Ireland. The project is part of the UK Rapid Test Consortium (UK-RTC) with the overall aim of developing a point-of-care test for the detection of Covid-19. The output from the study will also help inform decision making at a local and national level (Ulster University, 2020).

#### **1.11. Trimedika LTD**

Trimedika is the manufacturer of a non-contact thermometer, based in Belfast, NI, currently employing 14 people, and is led by CEO Roisin Molloy. The company was incorporated in 2016 and their thermometer has been CE marked and sold to hospitals since 2017.

Trimedika's business is driven by infection control and reducing waste. Research had shown Trimedika that 80% of hospital infections were spread by contact, so they innovated and produced a product which could accurately measure a patient's temperature without the need for ear / other bodily contact. Additionally, contact thermometers rely on plastic caps being used per patient, which is not green motivated and costs 4 pence per cap.

Trimedika's original target market was various hospital wards and clinics around the world. When the pandemic struck, they found demand for their thermometers vastly increased with hospitals ordering additional devices to measure patients at the door of the hospital, as well as receiving enquires from various schools and businesses. Some countries are now mandating non-contact thermometers to be used, so the pandemic has brought new business opportunities for Trimedika. Trimedika is also now developing a connected device so that time and date stamped readings can be recorded on patients records for accountability and litigation.

Trimedika found that businesses need to be careful when changing direction – small pivots are okay but you should stay true to your original researched business model. For them, this meant staying true to producing a medical grade, highly accurate device, to be used in hospitals and health care scenarios.

## **2. Ireland**

### **2.1. Tapa Healthcare**

Tapa Healthcare is an Irish medical company based in Dundalk and is led by CEO Peter Donnelly. The company was founded based on the concept of Early Warning Scores (EWS) which are used to proactively manage a patient's health. READS is the product currently marketed by the company which consists of software that is integrated seamlessly into a hospital server alongside the existing Electronic Health Records (EHR) system. READS is based on an efficient workflow involving the ability to assess, anticipate, and treat a patient. In the assessment stage a series of baseline measurements are obtained at point-of-care (POC) providing an overview of the patients current physical and mental state. READS has been developed to use purpose-built algorithms which use this data to predict a decline in a patient's condition thereby enabling anticipation. As a result, the patient can receive appropriate interventions at an early stage before deterioration begins. This preventative approach creates a better prognosis, streamlines the treatment process, and reduces workload by avoiding potential complications occurring due to deterioration. This system has been incorporated into hospitals in countries such as UAE, Germany, Denmark, and Switzerland where existing networks of EHRs have been established.

In response to the Covid-19 pandemic Tapa Healthcare has adapted READS through the addition of algorithms to predict deterioration of Covid-19 patients. This enables the many benefits of the system to be applied to this new cohort of patients. Additionally, many patients who recover from Covid-19 may suffer long-term complications due existing co-morbidities. This has led to an expansion of the existing target market with the aim of providing domiciliary care. This would enable the long-term monitoring of patients at home in cooperation with care workers who would be required to provide POC assessment. Plans to develop a new product based upon READS but with the specific purpose of providing home care has occurred because of the pandemic.

### **2.2. BiopixS**

BioPixS Limited is an engineering firm which currently is made up of 1 employee, but whom are in the process of adding two more employees. BioPixS Limited is based in Cork, Republic of Ireland, was

cofounded in May 2020 by the CEO and interviewee Sanathana Konugolu. The original motivation to begin the company was to produce equipment to create standards for the evaluation of biphotonic equipment. The equipment, known as phantoms, have different shapes and material to mimic human tissue. For example, they produce phantoms which mimic human muscle, the thyroid and kidneys. These phantoms have the same optical properties as the tissue they are mimicking, using reproducible material. The phantoms can then be used for validation, testing and tuning of equipment without having to collect real human tissue e.g. having to open someone's head to test equipment on a brain. Although the IP for these devices was created back in 2013, the company was founded in May 2020. The original target market was for companies who use light-based equipment and these phantoms are used to reliably test new devices. After the outbreak of COVID-19, the IP was extended to create phantoms which could be used in the pandemic, including phantoms of human skin and blood. These new phantoms are being used in a consortium of companies to fast track devices for COVID-19 such as non-invasive vitals monitoring. The target market of these vital sign monitoring devices is currently hospitals but eventually they hope to move towards the consumer market. Sanathana claimed that the pandemic has made companies more aware of their gaps in knowledge and their technology can allow acceleration of the develop of medical devices through rapid development of the required phantoms. These phantoms can also reduce the cost involved with testing and tuning medical devices and also reduce the number of animals being exploited for medical purposes.

### **3. Scotland**

#### **3.1. Interactive Health Limited (IHL)**

IHL is small company based in Inverness and currently consists of 4 employees which specialises in mobile learning and mobile health programmes. They have developed an app which aims to encourage individuals to make informed health choices and includes advice regarding a variety of physical and mental health problems. Considering the Covid-19 pandemic a new app was developed that was based on the existing technology. Its purpose was to address the mental health challenges that have arisen because of Covid-19 including depression and anxiety. The research and development have been funded by NHS Highland and is currently undergoing trialling amongst sample populations. It is hoped that future development will allow collaboration with Wyld Networks and enable the creation of a single application that combines technology and functionality offered by both companies.

### **3.2. Wyld Networks**

Wyld Networks has offices in Cambridge and Brighton and currently employs 11 people. The specialise in the development of wireless mesh software solutions and IOT networks. Wire mesh solutions are used to for the peer-to-peer connection of smartphones without the need for Wi-Fi or 5G. This is often utilised in dense locations such as stadiums, retail, and concert venues where many devices are present in a small area at the same time. This wireless connectivity can be used for the purpose of location-based advertising which is communicated to users within a defined geographical area.

Following the Covid-19 pandemic the current technology has been adapted by the addition of new capabilities. The target market has also shifted from advertising to use within a health and care setting, namely care homes. In this instance, the geozoning capability enabled by mesh networks is used to create heatmaps that indicate those areas within care homes where staff or visitors infringe on the 2m social distancing rules. This information can be used to create alerts when social distancing becomes a problem and for the creation of compliance reports that can help inform policy decisions and implement strategies to reinforce social distancing, enabling the safety of staff and patients.

### **3.3. CENSIS**

CENSIS is the Innovation Centre for sensing, imaging and Internet of Things technologies and is based in Glasgow with a team of 18. The centre contains in house expertise in hardware and software IOT technologies, and before the pandemic offered various IOT consultancy for Scottish businesses, seeing through the solutions end-to-end. Previous projects include IoT smart road gritting with sensors embedded in roads to give accurate asphalt temperatures, and IoT sensors to monitor the number of tourists on the west highland way to allow B&Bs and restaurants to purchase appropriate food stocks etc.

When the pandemic started, CENSIS were contacted by various companies about developing technologies for the return to the working environment and developed applications to support this. As well as developing 2 applications for social distancing in house, CENSIS were able to provide testing support to 3 companies who had developed applications based on Bluetooth RSSI measurements and Ultra Wide Band wireless technology at a testbed facility they set up in the semiconductor fabrication lab at the University of Glasgow.

CENSIS found that the pandemic allowed for accelerated development and uptake in their services as a lot of senior management quickly seen the advantages in connected health and wanted a bespoke solution developed for themselves. COVID-19 has also brought about funding for clinical IOT projects

which CENSIS is now involved with. The biggest lesson learned from CENSIS' perspective in the last months is that filtering and refining ideas, even in a crisis, is more essential than ever as there are a lot of underdeveloped and misunderstood technologies which are trying to make it to market.

## **4. Faroe Islands**

### **4.1. Thetis**

Thetis is a private veterinary and environmental agency located in Tórshavn, Faroe Islands. Thetis tests drinking water quality and food products for export, primarily fish and salmon. Before the COVID-19 pandemic, the staff count was 5.

Marita D. Magnussen, PhD and CEO of Thetis explains, that after the COVID-19 virus came to the Faroe Islands, the government enforced COVID-19 testing at the borders (airports and harbors). The government inquired Thetis directly, to take on this task.

Thetis was authorized to handle bacteria, not human viruses. They would need to reconfigure their lab, and upgrade their hardware to meet the government's request. But Thetis took on the project. They set up a new microbiological laboratory and invested in new lab equipment. Handling live human viruses normally requires a BSL (biosafety level) 3 accreditation, but as the BSL safety framework is not used in the Faroe Islands, Thetis implemented swabs that immobilised the virus. This way, they were able to lower risk, and safety requirements.

Talking to Magnussen PhD about how the pandemic has affected business ideas, "COVID has given us a push", she says. Thetis have shown to be able to work and adapt to the situation, she explains. Now, the government has become a major client, and Thetis has authorization to handle sensitive data.

A lesson learnt from the past events, is to be foresighted on how to invest in hardware. The hardware acquired for the COVID-19 tests, will enable them to perform botulism tests in the future. Only 2 other laboratories in the Danish Kingdom provide this service, she explains. Botulism tests are in demand from local salmon producers, and Marita expects them to outcompete their competitors in terms of costs.

### **4.2. Heilsufrøðiliga Starvsstovan (The faroese food and veterinary authority (HFS))**

The Faroese food and veterinary authority is a public body, working under national law. With a staff count of 58, HFS is responsible for supervising food manufacturing industries, food exporters, animal health- and disease. Historically, HFS has been working closely with salmon farmers.

HFS's target market is the public and private market. They do part of their work in microbiological laboratories. Bárður Enni, director of HFS explains, that in 2000-2006 the Salmon Isavirus (ISA) was found in the salmon sea farms. This saw an upscaling of HFS's microbiological laboratory, and large investments in hardware for virus testing. The investment proved to be instrumental in the government's COVID-19.

In early 2020 the COVID-19 virus began to spread globally. HFS probably were the only ones with the capacity to do mass testing at the initial stage - department manager, Debes Christiansen explains. Debes contacted the National Hospital's chief medical officer and epidemiologist, proposing that the HFS should do COVID-19 testing on their behalf. They agreed, effectively changing the HFS' role from doing veterinary tests to include human testing.

By early to mid-February, the HFS had set up the test procedure, and now had the capacity to perform COVID-19 testing on a large scale. Debes and Bárður attribute this achievement to staff experience and discipline, as lot of work had to be put into the processes to test human viruses, as well as research of the virus itself.

The large number of test kits in stock - originally purposed for veterinary ISA tests – allowed them to meet the test demand during the initial spike.

HFS only saw bottlenecks later on, with the growing global demand for test tubes and test kits. Testing efforts up until this point, had resulted in successful tracing and containment of the outbreak. Testing combined with societal slowdown, gave HFS time for preparation. The larger outbreak that followed in august, was also contained.

The COVID-19 pandemic did cause a change in HFS' role. From being a veterinarian authority operating under national law, one of their biggest clients was now the National Hospital. FHS is now doing COVID-19 research, and contributing to the scientific knowledge of the human virus.

### **4.3. Nemlia**

Nemlia is a company with 9 employees, situated in Torshavn, the capital of the Faroe Islands. Nemlia's mission is to use technology, to enable informed care to the elderly and dependent. The company has expertise within hardware and software development, with special focus on IoT (internet of things).

Before the COVID-19 pandemic, Nemlia was developing a video communication for a local care service. The aim was to provide video communication for the elderly and dependent, receiving

physical rehabilitation- and home visits. When society went into COVID-19 lockdown, development plans for video solution changed. Nemlia and care services worked together, to modify the product to care facilities. The video solution was set up in care homes, to connect residents to family and friends. This has helped maintain more normal everyday for the elderly and their families, throughout the lockdown.

The COVID-19 pandemic has left a larger group of people vulnerable and dependent. Therefore, Nemlia has seen an increase in the demand and needs for using video communication. This has seen Nemlia engage with a more varied clients with similar needs. The lockdown has provided opportunities to create a product, through a closer dialogue and engagement with users.

## **5. Sweden**

### **5.1. Curest AB**

Curest is situated in Luleå, Sweden, with personnel in Malmö and Skellefteå as well. Interviewed is Emil Lilja, the CEO of the company. Curest has specialized in user friendly health care solutions in physical therapy based on the ideas of physical therapists and virtual reality. Before the pandemic they designed distance spanning method to increase the quality of physical therapy. The solutions are mainly targeted at public and private practitioners in physical therapy. The main product consists of training programs using virtual reality headsets. The distance spanning nature of the service made it possible for users to continue delivering therapy to patients without having physical meetings. Due to the pandemic the speed of implementation has increased as the health care sector realises the potential of this type of product. The market is now more mature, but while there are bigger ambitions for innovation there is also less resources to put towards new systems.

The pandemic has resulted in more ideas for distance spanning solutions. The maturity of the market creates a good environment for further development. The pandemic has also made the health care more centred around the patient in some priority groups.

An important lesson has been the importance of product design, as patients need to do more by themselves. The objective has been to help the health care system help patients. The end user of the platform is both the care giver and the patient.

The technology allows for automated processes when personnel were needed in other units, as was the case in one of the regions employing the Curest's system. Instead of having to postpone services physical therapy patients could continue their treatment.

## **5.2. Boneprox AB**

Boneprox is mainly focused on Sweden Norway and Denmark, while recently extending to Japan. Interviewed is Peder Reman, CEO and co-founder of the company. Boneprox has specialized in image analysis of dental x-ray images. Image analysis is central with a mix of analysis from specialists and artificial intelligence. The platform Boneprox provided before the pandemic acted as specialist clinic that could support dental care with diagnosis and guidance. The main focus was diagnosis of osteoporosis using dental x-ray images of the jaw bone. The digital platform expedites the process of getting specialist help. The original target of the service were dentist practices in Scandinavia, meant as a spring board to later reach a bigger market. During the pandemic Boneprox has in cooperation with another actor developed an educational platform, Tandakademin.

Since the pandemic the market is more open to change, but the various actors are also more careful with their funds. Boneprox is also looking at other solutions for dental care. Lately especially communication solutions for dentistry personnel. The bigger aim is to facilitate transformation of dental care routines.

The main take away from the pandemic is that there for some time has been an actual need for innovation that there hasn't been enough time to process. There is more time for that now. There has also been a confirmation of the potential benefits of digitalization. More time and attention on innovation and digitalization also results in more creative ideas from those involved. Boneprox has gotten more suggestions and feedback from the users since systematic problem solving is on the mind of more people.

## **5.3. Cuviva AB**

Cuviva has 14 employees with several external consultant involved. Head office is in Gothenburg, Sweden. They mainly work with municipalities and regions in Sweden but have lately also worked in Britain. Interviewed is Karl-Johan Palmgren, CCO. Cuviva has specialized in digitalization and the democratisation of technology for the elderly. Their platform is focused on monitoring several health indicators and giving support to patients and healthcare users in their various treatments. Cuviva's platform is useful whether the patient has multiple diagnoses or more specific illnesses.

Cuviva had the platform on the market before the pandemic but has adapted it to the current situation. The platform is in its essence a distance spanning technology and is therefore well adapted for health care practices with less physical contact. The platform has more sensors than before the



pandemic, for example measurements of respiratory rate, and they have made adaptations to better fit support and follow-up for Covid patients.

Cuviva's platform allows patients to be moved to their home while the hospital still is able to keep track of the patient's health status. Municipalities and regions are now considering new digital solutions to a greater extent. Processes from earlier have halted and the climate is more reactive than proactive. While there are more discussions about new solutions it is hard to get concrete decisions. Most functions in Cuviva's platform were there before Covid as their product is designed to be broad. The Covid focus has rather been on minor adaptations to better fit the situational needs of the customers.

The pandemic has showed how adaptable and agile their solution is. There are however problems with longer implementation processes as the health care system's resources are urgently needed in other places.

### **The webinar series "Technology use for Covid 19 response"**

The series consisted of four webinars conducted autumn 2020, all recorded and published at Centre for Rural Medicines YouTube channel, also available through the website [www.healthcareatdistance.com](http://www.healthcareatdistance.com) for later viewing.

Using distance-spanning services for healthcare and care helps to protect our most vulnerable citizens from the pandemic. But what distance-spanning services exist? How can we bring them to the people that need them? And how do we fast-track innovation of healthcare and care? These are the questions that were highlighted in our webinar series.

#### *First webinar: Implemented distance spanning services in the Nordic (15th of October, 2020)*

In this webinar Bengt Andersson, Senior Adviser at Nordic Welfare Centre, and Niclas Forsling, Centre for Rural Medicine - Region Västerbotten, discussed distance-spanning solutions from the publication "Healthcare and care - 24 practical examples from the Nordics". The webinar addressed the question "What distance-spanning services exists?".

#### *Second webinar: Roadmap for service innovation (3rd of November, 2020)*

In this webinar, Kristin Standal from KS Norway presented their developed Roadmap for service innovation and Katarzyna Wikström from Region Västerbotten demonstrated how they in practice made use of the Roadmap for service innovation when digitally transform their healthcare provision

model. The webinar addressed the question “How can we bring distance spanning technology to the people that need them?”.

*Third webinar: Practical examples from digitally transformed service models in existing organisations (18th of November, 2020)*

In this webinar we addressed the question “How to fast-track innovation”. Sigurður E. Sigurðsson, chief physician Akureyri hospital, Iceland Halldór Sigurður Guðmundsson, operational manager for social services, Akureyri Municipality, Iceland and Kjetil Løyning, leader of e-health Agder 2030, Norway described their experiences and lessons learned from digitally transformed service models.

*Fourth webinar: The future of healthcare and care, what is the bottleneck? (14th of December, 2020)*

In this webinar Niclas Forsling, Centre for Rural Medicine and Bengt Andersson Nordic Welfare Centre demonstrated why innovation investments within healthcare and social care are necessary (especially for remote, rural, and arctic areas) in order to fully utilize the possibilities of distance spanning services for healthcare and care.

We have had between 30-40 participants at each webinar, all together more than 70 different participants. The gender balance of number of men and women are quite equal 60/40 split (more women than men).

## **6. Finland**

### **6.1. Solita**

Solita is an IT service company with more than 1000 employees, based in northern and central Europe and headquartered in Finland with offices in Helsinki, Oulu, Tampere, Lahti, and Turku. Before the pandemic, Solita provided end-to-end IT solutions for a wide variety of clients in the public and private sector. They have expertise in cloud infrastructure, design, integration, and data and have produced everything from a cloud first infrastructure CloudBlox for Savings Bank to the Omaolo service which allows personal well-being tracking and access to symptom and service assessments online. When the pandemic struck, Solita were tasked to develop the national COVID-19 contact tracing app for Finland, on behalf of THL (Finnish Institute for Health and Welfare). The app they developed was based on the DP3T concept using the Bluetooth API from Apple and Google. It was also integrated into the Omaolo.fi service / app already mentioned. Solita mentioned that although the app is based on a single use concept, they can see the app providing a basis for further products. The app has allowed them to

strengthen their position within the healthcare market and their services continue to expand within this space.

Regarding lessons learned, Solita noted that the worldwide co-operation among various actors with COVID-19 tracking application development has been phenomenal. Mobile companies, EU-wide health authorities, companies developing solutions and other related parties have worked towards common goal with good co-operation. The development of the Finnish contact tracing app was heavily based on previous work by Apple and Google and their assistance was essential. The European community of EN-based Covid-app developers has been active and helpful towards each other. The Finnish authorities provided expert team members and the project has proceeded remarkably well even with the big size and number of involved parties.

## **6.2. Biomensio LTD**

Biomensio is a tech start-up providing biosensor diagnostics and are based in Tampere, Southern Finland. The company is made up of 10 employees, of whom we spoke to the CEO and CSO. Biomensio's core Intellectual Property Rights / USP lie within patented new sensor technology. Specifically, Biomensio has strong expertise in biochemistry and in integrating assay chemistry with sensor technology. They were originally focused on use cases for this technology within the food industry and drug abuse applications, and had previously received a H2020 grant of €2.5 million for drug abuse applications. However, when the pandemic struck Biomensio was able to use their existing biosensor technology and extend it for use as a COVID diagnosis tool. They adapted their platform, creating a system which serves all applications. The tool can be used for the quick screening of health status, and has extended Biomensio's target market to less developed environments and countries, the tourist industry, and to larger employers who may wish to do a health screening on all employees before entering a building. Biomensio see that going forward, their technology could facilitate many types of quick and easy diagnostic tests, not just for COVID-19, and that the pandemic has highlighted the need for such testing.

Regarding lessons learned, Biomensio found that gaining access to the Finnish health care system was difficult. Procurement processes are in place making it very challenging for new technology, especially from a start-up, to enter the market, while pre-established companies who may be providing a less effective product get favoured. Contacts and flexibility are required within the health system to obtain patient samples, gain access to safe laboratories etc. to allow new products to succeed.

## **6.3. BioNavis**

Founded in 2006, BioNavis currently employs 6 individuals within the city of Tampere in central/southern Finland. They specialise in development and commercialisation of plasmon resonance technology. Initial research began at VTT, but since moved to BioNavis which was established to continue development of the technology as an independent organisation. The plasmon devices and SPR chips that were manufactured as a result have been marketed to universities and research institutes.

In response to Covid-19, the SPR sensor slides were adapted for the detection of antibodies in serum samples that have been produced due to infection. This has enabled the development of an anti-pathogen antibody assay that provides the ability to test for infection in a manner that is fast and cost-effective. Therefore, the product is suitable for the testing of large populations in a healthcare setting. The success associated with the application of this technology for healthcare purposes has resulted in plans to secure funding for additional research and development with the hope of expanding upon the products currently offered.

#### **6.4. iSTOC**

iSTOC is a small medical diagnostics company based in Finland. It comprises a range of expertise in areas such as machine vision, biomedicine, and point-of-care diagnostics with the aim of reducing turnaround time associated with the diagnosis and treatment of diseases. The major problems that the company originally aimed to solve was that the results of point-of-care tests are not numerical, nor are they saved automatically. iSTOC provide a mobile application that can scan test results which are then transferred to cloud storage where they can be analysed. The results can therefore be easily shared between decision makers and used to inform treatment options. The ability to collate a large number of test results has also enabled the technology to be used by manufacturers of diagnostic tests to determine the effectiveness of their product on a large scale and by regulatory bodies to help inform policy changes and implementation.

As a result of the Covid-19 pandemic, iSTOC has adapted their platform by adding additional features and functionality enabling it to screen large numbers of Covid-19 test results which can be communicated to health officials. This can be used to initiate treatment for infected individuals. It can also help manage outbreaks at a regional and national level.

#### **6.5. Lainisalo Ltd**

Lainisalo Ltd is based in Helsinki Finland and currently has 120 employees. Prior to the pandemic the company specialised in the painting of medical instruments in areas such as mammography, dentistry, and magnetic resonance imaging (MRI) but the focus of the company has since broadened due to Covid-19. Lainisalo developed an antiviral surface coating that was adapted into the form of a Covid-19 adhesive tape. The tape consists of copper and its oxidising properties eliminate microbes and viruses including Covid-19. The product is suitable in a range of industries and can be tailored to suit the needs of the customer including the size, thickness, and format which are all customisable. There has been interest from the food industry and considerations have been made regarding its use in filters to be used in large department stores or hospitals where air could be filtered to remove any Covid-19 virus particles. Commercialization of this filter is currently ongoing, and manufacturing has begun on a large scale.

## **7. Norway**

### **7.1 Var Healthcare**

Var Healthcare is a Norwegian company who employ 20 people. They are headquartered in Oslo but have affiliations in Copenhagen and Hamburg and have plans to extend business to the UK and Canada. The CEO and interviewee, Ann Kirstin Rotegård is a nurse who has developed a web-based application to replace the handbook carried by nurses to look up procedures.

Before the beginnings of the pandemic, Var Healthcare was created as a company by nurses for nurses that pioneered a platform providing online access to the procedures that nurses would need to perform. This online application contained a catalogue of medical procedures, including step by step instructions and images to assist in performing the procedures.

After the pandemic had begun, they adapted their software to the new procedures required when interacting with patients infected with COVID-19. For example, procedures detailing putting on masks and other PPE. It was also noted that some people had been performing intramuscular injections wrong, so they introduced online procedures detailing how to perform this. At the moment, the system is available in Danish and German, including the new COVID-19 procedures, an English version is also ready to be adopted.

When asked about lessons learned, Ann Kirstin explained that while there is the possibility for innovation, it is more important to have a well-prepared system.

### **7.2 Helseboka HelseApps**

Helseboka HelseApps (in English: Healthbooks HealthApps) is a Norwegian technology company who employ 19 people. They are headquartered in Harstad but have additional offices in Oslo and Bergen. The CEO and interviewee, Marius Christensen, is a physician who has moved to working full time on the development of applications to assist the healthcare system in Norway.

Prior to the pandemic, they had been developing an application which allows data collection prior to a patient attending a medical appointment. Prior to their appointment the application will request information from the patient and will advise them of any required tasks. This way the doctor and patient can be well prepared before the appointment. The application also allows secure messaging, video conferences, and other functionality.

Once the pandemic began, it acted as an accelerator for the company, where they went from approximately 100,000 users to over a million users. The company also adapted their existing application to become the only method of booking and queuing for the COVID-19 vaccine. The application allows people in Norway to express interest in the vaccine and allow them to be prioritised appropriately.

Looking into the future, Helseboka are planning to go international and roll-out the system to other countries and even have it used by non-medical companies. When asked if the company had any lessons learned they said that it helped to keep the management and production of new features lean. For example, if a new function was being generated, it was better to test it internally and release it to the public as any bugs would be discovered quicker this way and work could continue on newer functionality.

## **8. Iceland**

### **8.1. Origo**

Origo is one of the largest IT companies based in Iceland, currently employing approximately 500 people. The interviewee Guðjón Vilhjálmsson is their current director of healthcare solutions. Origo covers a spectrum of IT-related products including hosting, software development and IT services for the Icelandic health system, such as prescription services and a national patient portal system.

With a track record of successful healthcare-based IT solutions, Origo developed a system for COVID-19 testing of visitors to Iceland. It allowed travellers to pre-register online and pay for a PCR test which would be administered on arrival in Iceland. When a traveller signed up, they would be provided a bar code which would be used for tracking the persons test sample. In the case of a negative result, the

traveller is sent a text message, however, if the result was positive then an automated process of contacting relevant healthcare agencies would begin. This process was entirely developed by Origo from original sign-up to final contact. The testing system proved so effective that it was expanded out to all COVID-19 testing in Iceland and is being adapted for the upcoming vaccine roll-out.

When asked if Origo had learned any significant lessons about development during a pandemic, Guðjón said that effective project prioritisation can lead to big achievements within a small-time frame, for example the development and rollout of the COVID-19 testing system. Additionally, processes sometimes need to adapt to modern circumstances, for instance, the idea that you could go online and book a test without review is a foreign concept in comparison to typical healthcare processes. Since developing the software, Origo have been approached by the Directorate of Health to adopt the COVID testing software for the country's cancer screening process.

## **8.2. Memaxi**

Memaxi provides a telecare and communication solution to connect beneficiaries, families, and professional health care workers, and is headquartered in Reykjavík, Iceland, while the development team is based in Warsaw, Poland. The company was started in 2014 and developed the Memaxi SaaS solution to facilitate care planning by bringing relatives and care providers together, allowing for a central overview and information about a person's care package in one place, person-centred care plans, paperless care procedures, and information exchange with other care providers. The software consists of three main applications; a simplified Memaxi display app for the beneficiary to use, the Memaxi Connect app for relatives to use, and the Memaxi web application for care providers to use and collaborate on. Memaxi's target market are stakeholders in the care network, and before the pandemic were largely focused on home assistance carers and the beneficiaries of this.

In the pandemic, Memaxi were able to make good progress in marketing their product for nursing homes; nursing homes were always on Memaxi's roadmap but the pandemic helped healthcare providers realise they needed a telehealth solution. The city of Reykjavík also partnered with Memaxi in the pandemic making them the only way of reaching beneficiaries who refuse to let carers inside their homes. Memaxi has also developed a call centre with Reykjavík and the application now supports video calling functionality, as well as face recognition for identification and end to end encryption allowing for quick check-ups and a faster way of communicating with relatives.

## **8.3. Icelandic Directorate of Health**

The National Centre for E-Health is part of the Icelandic Directorate of Health and provides technical solutions for the Icelandic healthcare system. The centre is comprised of a team of 70 and is based in Reykjavík, Iceland. The centre has been responsible for the development of Iceland's EHR (Electronic Health Record) system and the running of this system, as well as the upkeep of various national databases for health. Additionally, the centre has ensured that all GP offices (both private and public) are linked centrally on a national level and developed a web app allowing members of the public to book appointments both with public GP's and private specialists using the same application.

While the National Centre for E-health do not employ any software developers, they are the institution which conceived the COVID-19 health solutions for the country. They developed the contact tracing app concept and specifications which was then developed by volunteers in a 10 day period. The Iceland contact tracing app was developed before the decentralised API for Bluetooth contact tracing was created, and is therefore unique in that it uses GPS and stores data locally on your phone. If you get infected, you are then prompted to share your data. 10 days after launch, 180,000 devices had installed in the app, and now 230,000 devices run the application (out of a population of 365,000). The centre were also responsible for conceiving the testing and monitoring solution for tourists which Orgio then developed, so that they could monitor every case of COVID in Iceland – including every person who has been put into quarantine because of these cases. Additionally, the centre has been testing and deploying a video consultation solution delivered by Pexip which links into the centralised patient portal. Phone consultations and virtual visits have taken off considerably and there are now a few hundred a day taking place.

The pandemic has shown the Directorate of Health how much technical solutions can help facilitate the healthcare needs of the country; that computers and software can handle a lot of things that were previously done by a human. The COVID screening solution has shown the Directorate that the healthcare system can handle a lot of throughput with minimal labour; that one programmer could replace 100 healthcare workers. They are now investigating changing their cancer screening system to use the same system that was developed for COVID screening. Additionally, the Directorate has learnt to trust the public more. When they developed the online booking system for a COVID test, they were worried that the system would be inundated with thousands of bookings which weren't necessary as the testing was free – but the public proved that they respected the system and only used it when they felt it necessary.

#### **8.4. Kara Connect**



Kara Connect is an Icelandic online therapy company which is currently made up of 10 employees. Kara Connect is based in Iceland, but they also have presence within Ireland and Denmark. The interviewee, Thorbjorg Helga, co-founded Kara Connect, after a career in politics and online speech therapy, where she noticed that technology could be utilised to provide help without the obstructions of geographical location.

The original idea behind creating Kara Connect was to provide a platform for health professionals and child protection services, with this platform now extended into charities, clinics and school counselling services. This online platform allows a lightweight, secure solution for these facilities which can increase the number of access points for rural areas and people who are isolated, stigmatised or are afraid to access help services. The internal services provided by Kara Connect included, calendars, waiting lists, chat, payment portals, room and resource booking and other services. These services are available as both a web-based application and a mobile phone application.

Once the COVID-19 pandemic begun, additional support and services were added to Kara Connect and the system was scaled up to new users. This increase in scale also brought improvements in system security. In future, they hope to add additional functionality into Kara Connect which will allow one to one personal meetings with a secure translator inside, amongst other business ideas.

## **9. Greenland**

### **9.1. EEG-Siila ApS / Innovation Greenland**

Grom Geisler Vlod is an entrepreneur who worked at his own ICT consultancy company, EEG-Silla and, more recently, works for Innovation Greenland. Greenland acted swiftly in response to the pandemic and sealed its borders, prohibiting normal travel by ordinary people in or out of travel, as well as shutting down internal air travel. No ordinary people were allowed to enter or exit the capital. Now, only travellers approved by the authorities are allowed to enter the country and they must quarantine for 14 days upon arrival. Thanks to this aggressive approach to virus containment, the country has only seen 30 cases since the start of the virus.

However, when the virus first started making headlines, Greenland was worried about how COVID could spread in their country. Grom, an IT consultant and entrepreneur, noted that the healthcare staff were lacking in face visor PPE equipment, which were being used worldwide by healthcare workers to prevent the spread of airborne germs. In April 2020 Grom, using his personal equipment, 3D printed face visors and distributed these to the healthcare system of Greenland to ensure they had

enough protection equipment in place. Once it was clear the virus was not going to overwhelm the healthcare system, Grom stopped making the visors.

## **10. Other Countries**

### **10.1 USA - Sencio**

Sencio is based in New England, USA, consists of 30 employees and provides a service to over 1100 users. The company specialises in using artificial intelligence (AI) to deliver healthcare management to patients in the home setting. This is achieved by using artificial intelligence (AI) to determine an appropriate workflow and response, enabling patients to receive the right care at the right time.

The central product offered by the company is known as Ibis which integrates AI with communications technology and results of self-assessment to identify any health abnormalities. If problems are detected, they can be communicated to the patient's clinician and a response can be initiated in a timely and cost-effective manner. This provides particular use to elderly individuals who live alone or those situated in remote locations who would otherwise not have access to healthcare services.

Elderly individuals and those with chronic co-morbid conditions are those most likely to experience serious adverse effects due Covid-19 infection. The ability of Ibis to monitor health allow it to detect both the onset and worsening of Covid-19 symptoms and initiate immediate medical intervention if required. Covid-19 has helped to highlight the complex health needs amongst these individuals. It has shown that traditional methods of monitoring patients using scheduled appointments with GPs requires modernisation to improve efficiency and cost-effectiveness. One of the ways of achieving this is by incorporating virtual consultations into routine care.