

Innovation-driven responses to the COVID-19 crisis

Digital healthcare and service solutions to help fight COVID-19



About this brochure

This brochure presents examples of some of the innovative Danish digital healthcare and service solutions that help fight COVID-19. These initiatives make a difference for both Danish citizens and healthcare professionals.

We hope to inspire you.

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COVID-19 – a world wide crisis

 The COVID-19 crisis affects all countries in the world. Countries have taken slightly different approaches to the outbreak of COVID-19, while also being at different stages of the outbreak. Some countries have seen a peak in COVID-19 cases and are gradually opening up their societies again, while other countries have successfully managed to flatten the curve of diagnosed COVID-19 patients but do not know, whether the curve will go up or down in the near future.

Between the countries, some learnings and initiatives are a commonality:

- Reducing personal contact and keeping distance between citizens in order to avoid further spread of the virus
- Increasing hygiene measures in order to remove virus from physical items
- Introduce large-scale and rigorous testing in order to have real-time and precise information about the outbreak
- Establish real-time and accurate information about hospital capacity in order to prepare for a rapid and sudden increase in the number of admitted COVID-19 patients
- Increase ICU ventilator capacity in order to prepare for a rapid and sudden increase in the number of COVID-19 patients admitted to ICU departments
- Significant increase in tech solutions such as telemedicine, remote monitoring and disease (self) management that allow healthcare to be provided at home

It is a race against time to keep the outbreak under control and ensure sufficient healthcare capacity to handle the excess number of COVID-19 patients. For some countries, where the healthcare system is already under extreme pressure, a race to increase capacity immediately, and for other countries, a race to plan ahead and ensure capacity, according to forecasts.

In this critical situation, public healthcare authorities, companies large and small and universities stand united to combine all resources to step up capacity to handle the crisis. This brochure contains examples of some of the extraordinary Danish initiatives, which are making a difference for Danish citizens and healthcare professionals.

We hope to inspire you.

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Identifying and testing COVID-19 patients

● The COVID-19 outbreak has in some countries developed an explosive growth, which has resulted in an immediate overload of the healthcare system. As the situation in those countries gradually improves, it is important to understand how the state of COVID-19 develops among citizens. Is the outbreak's impact continuing to diminish or is the number of COVID-19 patients suddenly growing again?

Being able to test for COVID-19 and knowing exactly which proportion of a country's population is infected, or has been infected, is of course also key for planning and controlling the outbreak in countries that have been fortunate so far, to avoid the explosive development of the outbreak.

When emergency call-centers with high accuracy can determine whether a patient call is a potential COVID-19 case, the right advice to patients can be provided immediately and on first-hand. This ensures that the patient contacts a protected COVID-19 emergency department, avoiding that the patient contributes to the outbreak by going to a GP or a normal emergency department.

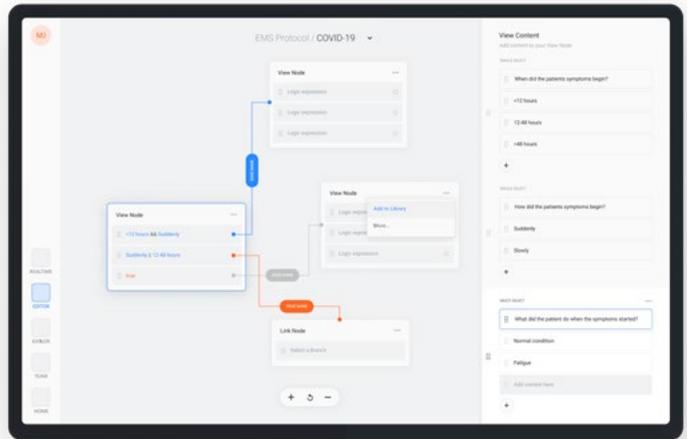
Rapid testing and results are essential. Reducing the time lap between taking a COVID-19 blood sample, until the result is available, makes it possible to initiate quarantine or treatment of the patient faster, thereby reducing the patient's contribution to the outbreak. Technology can also contribute with solutions to avoid the need to move and touch blood sample canisters, which again help reduce the outbreak.

Innovative solutions

Identifying and triaging COVID-19 patients with artificial intelligence

Artificial intelligence helps the emergency medical services by analyzing patient interviews to detect the risk of COVID-19.

To avoid a collapse of the healthcare infrastructure, a key task during a pandemic is to manage population health and avoid drastic changes in demand for healthcare services. Emergency medical services play a key part in this and automated solutions augment the capacity of this critical function.



To support the emergency medical services, the Danish company Corti has developed an innovative solution based on artificial intelligence, which is capable of analyzing patient interviews in text, video, or audio formats and detecting whether there is a high risk of COVID-19. The technology has already learned from more than 100,000 medical interviews about COVID-19, starting from the very beginning of the outbreak. This means that the solution helps to identify COVID-19 patients and supports real-time decision-making at the dispatch center. By analyzing the call and “listening” to patients’ symptoms, it can alert the medical dispatcher who is handling the call. In a matter of seconds, the software can estimate how high the risk is and direct the medical dispatcher to choose the most effective intervention in each case, in order to prevent spread of the infection.

“During this pandemic crisis, healthcare professionals have remained our backbone and provided the patients with the best care possible, often at personal risk. With our AI technology, we hope to be able to relieve some of the immense strain that healthcare professionals are currently operating under and give them, as well as patients, the best solution possible” - Andreas Cleve, Co-Founder and CEO, Corti.

The solution is being tested and will be implemented in Copenhagen in the Capital Region of Denmark, Seattle in the State of Washington, USA, and SOS Alarm throughout Sweden.

If you are interested in more details about the company Corti, please visit their homepage (<https://www.corti.ai/>) or take a look at our catalogue “Automation of Healthcare Processes”.

Innovative solutions

Innovative method to detect COVID-19 on real-time PCR

 Danish biotechnology company helps combating the COVID-19 outbreak with innovative test method.

Scientists from the Danish biotechnology company, PentaBase, have developed an innovative, robust and resource-effective solution to detect the presence of nucleic acids from COVID-19 in humans and thereby help to determine if a patient is tested positive for the virus.

By optimising and combining the three assays of the conventional COVID-19 test panel recommended by WHO, a sensitive and specific multiplex test has been created.



“The Danish healthcare system was lacking consumables and reagents necessary in the detection of COVID-19, and we were able to help. From the beginning of the outbreak, we worked around the clock to create the CoviDetect™ – a multiplex Real-Time PCR assay, which increases testing capacity with three times as many samples and reduces dependency on consumables” – Ulf Bech Christensen, CEO, PentaBase.

The innovative test method has been approved and validated in close cooperation with the pharmaceutical company Novo Nordisk and Rigshospitalet in the Capital Region of Denmark.

The analysis for COVID-19 detection is done in a three-step workflow. The infection is determined by finding nucleic acids from COVID-19 in the test sample collected from the patient. To analyze the sample, the nucleic acids need to be extracted from the deactivated virus, purified and copied in a DNA form through reverse transcription. This is necessary as the instrument used can only analyze DNA. Then, multiplex Real-Time PCR (polymerase chain reaction) amplification is performed. This means that a patient's test can be analyzed in one tube in contrast to three tubes used in conventional testing. Therefore, the testing capacity is tripled while the dependency on consumables is reduced. Finally, upon analysis, positive PCR results indicate an active infection with COVID-19.

The solution has been developed in an open-platform design and therefore works on standard laboratory equipment.

If you are interested in more details about the company Pentabase, please visit their homepage (<https://www.pentabase.com/>).



Innovative solutions

Testing capacity and safe transportation is critical in the fight against COVID-19

- Innovative blood sample solution helps Danish hospitals to immediately react and increase their COVID-19 capacity.

The Tempus600 blood sample solution by the Danish company TIMEDICO provides a direct transport line from the hospital ward to the laboratory. All types of small clinical samples can be sent with the systems - including COVID-19 samples, which enables faster response time and reduces the risk of transmitting virus between the wards.

Two hospitals in the Region of Southern Denmark have already implemented the solution in their COVID-19 departments. In just two days, at the Hospital of South West Jutland, in Esbjerg, an existing sending station was moved to the newly established COVID-19 department for transportation of samples directly to the laboratory. Additionally, at the hospital in Southern Jutland, in Aabenraa, the orthopedic surgery department has just been turned into a COVID-19 department and when the patients start to arrive, the plan is to use the existing sending stations to transport blood samples directly to the biochemical laboratory for analysis.

The solution can be installed in the COVID-19 department or test center for transporting the COVID-19 specimen to any laboratory destination. The short installation time (just one week for new hospitals) helped the Danish hospitals in their immediate and swift reaction to the crisis. Samples are handled by only one person from sampling until the specimen lands in the laboratory for analysis. Sample tubes are sent from the department to the laboratory using compressed air. As the solution is a closed system, no air is transferred from the ward to the laboratory. Therefore, the risk of transmitting virus between the wards, or the specimens disappearing during transport is minimal.

The samples are sent unpackaged just after sampling, avoiding the time and resource-intensive transportation of the samples, which ensures fast response times and optimal treatment of critical patients.

If you are interested in more details about the company Timedico, please visit their homepage (<https://www.tempus600.com/>).



Optimising hygiene to reduce further outbreak

● When a COVID-19 patient has touched or coughed on a surface, the virus can survive 24 hours on some surfaces and on others, like plastic and steel, up to 72 hours. Hospitals receiving both COVID-19 and regular patients have immediately reacted by enforcing even stricter hygiene and shorter cleaning intervals.

In a situation, where the COVID-19 pandemic increases the number of patients, it is a further challenge for hospitals to implement new and very comprehensive cleaning rounds. Many hospitals around the world have therefore decided to implement robotic solutions in order to meet the need for an increase in cleaning capacity. At the same time, the use of robots reduces contact between cleaning staff and infected areas, which also help to reduce spread of the disease.

Controlling the hygiene challenge at hospitals is also a question about optimal hygiene among the hospital staff and patients. New sensor-based solutions enable hospitals to constantly and automatically monitor hygiene procedure compliance among staff and patients. Constantly collecting data, the sensor-based solutions also provide tracking of person contacts, which enables hospitals to trace cases of further COVID-19 infected patients or staff, if infection seems to have happened at the hospital.

Innovative solutions

China buys Danish robots to fight COVID-19

Chinese hospitals deploy Danish self-driving disinfection robots as a new and powerful weapon against the spread of COVID-19.

With ultraviolet light, the robot from Danish company UVD Robots can disinfect and kill viruses and bacteria autonomously, effectively limiting the spread of coronaviruses without exposing hospital staff to the risk of infection. The robots have been deployed in all Chinese provinces and thereby more than 2,000 Chinese hospitals have the opportunity to ensure effective disinfection, protecting both their patients and staff.

Before entering into the agreement with UVD Robots, Sunay Healthcare Supply, a medical equipment supplier to the Chinese market, did its due diligence and screened the market for the best technologies to fight the coronavirus and found the UVD robot to be superior compared to other technologies.

The invention increases the safety of both staff, patients and their relatives by reducing the risk of contact with bacteria, viruses and other harmful microorganisms. The concentrated UV-C light emitted by the robots as they drive have a germicidal effect that removes virtually all airborne viruses and bacteria on the surfaces of a room.

As such, the innovative UVD robot can help combat the spread of the virus in China. "In a severe crisis like this where the world health is threatened, our innovative technology really proves its worth" - Per Juul Nielsen, CEO, UVD Robots.

Now sold in more than 40 countries, the innovative Danish company already delivers its self-driving disinfection robots to hospitals in other parts of Asia in addition to healthcare markets in Europe and the United States.

If you are interested in more details about the company UVD Robots, please visit their homepage (<http://www.uvd-robots.com/>) or take a look at our catalogue "Automation of Healthcare Processes"



Innovative solutions

Improve hand hygiene and reduce further outbreak



● Technology-driven hygiene solution decreases further spread of COVID-19 and makes it easier to comply with strict hygiene protocols protecting both patients and hospital staff.

All over the world, hand hygiene has become a key concern in order to prevent further spread of COVID-19. In hospitals, a high level of hand hygiene is vital to reduce risk of infection among patients and staff. With the purpose to improve hand hygiene and reduce infections, Danish company Sani Nudge has developed an innovative sensor-based solution, which has already been implemented in nine different hospitals across Scandinavia.

The technology tracks hospital staff in situations that require hand hygiene and marks them compliant with protocols when they have used soap and sanitiser at the right time, and in the right place. The solution generates data about location and movement collected through hardware installed in the hospital facilities and in ID badges worn by hospital staff. This allows hospitals to keep track of the whereabouts of staff – which rooms they enter, who they interact with, when they perform rounds and more. During an outbreak such as the COVID-19, when hospitals experience an unprecedented and unpredictable flow of patients, these data can prove vital by providing information about who met who and when.

“In a hospital, there is an average of 100 hand hygiene opportunities in each room, which gives a lot of opportunities for COVID-19 to spread. By tracking staff movement, our technology helps to maintain a high level of hand hygiene and reduces the risk of infection” - Theis Jensen, CEO, Sani Nudge.

As a result, the automatically monitoring of hygiene procedure compliance among staff and patients has proven to be very effective. It helps to break the chain of infection, improves hand hygiene by 200-300%, and reduces infections by 29-64%.

If you are interested in more details about the company Sani Nudge, please visit their homepage (<https://saninudge.com/>) or take a look at our catalogue “Automation of Healthcare Processes”.



Efficiency and hospital capacity

● A pandemic is an extraordinary situation, which does not respect the usual capacity limits of our healthcare system. Countries are implementing initiatives to increase their COVID-19 related hospital capacity and first steps should always be to increase utilization of existing equipment and staff. It is all a matter of knowledge about the national capacity of staff and needed COVID-19 equipment and how to be able to increase efficiency and utilization of this capacity.

Hospitals which have already implemented Real-time Location and Tracking Solutions (RTLs) are able to immediately pinpoint and document equipment and capacity to handle COVID-19 patients. Hospitals which are using RTLs to coordinate both equipment, staff activity and patients can also document the availability of educated and available staff – and they can at all times report the exact capacity for new patient admittance, given the patients they already have in treatment. Shortage of protection equipment has been an issue for many hospitals and RTLs tracking of supplies enables hospitals to report their stock status in a similar manner, in order to ensure that both capacity and needed supplies are available for new COVID-19 patients.

Another way to increase COVID-19 capacity is to avoid admittances to hospitals unless this is absolutely necessary. This involves the challenge of being able to monitor and react to potential deteriorating and worsening conditions for COVID-19 patients who are staying at home. When telehealth and home monitoring is implemented to follow COVID-19 patients at home, it becomes possible for hospitals to fine-tune their capacity and reduce the number of at-risk COVID-19 patients, who are admitted to hospital at any time.

Innovative solutions

Logistics and communication increases COVID-19 capacity

Innovative logistics solution provides a complete overview of COVID-19 patients and protective gear in real time – across wards, departments, hospitals, municipalities, regions, and countries.

By integrating the two solutions Sitaware and Columna by Danish company Systematic as well as incorporating COVID-19 data from e.g. Johns Hopkins University, it is now possible to get a complete overview of where patients with COVID-19 are hospitalized, how many beds are available at the various hospitals and hospital wards, what protective gear is available or missing at which hospitals, and much more.

The solution provides a visual overview of countries, regions, municipalities, and hospitals that have available relevant data on e.g. the number of hospitalized patients with COVID-19. Each hospital can update its data manually or choose to integrate the solution with the hospital's electronic health record, thereby automatically transferring relevant data to the solution where it is continuously presented in real time. This optimizes distribution of patients and protective gear across different hospitals and municipalities and thus helps to avoid overcrowding of patients and shortage of protective gear.

Parts of the solution are already implemented at the hospitals in the North Denmark Region. Here, doctors and nurses can always monitor the bed capacity in all departments and wards including the newly established pandemic wards that handle patients diagnosed with COVID-19. Moreover, the solution enables users to transfer bed spaces from one ward or department to another, making the digital overview completely aligned with the actual hospital setup. Therefore, clinicians in the North Denmark Region always know exactly how many beds are available, where these are located, and which departments and wards that are under pressure due to overcrowding of patients.

If you are interested in more details about the company Systematic, please visit their homepage (<https://systematic.com/healthcare/>) or take a look at our catalogue "Automation of Healthcare Processes".



Innovative solutions

Danish telehealth platform helps Norwegian municipalities fight COVID-19



- Norwegian municipalities implement Danish telehealth platform as an important tool to fight COVID-19 and increase healthcare efficiency.

In a fast response to the COVID-19 crisis, all municipalities in the Norwegian region of Agder as well as the municipalities of Gjerdrum and Ullensaker have implemented a Danish telehealth solution to help monitor and provide safe surveillance of COVID-19 patients or patients at risk of serious COVID-19 symptoms. The solution called COVID-19 telemedicine is provided by the Danish company OpenTeleHealth and Siemens Healthineers.

Telemedicine is used to treat and monitor chronic patients in their own homes. The purpose is to promote coping with one's own health situation by preventing, detecting, and treating the worsening of the disease. The benefits of telemedicine are already well documented but since the outbreak of the coronavirus, it has become apparent that telemedicine is a necessity in the fight against COVID-19.

To reduce the risk of exposure for the valuable healthcare staff, the solution offers web-based healthcare staff training, which is available for large scale roll-out. It also collects, stores, and analyzes medical records to map the virus, and thus offers structured data collection.

The Norwegian municipalities are the first to try out the solution and with the ongoing infection, distance follow-up will help to relieve the healthcare services in assessing illness and follow-up of patients. For COVID-19 patients, it can create greater security due to the fact that they can get help while staying at home.

The solution is easy to use and reliable. At the same time, the set-up is quick, and little or no investment in technology is required.

If you are interested in more details about the company OpenTelehealth, please visit their homepage (<http://opentelehealth.com/>) or take a look at our catalogue "Automation of Healthcare Processes".



ICU and ventilator capacity

- The outbreak of COVID-19 is monitored pursuant to five main indicators:
 - The proportion of the population, which has been diagnosed with COVID-19
 - The number of COVID-19 patients admitted to hospital
 - The number of COVID-19 patients admitted to ICU
 - The number of COVID-19 patients in treatment with ventilators
 - The total number of deceased COVID-19 patients

Hospital ICU and ventilator capacity is the most important aspect to control, in order to save a patient's life. Hospitals that are able to initiate ICU and/or ventilator treatment immediately when this is needed, increase the survival rate from COVID-19 compared to hospitals lacking the necessary ICU or ventilator capacity. Unfortunately, the increase - and in some countries explosive increase - in the number of COVID-19 patients, who need ICU and/or ventilator treatment, has resulted in lower survival rates when necessary hospital capacity has been unavailable.

The worldwide ventilator availability and production does not match the current demand for additional ventilators, needed by hospitals to handle the pandemic worst-case scenarios.

Planning ahead, hospitals can work with strategies to deploy oxygen treatment for patients, who are not in acute need of ventilator treatment, and then only at a later stage (if needed), use ventilator treatment. This strategy makes it possible to postpone or avoid the use of ventilators and thereby increase the capacity.

Denmark has a strong tradition for research and public-private cooperation. Witnessing the potential challenge of ensuring enough ventilator capacity, Aalborg University has developed and tested an emergency ventilator, which can be produced in large numbers and utilised, if a hospital runs out of ordinary ventilator capacity.

Innovative solutions

Oxygen robot reduces risk and supports nurses to handle more COVID-19 patients



New robot technology improves oxygen treatment of COVID-19 patients and optimizes work flow for hospital staff.

Many COVID-19 patients admitted to hospitals suffer from serious respiratory infections that can lead to breathing problems and require oxygen treatment.

In a close collaboration, the Danish company O2matic and Hvidovre Hospital in the Capital Region of Denmark have developed an innovative oxygen robot that can improve the supply of oxygen to patients infected with COVID-19. At the same time, the solution reduces the contamination risk for healthcare professionals by limiting the physical contact with infected patients.

In the beginning of March, the first corona patients were treated with good results. The oxygen for the patients has so far been dosed manually by nurses up to 50 times per day, taking up much of the staff's limited time, especially considering the safety measures taken by the staff when attending the patients. The oxygen robot measures the oxygen level in the patient's blood every second and accordingly adjusts the dose of oxygen - ensuring that the patient receives the right amount of oxygen.

Based on the good results, the Capital Region of Denmark has ordered 40 oxygen robots for use at hospitals in the entire region.

"With the COVID-19 crisis, we both need more equipment and more staff, and time is essential. It is, therefore, a big advantage that robot technology, in this case, oxygen robots, can help us reduce manual tasks and release the pressure on our staff" - Sophie Hæstorp Andersen, Chairman of the Region Council at the Capital Region of Denmark, according to a press release.

The oxygen robot is already in use at many hospitals in Denmark and 10 other countries including Italy. O2matic is preparing the production of the next 500 oxygen robots, which are all produced by the high-tech company, Alpha Electronics in Denmark.

If you are interested in more details about the company O2matic, please visit their homepage (<https://o2matic.com/en/>) or take a look at our catalogue "Automation of Healthcare Processes".

Innovative solutions

Emergency ventilator to combat global ventilator shortage

In a public-private cooperation, a new emergency ventilator has been developed to help healthcare professionals save more lives during the COVID-19 crisis.

All over the world, thousands of COVID-19 patients require acute breathing support by a mechanical ventilator. To address the potential challenge of ensuring enough ventilator capacity, Aalborg University in North Denmark Region has, in collaboration with industrial partners, developed an emergency ventilator for use during the COVID-19 crisis, if a hospital runs out of ordinary ventilator capacity.

“A global shortage of mechanical ventilators threatens to increase the number of deaths to unnecessary high levels. To address this, we have developed an open source emergency ventilator, and we share all information and designs to enable healthcare systems to treat more patients” – Professor Stephen Rees, Aalborg University.

The CoRESCUE AAU Pandemic Ventilator is an open source emergency ventilator available for all and thereby benefits healthcare systems and patients across the world. It is relatively easy to build, it is solid, and it can be built at an affordable cost.

Where possible, the ventilator is built from standard industrial parts that are widely available and is not competing with ventilator manufacturers. The team behind the ventilator includes experts in respiratory physiology, mechanical ventilation, and in software and hardware design and construction. As such, the team understands the need for appropriate ventilatory management, how to deliver this, and how to design and develop the necessary technology – mechanical ventilators.

All information and the complete design are provided online, in the form of reference implementations and design specifications with the purpose to enable other countries to build and test emergency ventilators and to obtain rapid local approval.

The emergency ventilator has been authorized by the Danish Medicines Agency as exempt from CE marking requirements for use on COVID-19 patients in Denmark, in cases when no CE marked ventilators are available.

If you are interested in more details about the emergency ventilator by Aalborg University, please visit their homepage (<https://corescue.org/>).



