SIEMENS Healthineers

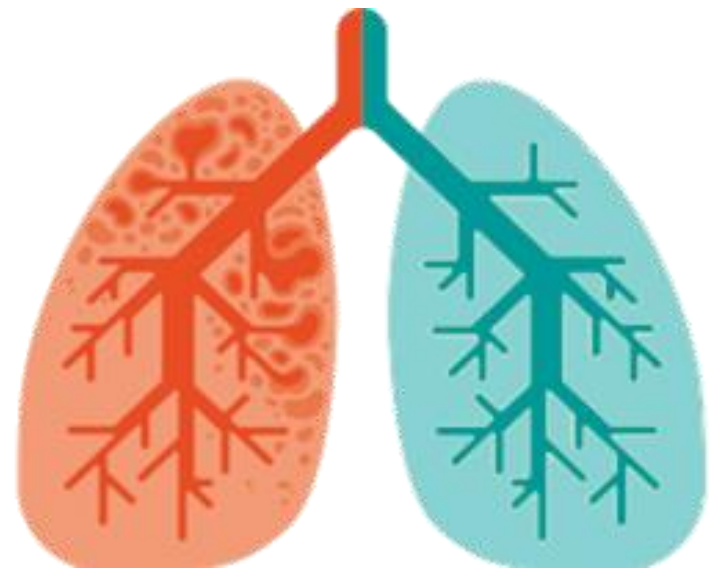
Innovation Think Tank
Proactively drive innovation to improve human life

INFECTIOUS DISEASES

FACTS AND FIGURES

SYMPTOMS INCLUDE[1,2]

FEVER
CHILLS
CONGESTION
COUGH
NAUSEA
VOMITING
DIARRHEA
FATIGUE
MUSCLE ACHES
HEADACHE



Types of infectious diseases[2]

- ✓ Bacterial infections
- ✓ Viral infections
- ✓ Fungal infections
- ✓ Parasitic infections
- ✓ Transmissible spongiform encephalopathies/ Prion diseases

1.5 million children <5 years of age lose their lives to vaccine-preventable diseases every year[6]

Lower respiratory infections were the 4th leading cause of death in 2019[7]

Globally, until May 2023 >765 million people have been diagnosed with and >6.9 million died due to COVID-19[8]

Modes of transmission[3]

- ✓ Foodborne and waterborne diseases
- ✓ Vector-borne diseases
- ✓ Diseases transmitted to humans by animals
- ✓ Sexually transmitted diseases
- ✓ Bloodborne diseases
- ✓ Airborne diseases
- ✓ Diseases transmitted via soil

In 2021, 38.4 million people were living with HIV, 2/3rd (25.6 million) of them are in the WHO African region[9]

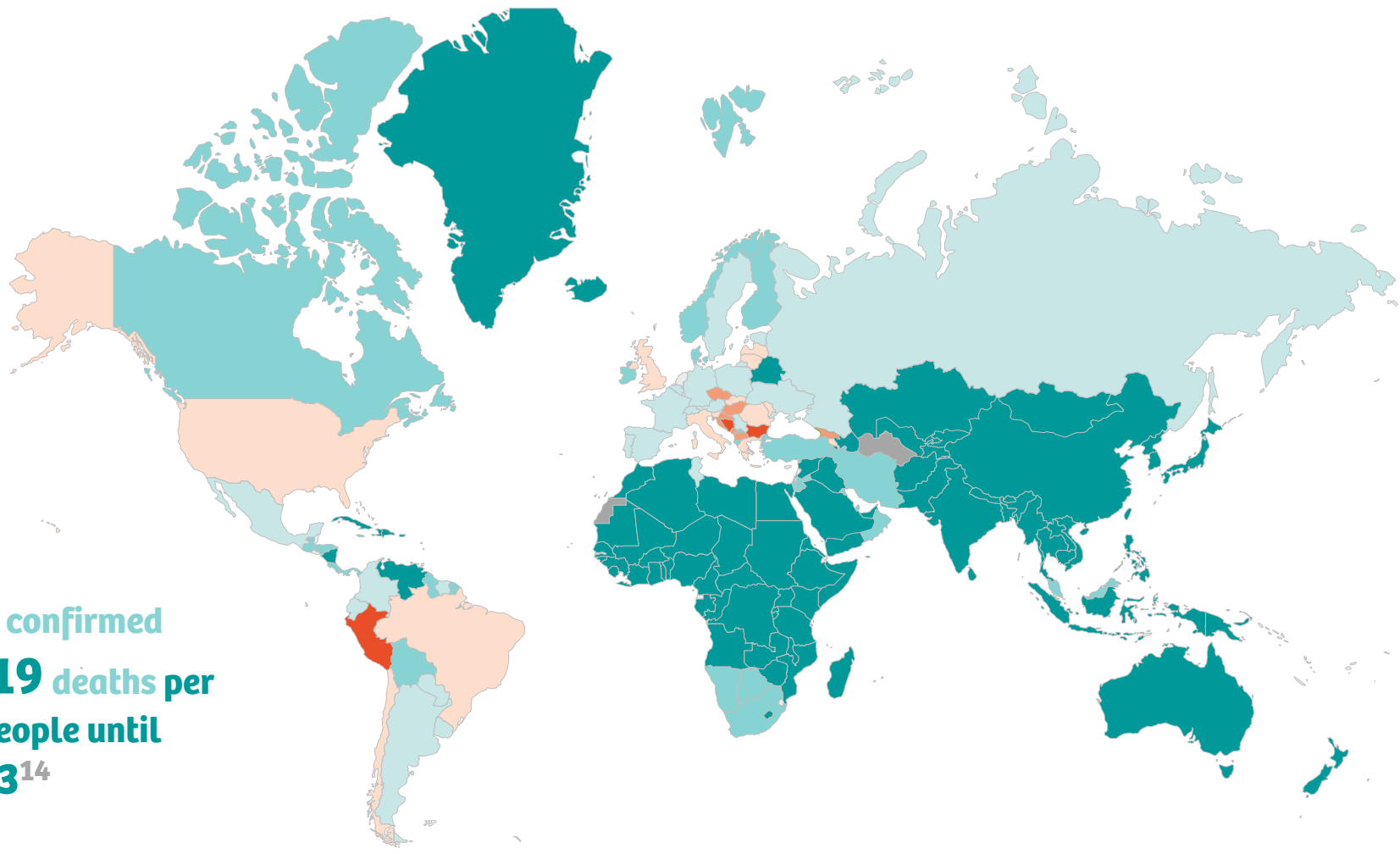
1.6 million people died from tuberculosis in 2021[10]

100-400 million dengue infections occur each year[11]

In 2020, there were an estimated 241 million cases of malaria worldwide[12]

In 2019, 296 million and 58 million people worldwide were living with chronic hepatitis B and C infection, respectively[4,5]

Global infectious diseases diagnostics market (in billion USD)[13]



Cumulative confirmed
COVID-19 deaths per 1,000,000 people until April 2023[14]

0 – 1000
1000 – 2000
2000 – 3000
3000 – 4000
4000 - 5000
5000+
No data

Disclaimer:
This publication on the infectious diseases pathway framework was updated on 17.05.2023. It cannot be taken as a recommendation for the readers, especially not as a guideline for treatment, and it is not a medical document. There is no guarantee for completeness or global correctness, the various pain points, solutions, and statistical data are examples only. Sources are multiple, such as public statistics, expert opinions, open innovation workshops, research, own data and many more (see references).
The products and features mentioned may not be available in all countries and their future availability cannot be guaranteed. Some products mentioned are planned and under development.

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INFECTIOUS DISEASES

Disease pathway analysis with pain points and solution examples

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An extensive research-based analysis from 40+ scientific articles and journals in combination with hospital workflow experience allowed the identification of pain points and solutions.

These solutions were proposed based on AI, IoMT, AR/VR, biosensors, nanorobotics and smart wearable technologies.

THROUGH THIS CAREPLAN WE HIGHLIGHT DATA FROM A COLLECTION OF

56 pain points

40 solutions

15 connected to different stakeholders

Solution categories

- **Existing in healthcare sector**
- **Ongoing research in healthcare**
- **Futuristic solution (may or may not be implemented)**

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[a]TORCH and Special ID Assays (SHS): The products/features (mentioned herein) are not commercially available in all countries. Due to regulatory reasons their future availability cannot be guaranteed. System and assay availability is subject to local regulatory requirements.
[b]Atellica Integrated Automation (SHS): The products/features (mentioned herein) are not commercially available in all countries. Due to regulatory reasons their future availability cannot be guaranteed.

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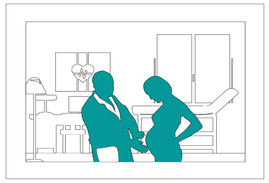
1 PRENATAL

Scenario: At the obstetrician's office

STAKEHOLDERS

- **Pregnant woman** — Receives care services from healthcare providers.
- **Family** — Tries to support the pregnant woman with her needs throughout the pregnancy.
- **General practitioner** — Supports the patient with general health issues.
- **OB/GYN** — Tracks and observes mother's and fetus' health. Also provides special care for high-risk patients.
- **Pediatrician** — In charge of the health check-up of the newborn.



Pregnant woman gets infected with a virus and worries about transmitting it to the unborn. She visits the hospital for check-up.

1
PAIN POINT
Pregnant women and their family members may not be aware of the various infectious diseases affecting pregnancy and their impact on the fetus.

SOLUTION
Process innovation

★ **Education campaigns**

To help prevent infections before and during pregnancy, people can be educated about infectious diseases caused by TORCH organisms (Toxoplasma gondii, HIV, Rubella, Cytomegalovirus, Herpes simplex virus), Zika virus, Syphilis etc., their risk factors, and preventive measures such as appropriate hand hygiene, avoiding unpasteurized milk and products, reducing contact with saliva and urine from babies, not touching dirty cat litter, avoiding contact with people with infections, and not travelling to endemic areas.[1]

2
PAIN POINT
Pregnant women in remote or rural areas may be at a higher risk for certain infections due to poor sanitation and other socioeconomic factors, but are often diagnosed late due to reduced access to medical facilities.

SOLUTION
Process innovation

★ **Mobile health clinics**

Deploying mobile clinics to remote locations can address the issue of access to tests and inequity in many underprivileged communities, thus aiding in timely management and preventing complications.

3
PAIN POINT
Infections caused by herpes simplex virus, hepatitis B virus, HIV, Toxoplasma gondii, etc. can pass from mother to baby through placenta or during delivery, and result in neonatal infection and/or congenital malformation.

SOLUTION
Clinical innovation & Sensing

★ **TORCH and special infectious disease assays [a]**

A comprehensive assay menu for TORCH infections, Epstein Barr virus, H. pylori, Syphilis, Zika virus can help laboratories address critical and common infectious diseases in pregnancy, aid clinicians make critical decisions and address fetal outcomes if infected, for improved prenatal and specialty care.[1]

SOLUTION
Process innovation

★ **Strategies for prevention of congenital infections**

Measures can be taken to vaccinate women prior to pregnancy to generate protective maternal immunity, provide passive or active immunization during pregnancy to boost immunity, or promptly diagnose and treat the infection during pregnancy.[1]

2 PREVENTION

Scenario: In the park

STAKEHOLDERS

- **Patient** — Maintains a healthy lifestyle by following good food habits and exercise.
- **Family** — Supports and encourages the patient to follow a healthy lifestyle.
- **General practitioner** — Provides care related to general medical issues and advises the patient to lead a healthy lifestyle.
- **Ministry of Health** — Formulates and legislates health policies. Works together with other health institutions to control infections diseases.
- **Medical device companies** — Develop effective products to help prevent infectious diseases.
- **Society** — Participates in awareness programs regarding infectious diseases.

Patient tries to eat healthy, engage in physical activity and follow general hygiene guidelines in order to avoid contracting infectious diseases.

1
PAIN POINT
People in remote and rural areas, especially in low-income countries, lack sufficient access to vaccination and are at a higher risk of contracting infectious diseases.

SOLUTION
Process innovation & Digitalization

★ **Global vaccination campaigns**

These must ensure an equitable distribution and accessibility to vaccines worldwide so that all individuals and communities enjoy lives free from vaccine preventable diseases. Such campaigns can be facilitated by mobile medical units for door-to-door immunizations, and real time vaccine monitoring analysis for daily tracking of vaccine coverage, utilization, and wastage.[4,5]

2
PAIN POINT
Frequently touched surfaces in hospitals like faucets are reservoirs for nosocomial pathogens like MRSA, VRE, Pseudomonas spp. or Acinetobacter spp. and therefore a risk for patients and staff.

SOLUTION
Sensing

★ **Sensor based dispenser**

Electronic, touchless, sensor-operated faucets improve hygiene, and help to prevent the spread of healthcare-associated infections by decreasing instances of cross contamination.[4]

3
PAIN POINT
Improper injection techniques, inappropriate use of invasive devices like catheters, poor knowledge of infection control measures, and lack of infection control policies can result in a high infection rate.

SOLUTION
Process innovation

★ **Infection prevention and control guidelines**

It is a practical, evidence-based approach preventing patients and health workers from being harmed by avoidable infections. It affects all aspects of health care, including hand hygiene, surgical site infections, injection safety, antimicrobial resistance and how hospitals operate during and outside of emergencies.[1]

SOLUTION
Digitalization

★ **Virtual reality based training**

VR can be a useful tool for learning and practicing appropriate infection control measures such as hand hygiene and donning PPE, training the staff on invasive procedures such as catheter insertion, intubation, safe injection practices, and providing comprehensive infection control training to prevent postoperative wound infections and other healthcare associated infections.[4]

4 COVID-19
PAIN POINT
Not following common hygiene standards can increase risk of infection in hospitals and other public facilities, especially during the pandemic.

SOLUTION
Automation

★ **Hygiene robot**

A robot could be used to go around the facility to detect if people are wearing mask or not and provide it when required, sanitize their hands and check if they are maintaining social distancing through thermal sensors.

5
PAIN POINT
Traditional vaccine development and production process may take years.

SOLUTION
Digitalization & Clinical innovation

★ **Digital twin for vaccine development**

It collects real time insights by combining the virtual and real realms of vaccine development and manufacturing in a closed loop. When the digital twin is connected to the real process, the physical sensors send data to the twin and the simulated insights are fed back to the control system, ensuring faster, less wasteful, and more cost-effective process.[9]

3 SYMPTOMS

Scenario: In the park

STAKEHOLDERS

- **Patient** — Starts to experience early symptoms of an infectious disease and is worried about the consequences.
- **Family** — Worries for the patient's health and encourages him/her to see a doctor.
- **General practitioner** — Recognizes symptoms, provides initial care and refers the patient to a specialist.
- **Infectious disease specialist** — Specializes in treating infectious diseases.
- **Medical device companies** — Design innovative technologies to help patients with their symptoms.

Depending on what infection the patient contracted, he can display a wide variety of symptoms such as coughing, chest pain, fever, gastrointestinal symptoms or severe headache.

1
PAIN POINT
Infections have an infinite range of presentations, from acute life-threatening conditions to chronic diseases of varying severity to no symptoms at all. Physicians may find it difficult to associate symptoms to a particular disease.

SOLUTION
Digitalization

★ **Clinical decision support system**

It analyzes patient's data like chief complaints and history of present illness for an accurate assessment of features and duration of the disease, past medical history, medication, vaccination, dietary, family and contact history, travel, occupation, animal exposures, dietary, introduction drug injection use, and sexual history, and symptoms to provide a differential diagnosis and care recommendations.[10,11]

2
PAIN POINT
Many infectious diseases share similar symptoms, such as fever, headache, muscle aches, diarrhea, etc. which can make it difficult to determine the specific infectious agent causing the illness.

SOLUTION
Digitalization

★ **Predictive models**

An ML based model can be trained to map parameters like age, gender, lifestyle and symptoms to a particular disease using various algorithms and classifiers. Such systems can take patient's details as input and assist clinicians in diagnosing and classifying infectious diseases.[12]

3
PAIN POINT
Symptoms of sepsis can easily be missed or misdiagnosed. About 1.7 million adults develop sepsis every year in the United States and more than 250,000 of them die.[13]

SOLUTION
Digitalization

★ **Sepsis detection using AI**

A targeted real-time early warning AI system can search medical records and clinical notes, combine it with current symptoms and lab results to identify patients at risk for life-threatening complications like sepsis, and suggest treatment protocols to clinicians, such as starting antibiotics. It tracks patients from when they arrive in the hospital through discharge, ensuring that critical information isn't overlooked.[13]

4
PAIN POINT
Patient may experience itching or burning around the genitalia, abnormal discharge or painful urination but may not visit the doctor due to sociocultural factors.

SOLUTION
Process innovation

★ **Information, education and counselling**

It can be used to train health workers, raise public awareness, improve people's ability to recognize the symptoms of sexually transmitted infections, overcome the associated stigma by creating a positive environment for discussion, and increase the likelihood that people will seek care and encourage a sexual partner to do so. This can help reduce the burden of untreated infection.[14]

5
PAIN POINT
There may be a risk of transmission of the infectious agent to the family members or other individuals.

SOLUTION
Process innovation

★ **Transmission-based precautions**

In addition to standard precautions like hand hygiene, transmission-based precautions such as appropriate patient placement or patient isolation in a private room with closed door, use of masks or gloves, using disposables or dedicated equipment, utensils or other personal items for the patient, and ensuring room cleaning and disinfection can help prevent contact, droplet and airborne infection transmission.[15]

6 COVID-19
PAIN POINT
Patient shows symptoms but does not visit the hospital due to fear of contracting COVID-19.

SOLUTION
Digitalization

★ **Telemedicine**

It enables the patient to consult a physician online via chat, audio or video call where he/she can discuss the symptoms, based on which tests can be recommended, and medications can be prescribed.

4 DIAGNOSIS

Scenario: At the doctor's office

STAKEHOLDERS

- **Patient** — Receives diagnostic services from various health professionals.
- **Family** — Tries to be supportive and accompanies the patient to the hospital.
- **Infectious disease specialist** — Physically examines the patient and chooses the diagnostic measures.
- **Microbiologist** — Makes a diagnosis based on PCR, ELISA, cell culture, etc. of patient samples.
- **Radiologist** — Interprets medical images, e.g., chest x-rays or CT scans.
- **Medical device companies** — Develop and create innovative cost-effective diagnostics tools.

Doctor examines the patient and suggests blood testing to measure specific parameters or culture of pus, blood or urine to get information about the exact type of disease-causing agent.

1
PAIN POINT
Laboratory based testing may not be widely available in remote and rural areas where the burden of infectious diseases is often high.

SOLUTION
Clinical innovation

★ **Point of care tests**

Low-cost point of care testing that is easy to use, provides rapid and accurate results can be deployed in resource-limited settings.

SOLUTION
Process innovation

★ **Public-private partnerships**

Governments and international organizations can partner with private or local healthcare providers and/or medical device manufacturers to expand access to existing diagnostic services.

2
PAIN POINT
Lack of early and accurate diagnosis of respiratory infectious diseases can lead to a high transmission rate and adverse complications.

SOLUTION
Clinical innovation

★ **Syndromic testing**

A syndromic assay is a qualitative in vitro nucleic acid amplification test that helps in detection and differentiation of specific viral and bacterial nucleic acids. Such an assay enables testing of multiple pathogens simultaneously using a single sample, thereby saving time and resources and increasing testing efficiency.[16]

3
PAIN POINT
Due to a broad mix of testing performed by most labs, they may face staffing, financial, and operational pressures.[17]

SOLUTION
Automation & Digitalization

★ **Lab automation [b]**

An automation system that provides revolutionary sample management technology for independent control over samples, automation of lab quality control processes, intelligent software and IT to run lab operations easily, built-in specific sample sorting, retrieval and archiving functions to manage samples throughout all phases of testing, while also connecting seamlessly with existing LIS can provide workflow efficiency by empowering lab to meet evolving testing needs.[18]

4
PAIN POINT
Geriatric or non-ambulatory patients may find it difficult to visit the hospital for laboratory tests.

SOLUTION
Process innovation & Digitalization

★ **At-home sample collection**

Patient can send an intimation via a smartphone app to a hospital or a diagnostic center, which sends a technician or sample collection kits with test instructions to the patient's home. These samples are then taken back to the facility for testing and results are shared through the app.

5
PAIN POINT
There is a frequent overlap of imaging findings between the various infectious etiologies of pneumonia, as well as various other disease conditions, including inflammatory conditions, vasculitis, and malignancy.[19]

SOLUTION
Digitalization

★ **Automatic pattern recognition tool**

Pattern recognition algorithms can be developed and trained on large datasets of image findings to recognize patterns and subtle differences in imaging features, thereby aiding in differentiation of infections caused by different organisms, as well as other disease conditions. It can act as a supportive tool for radiologists in accurate decision making.[20,21]

5 TREATMENT

Scenario: At home in the living room

STAKEHOLDERS

- **Patient** — Receives treatment from health care providers.
- **Family** — Supports patient throughout the treatment.
- **Infectious disease specialist** — Prescribes medication and advises other treatment measures.
- **Insurance company** — Covers the treatment costs for patient.
- **Pharmacy** — Provides the necessary medication for patient.
- **Medical device companies** — Develop and create innovative options for effective treatment of infectious diseases.

Patient follows recommended medical treatment.

1
PAIN POINT
Poor information exchange between the laboratory and physicians affects treatment decision, implementation and patient outcome.

SOLUTION
Digitalization

★ **Integrated data exchange system**

An automated system for delivering laboratory test results to physicians electronically which can send notifications when results are available and alerts for critical test results, ensuring timely access. It can be integrated with the EHR system or implemented through secure email or web portals.[22]

2
PAIN POINT
Finding the right treatment can sometimes be challenging as it depends on various factors such as the infectious agent, disease severity, skills and experience of the physician.

SOLUTION
Clinical innovation & Digitalization

★ **Patient digital twin**

Digital twin can collect real time data from wearables and electronic health records to provide a continuous monitoring system for understanding patient health status. Moreover, it can simulate different treatment scenarios in terms of effectiveness and side effects, thus enabling doctors to select the right therapy.

3
PAIN POINT
Irrational prescription of antimicrobials, over the counter drug dispensing, missing prescribed doses, or stopping the treatment too soon can lead to development of antimicrobial resistance (AMR).

SOLUTION
Process innovation

★ **Antimicrobial stewardship programme**

It is an organizational or system wide healthcare strategy to promote appropriate use of antimicrobials across human health, animal health and the environment through the implementation of evidence-based interventions. It can optimize the use of antimicrobials, improve patient outcomes, reduce AMR and health-care-associated infections, as well as save health-care costs. Furthermore, improving awareness and understanding of AMR among the public through effective communication, education and training can be beneficial.[23]

4
PAIN POINT
Patient might not comply to the prescribed treatment regime due to elimination of symptoms after taking a few doses, or development of side effects.

SOLUTION
Digitalization

★ **Treatment management tool**

It can provide education to the patient on the significance of completing the medication course, common medication side effects, and consequences of non-adherence, while also sending digital reminders for medicine intake, as well as enabling real time communication between the patient and physician to discuss about prevailing concerns and their management.

5 COVID-19
PAIN POINT
Patient may avoid visiting the pharmacy due to long travel distances or fear of infection during the pandemic.

SOLUTION
Digitalization & Process innovation

★ **At-home medication delivery**

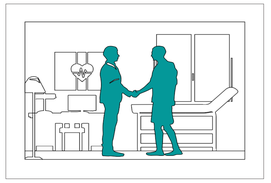
Prescription medications can be ordered online from an e-pharmacy and delivered to the doorstep by a delivery person or a drone.

6 FOLLOW-UP

Scenario: At the doctor's office

STAKEHOLDERS

- **Patient** — Routinely visits the hospital for follow-ups with care provider.
- **Family** — Supports and reminds patient of routine follow-ups.
- **Infectious disease specialist** — Monitors the effectiveness of treatment and health progress.
- **General practitioner** — Follows up with patient to ensure effective recovery.
- **Pharmacy** — Provides medication for ongoing therapy.
- **Dietician** — Suggests appropriate meal plans for the follow-up period.



Patient revisits the hospital for regular follow-ups to reevaluate treatment options.

1
PAIN POINT
Patient may not consume a nutritious diet due to loss of appetite and inability to take solid food.

SOLUTION
Process innovation

★ **Meal replacement beverages**

Fluids such as shakes or soup containing all the required nutrients and calories can be given as an alternative to solid foods.[24]

2
PAIN POINT
Patients may suffer from psychological issues like anxiety or depression after infection with Herpes simplex virus, Herpes zoster virus or HIV.

SOLUTION
Digitalization

★ **Online support groups**

These groups provide a safe environment for the affected individuals to share and discuss the impact of the disease on their lives and seek information, advice and support from peers.[25,26]

3
PAIN POINT
Patients in remote areas or with time consuming jobs are less likely to go for regular follow-up.

SOLUTION
Digitalization

★ **Virtual consultation**

Video conferencing allows for a meaningful face-to-face encounter without the inconvenience of having patients drive all the way to the hospital for a brief appointment. Moreover, doctors can prescribe medications and make necessary adjustments via telemedicine.

4 COVID-19
PAIN POINT
Patients with infectious diseases like COVID-19 may be at risk of complications.

SOLUTION
Sensing & Digitalization

★ **Remote patient monitoring**

Wearable biosensors can be used to measure vital signs like blood pressure, heart rate, respiratory rate, temperature, oxygen saturation, and weight. This data can be sent to the care team via an app for continuous patient monitoring to detect any significant changes at the earliest. The app can also prompt an automated alert in case of out of range parameters, based on which further management can be done.[27]

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