SIEMENS Healthineers

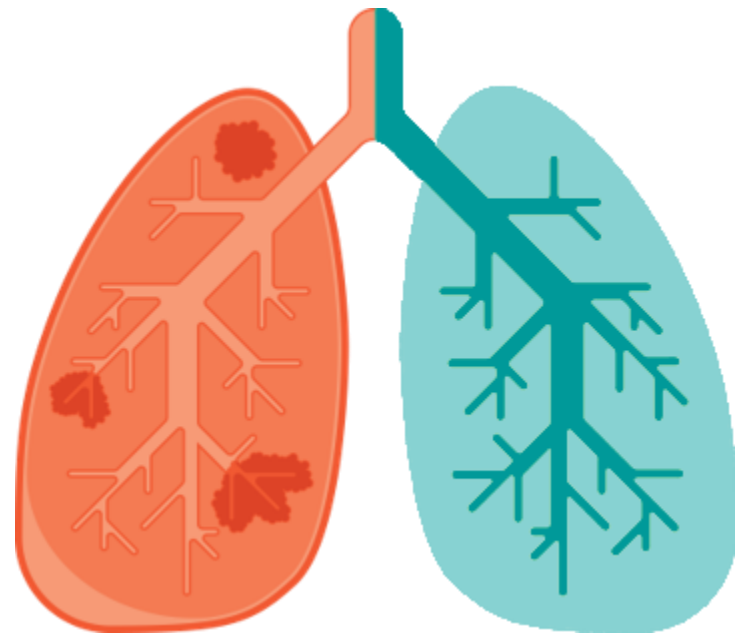
Innovation Think Tank
Proactively drive innovation to improve human life

LUNG CANCER

FACTS AND FIGURES

SYMPTOMS INCLUDE[1]

PERSISTENT OR WORSENING COUGH
CHEST PAIN
SHORTNESS OF BREATH
WHEEZING
COUGHING UP BLOOD
FATIGUE
UNINTENTIONAL WEIGHT LOSS



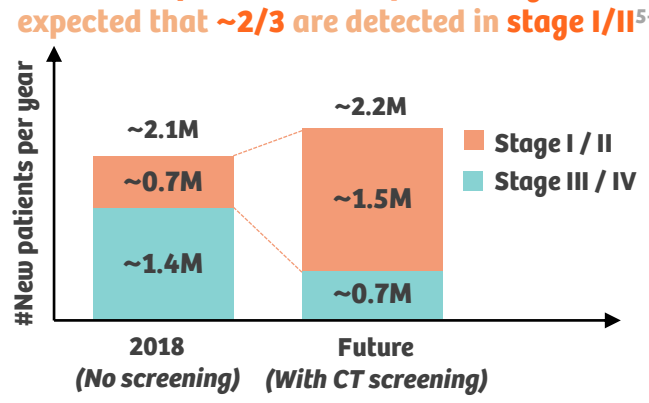
2nd most common cancer in the world[2]

2.2 million new cases & 1.8 million deaths globally in 2020[2]

2/3rds of lung cancer deaths globally are due to tobacco smoking[3]

Outdoor air pollution contributes to 29% of deaths and disease from lung cancer worldwide[4]

Today ~1/3 of all new cases are stage I/II. With the implementation of screening, it is expected that ~2/3 are detected in stage I/II[5-8]



The 5-year survival rate is ~57% for patients with stage 1 lung cancer and only ~4% for those with stage 4 disease[5,9]

COVID-19

Lung cancer patients with COVID-19 have a high case fatality rate[11]

Over the past 4 decades in the US, lung cancer diagnoses have been rising in women and dropping in men[12]

US $1.68
Additional investment per capita in Tobacco cessation over a 10-year period (2021-2030)[10]

By 2030

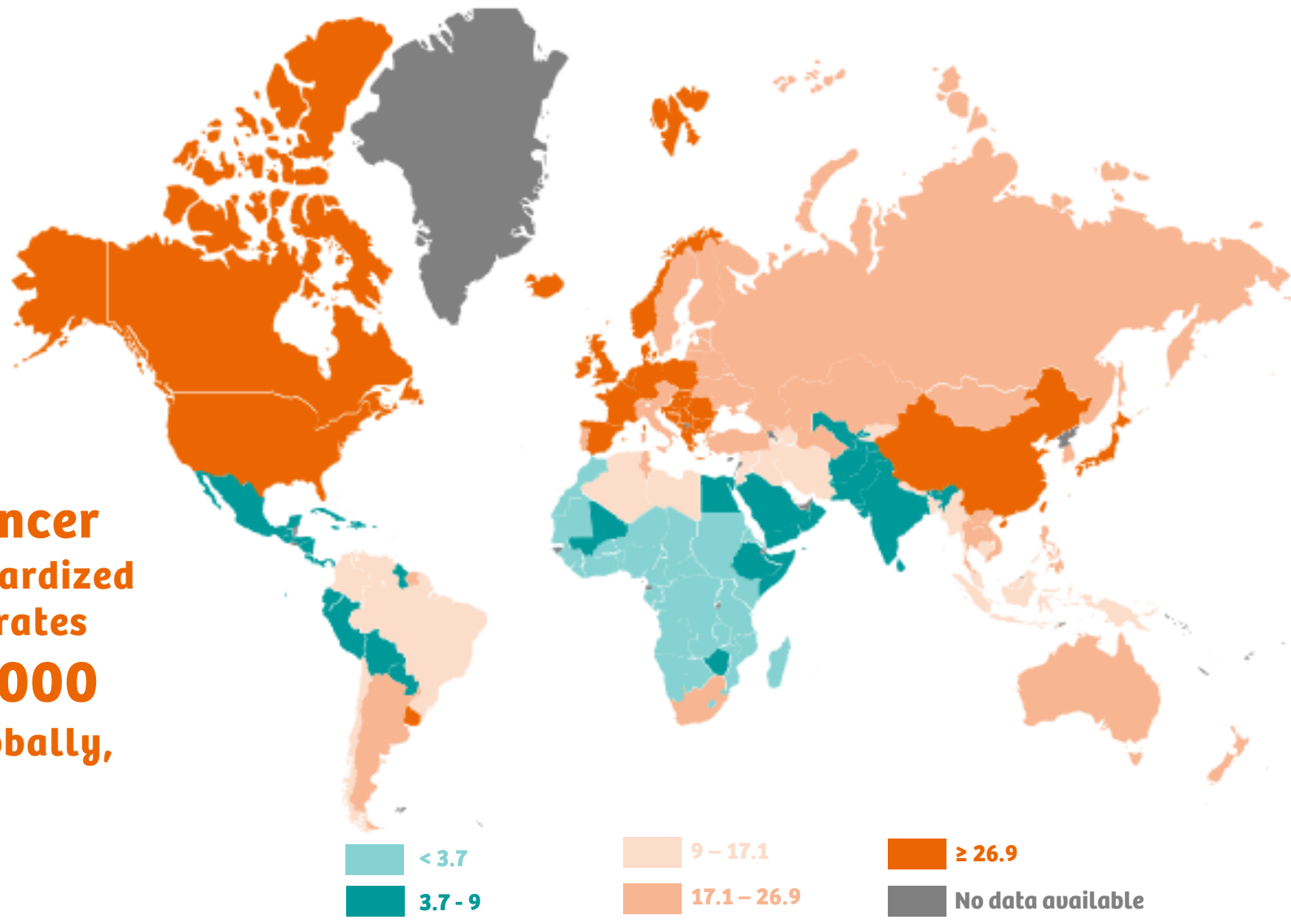
152 Mn Successful quitters[10]

Nearly **3 Mn** lives saved[10]

Cost of lung cancer treatment in the US[13]

Surgery: $15,000+
Chemotherapy: $10,000-$200,000+
Radiation: $10,000-$50,000+
Drug therapy: $1,500-$4,000+

Lung cancer Age-standardized incidence rates per 100,000 people globally, 2020[14]



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LUNG CANCER

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

72 pain points

88 solutions

16 connected to different stakeholders

1 PREVENTION

Scenario: In the living room

STAKEHOLDERS

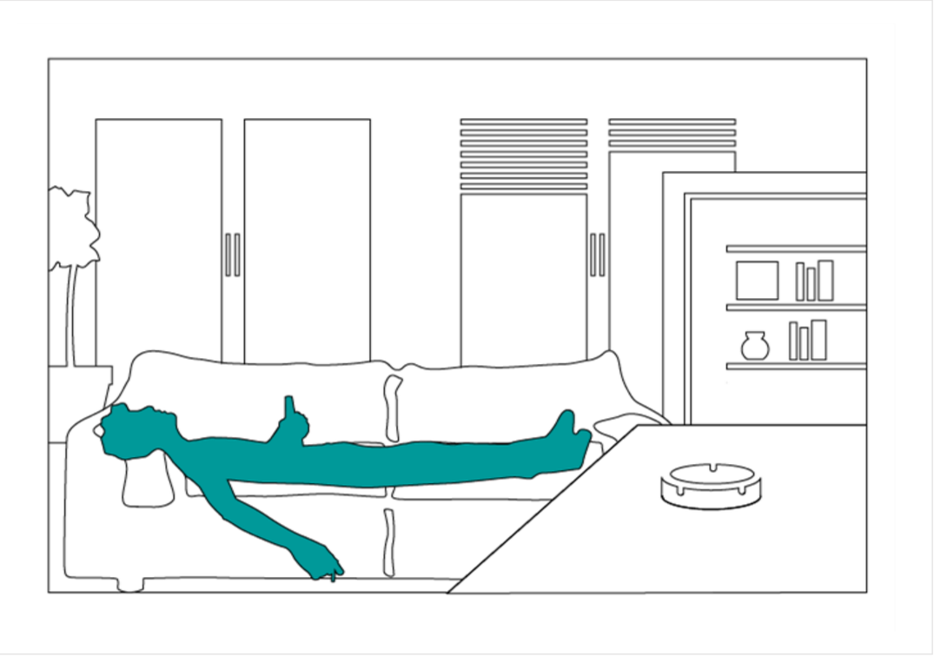
Patient – The patient struggles with addictions like smoking.

Family – Worries for the patient and wishes to be of support.

General practitioner – Helps with general health questions and discusses prevention strategies with the patient.

Ministry of Health – Formulates and legislates health policies as well as strategies for health facilities.

Medical device companies – Create innovative tech solutions that help the public to stay active and live a healthy lifestyle.



The patient struggles with an unhealthy lifestyle, regularly drinking alcohol and smoking.

1 PAIN POINT: Lung cancer is a leading cause of cancer mortality; most lung cancer patients are diagnosed in advanced stages (stage 3 or 4), where only palliative treatment is possible.[1]

SOLUTION: Process innovation

Lung cancer prevention strategies

Smoking cessation interventions (primary prevention) and low-dose CT screening for early diagnosis of lung cancer (secondary prevention) in high-risk individuals, in addition to public awareness campaigns on lung cancer, its risk factors and maintenance of a healthy lifestyle, can enable timely curative therapy and thus long-term mortality reduction.[2]

2 PAIN POINT: Lack of awareness, access challenges, cost concerns, travel time etc. are some barriers to lung cancer screening, especially in rural and remote regions.

SOLUTION: Process innovation

Mobile screening units

To raise awareness, save time, costs and increase availability for high-risk patients in rural and remote areas, grassroots engagement along with deployment of mobile screening units can enable individuals to get examined within a few minutes and get certainty about the state of their lung health, without having to visit the hospital.[3]

3 PAIN POINT: Tobacco use accounts for 25% of all cancer deaths globally and is the primary cause of lung cancer.[4]

SOLUTION: Process innovation

Tobacco control policies

Increasing excise taxes and prices on tobacco products, implementing plain packaging and/or large graphic health warnings on all tobacco packages, enacting and enforcing bans on tobacco advertising, promotion and sponsorship, sales control, smoking restrictions etc. are some key measures for primary prevention of lung cancer.[5]

4 PAIN POINT: Cigarette smokers have a 10-fold or greater increased risk of developing lung cancer compared to those who have never smoked.[6]

SOLUTION: Digitalization

Personalized quitting plan

An AI based virtual health worker can provide digital counselling services in real time to those trying to quit tobacco and offer a personalized quitting plan based on a series of interactive questions. It also recommends digital cessation programmes available in the country.[7]

5 PAIN POINT: Environmental tobacco smoke (ETS) or secondhand smoke can increase the risk of lung cancer development.[8]

SOLUTION: Digitalization & Process innovation

Secondhand smoking survey instrument

With a brief, validated online survey instrument, the exposure to ETS can be assessed. Data from this can be used for evaluation of exposure profile based on the secondhand smoke exposure scale, risk calculation, creating smoke free areas in all indoor workplaces, public places, public transport, and implementing effective mass media campaigns to educate the public about the harms of smoking and ETS.[5,9]

6 PAIN POINT: Outdoor air pollution contributes to 29% of deaths and disease from lung cancer. Besides, most of the world's population lives in areas which exceed annual WHO limits for particulate matter (PM2.5).[5,10]

SOLUTION: Process innovation

Air quality surveillance system

With this, it is possible to inform the population about the health risks associated with inhaling particulate matter. Assessments of emissions and its sources can be done to find efficient interventions like reduced trash burning, use of cleaner vehicles and fuels, and guide policy. Additionally, combination with weather forecast can enable people to avoid high risk periods and shift activities to periods with lower pollution.[11,12]

7 PAIN POINT: Radon, a leading cause of lung cancer, may be found in high concentrations in indoor environments like homes; exposure to it can be caused by cracks in walls or floors, sumps or drains.[13]

SOLUTION: Process innovation

National radon policies and regulations

Measures can be taken to provide information on levels of radon indoors and the associated health risks, establish a national annual average residential radon concentration reference level, develop radon measurement protocols, implement radon prevention in building codes, promote education for building professionals and provide financial support to remove radon from existing buildings by increasing under-floor ventilation, installing a radon sump system, sealing floors and walls, and improving the ventilation of the building.[13]

8 PAIN POINT: Occupational exposure to carcinogenic agents such as asbestos, arsenic, bischloromethyl ether, hexavalent chromium, polycyclic aromatic hydrocarbons etc. can increase the likelihood of developing lung cancer.[6]

SOLUTION: Process innovation

Work health policies

Strengthening occupational protection with meaningful pollution exposure limits in workplaces and its continuous monitoring, developing preventive guidelines, offering awareness campaigns and conducting regular medical examinations.[14]

9 PAIN POINT: A prior lung disease such as chronic bronchitis, emphysema, and tuberculosis increases the risk of developing lung cancer.[6]

SOLUTION: Digitalization

AI based predictive model

Using parameters like patient age, sex, genetic history, body mass index, smoking intensity, occupational exposure, presence of prior lung diseases, and other clinically relevant information, along with laboratory and imaging results, an AI based model can be used to predict the risk of lung cancer.[15]

2 SYMPTOMS

Scenario: At home

STAKEHOLDERS

Patient – Experiences cough, fatigue and unwanted weight loss.

Family – Is worried for the patient and suggests to see a doctor.

General practitioner – Thoroughly listens to the patients' symptoms, examines him/her and refers to an expert.

Pulmonologist – Patient gets referred to a pulmonologist: an expert for diagnosing and treating lung diseases.

Medical device companies – Create innovative tech solutions to help track and monitor symptoms of lung cancer.

The patient feels increasingly weak, also noticing an unwanted loss of body weight. The family is subsequently worried.

1 PAIN POINT: Patients with symptoms of lung cancer in remote areas may lack awareness and face limited access to care due to little integration between primary care and tertiary care, slow referral processes, etc.[16]

SOLUTION: Process innovation

Optimal care pathways

Structured care plans specific to lung cancer that define all tasks to be pursued, their timeframe, sequence and the professionals involved. In combination with electronic health record management, rapid clinical and pathological diagnoses, and prompt referral to an appropriate center for further care can be facilitated.[5,16]

SOLUTION: Digitalization

Telemedicine

Telehealth can enable efficient shared care and can be explored for all patients. Especially in some rural or remote locations, patients can benefit from accessing specialists via tele-consultations.

2 PAIN POINT: A change in the character of COPD, particularly if associated with other new symptoms, should always raise suspicion of lung cancer but is often ignored by the patient.

3 PAIN POINT: Many patients with lung cancer suffer early on from breathlessness, potentially missing out on the implication these symptoms have.

SOLUTION: Sensing & Digitalization

Respiratory wearable sensors

In future, wearables placed on the patient's chest could monitor breathing patterns and recognize changed coughing patterns or other irregularities early on. Further analysis with incorporation of the patient's digital health history can lead to recommendations to visit a primary health care provider for a check-up.[17]

4 PAIN POINT (COVID-19)**:** Lung cancer and COVID-19 can share similar symptoms, potentially leading to patients incorrectly attributing their symptoms to the infectious disease instead of cancer.

SOLUTION: Process innovation

Patient education efforts

Efforts must be undertaken to educate patients on the similarities of lung cancer and COVID-19 symptoms: a new, continuous cough is a concerning symptom patients should tell their doctor about, especially if it is accompanied by loss of appetite, unplanned weight loss, or fatigue.[18]

3 DIAGNOSIS

Scenario: At the hospital's radiology department

STAKEHOLDERS

Patient – Undergoes several tests like imaging and blood work.

Pulmonologist – Performs bronchoscopy and lung biopsy and refers the patient to an oncologist for further management.

Radiologist – Evaluates medical images (CT, MRI, etc.) in order to diagnose the patient and plan treatment options.

Interventional radiologist – Performs CT-guided percutaneous biopsy.

Pathologist – Evaluates tissue samples and characterizes the type of lung cancer.

Medical device companies – Create innovative tech solutions to help diagnose the patient quickly and successfully.

The patient receives a CT scan of thorax to identify any suspicious lesion in the lung.

1 PAIN POINT: Scanning error, recognition error, decision-making error, satisfaction of search, short timeframes for a case and bad image quality can result in missed lung cancer diagnosis.[19]

SOLUTION: Clinical innovation & Digitalization

AI-Rad Companion (AIRC)[a]

AIRC helps to reduce the burden of basic repetitive tasks and supports the doctor's interpretation of the data by automatically providing results of its analysis for review, confirmation and possible inclusion in the final report or care pathway – to raise precision and ensure high quality outcome in diagnostic decision-making. AIRC Chest CT can detect and highlight lung nodules, after segmentation of which, the volume, maximum 2D & 3D diameter, and tumor burden are automatically calculated.[20]

2 PAIN POINT: For a definitive diagnosis, a biopsy is obligatory. Biopsies require multiple tissue samples which is a complex process and there is a risk of complications.

SOLUTION: Clinical innovation

myNeedle companion

It harmonizes planning and guidance for percutaneous needle procedures across modalities and allows planning advanced procedures requiring multiple needles. By using the integrated software-assisted path planning and guided insertion, both routine and complex procedures can be simplified. Additionally, the integrated laser guidance system visualizes the needle entry point and angle, with the aim of increasing efficiency and reducing variations of outcomes in interventional radiology.[21]

3 PAIN POINT: Based on the expertise, different pathologists evaluating a biopsy sometimes come to varied conclusions regarding the diagnosis, leading to potentially different treatment.

SOLUTION: Digitalization

Digital pathology[b]

From AI-enabled diagnostic workflows to remote access and consultation, the digital pathology platform can empower the modern laboratory, driving efficiency and quality as they embrace pathology's computational future. Integration of enterprise imaging and digital pathology can help pathologists and other healthcare professionals in making more informed decisions about patient care, avoid duplicative tests and treatments and improve patient outcomes.[22]

4 PAIN POINT: Tissue biopsy, the gold standard for cancer molecular testing, is invasive, inappropriate for early detection, can examine only one tissue at a time and usually cannot reflect the mutational landscape of the whole body.[23]

SOLUTION: Clinical innovation

Liquid biopsy

Circulating tumor DNA (ctDNA) can be measured with highly sensitive laboratory equipment to diagnose lung cancer with blood tests. It helps in early diagnosis and detection, prognosis prediction, detecting mutations and structural alterations, minimal residual disease, tumor mutational burden, and tumor evolution tracking, allows real-time monitoring, has relatively high sensitivity and specificity and is minimally invasive when compared to surgical biopsy.[24,25]

5 PAIN POINT: If CT is unclear or in case of metastasis, PET/CT may be required. PET/CT scanning with a small field of view for a dynamic measurement does not allow the clinicians to dynamically follow tracer kinetics through the body.

SOLUTION: Clinical innovation

Advanced dynamic PET/CT[c]

With 106 cm axial PET field of view, it offers a whole-body (vertex to thighs) perspective so the clinician can scan more in one position to dynamically follow tracer kinetics throughout the body.[26,27]

4 TREATMENT

Scenario: In the oncology conference room

STAKEHOLDERS

Patient – Begins a multimodal treatment depending on the cancer stage.

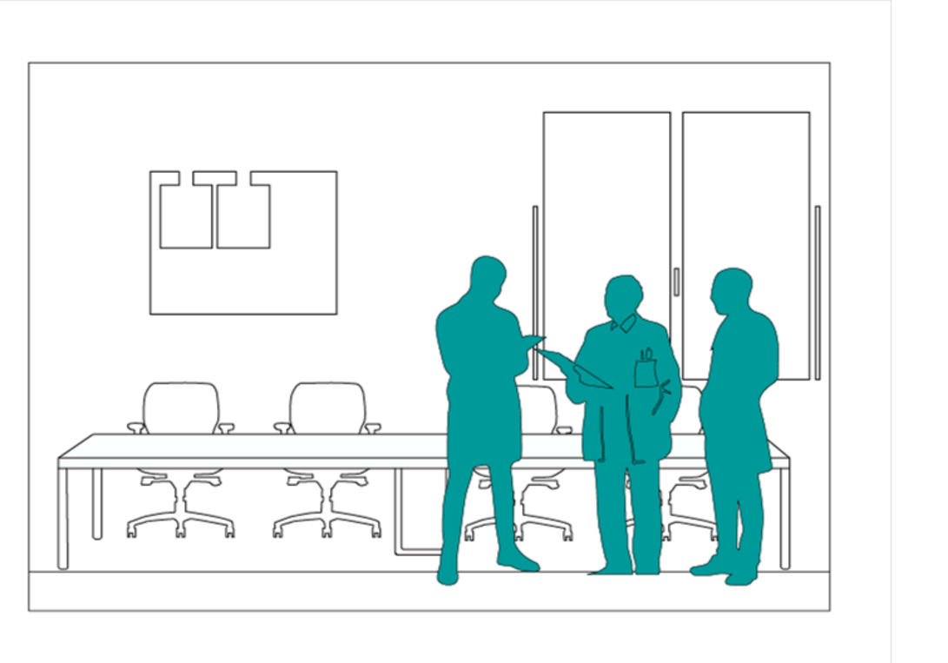
Radiation oncologist – Plans radiation therapy and monitors the treatment progress.

Thoracic surgeon – Performs surgery to remove cancerous tissue in the lung.

Interventional radiologist – Performs interventional procedures like ablation.

Medical oncologist – Prescribes chemotherapy, targeted therapy, immunotherapy or other supportive care and monitors the treatment progress.

Medical device companies – Create innovative tech solutions to help treat the patient effectively.



In a tumor board review, doctors from different disciplines come together to find the best multidisciplinary therapy for the patient.

1 PAIN POINT: Time lag between diagnosis and therapy leads to upstaging and lowers survival chance.

SOLUTION: Process innovation

One-Stop Clinics

In these clinics, patients are seen by multiple specialists on the same day and multiple investigations are organized, enabling rapid diagnosis and multi-disciplinary treatment decisions.[16]

2 PAIN POINT: Defining an optimal therapy mix and sequence for a patient can be challenging as it depends upon type and stage of cancer and patient-related factors like age, comorbidities, performance status, insurance, patient's preference, etc.

SOLUTION: Digitalization

AI based optimal therapy design

Based on registries and outcome-focused treatment databases, artificial intelligence algorithms can suggest an optimal treatment combination and sequence by an assessment of the treatment methods and outcomes of similar patients. These optimal therapy combinations can help to maximize survival e.g., ablation plus immunotherapy.[28,29]

3 PAIN POINT: Without proper imaging modalities during surgical treatment, minimally invasive surgeries are much more difficult to perform.[30]

SOLUTION: Automation

Intelligent surgery system[d]

An imaging device with procedural intelligence can aid the physician to standardize and speed up the process while enhancing precision and patient safety throughout the workflow steps such as image acquisition, planning, localization and resection for optimal patient outcomes.[31]

4 PAIN POINT: Planning of radiation therapy can be difficult and time consuming due to breathing irregularities, prolonged scanning procedure or complex manual contouring of organs at risk.

SOLUTION: Clinical innovation

Advanced RT planning system[e, f]

Improving the 4D CT image quality in case of breathing irregularities by adapting to the patient's breathing pattern in real time can minimize artefacts, and AI-assisted Autocontouring of Organs can enable streamlined organs at risk contouring and result in time saving and reducing unwarranted variations with high-quality contours.[32]

5 PAIN POINT: During radiotherapy planning, clinicians might find it difficult to target the tumor volume precisely and track volume changes in every session; inaccurate planning can result in suboptimal clinical outcome.

SOLUTION: Clinical innovation

AI driven adaptive RT planning[g]

With this adaptive technology, the physician in charge can evaluate changes in anatomical structures at each session which helps in precisely adapting the therapy settings such as the volume to be targeted and the amount of applied radiation, enabling a patient-centric and personalized approach - from initial planning to on-couch adaptation and treatment monitoring.[33,34]

6 PAIN POINT: The individuality of every lung cancer case makes adaption of the right radiotherapy technique and highly precise dosage control challenging.

SOLUTION: Clinical innovation

High precision cancer treatment[h]

One product that combines high-precision dosage control with sub-millimeter accuracy, enhanced soft-tissue visualization and motion management, advanced imaging and treatment options like volumetric-modulated arc therapy, stereotactic body radiation therapy or intensity-modulated radiation therapy for a broad range of patients, can aid in provision of intuitive, innovative and integrated care.[35,36]

7 PAIN POINT: Cancer treatment with radiation therapy is often time consuming and needs many appointments.

SOLUTION: Clinical innovation

Flash therapy

Prospectively, Flash therapy, an experimental treatment modality delivering radiation therapy, could enable the physicians to apply ultra-high doses within a few seconds in 1 to 3 appointments which could make multiple appointments over many weeks expendable.[37,38]

8 PAIN POINT: Even in the early stages of lung cancer, some patients might not be eligible for surgery and radiotherapy.

SOLUTION: Clinical innovation

Thermal ablation

It offers treatment of medically inoperable early-stage lung cancer, is a relatively cheap therapy, and can be repeated. Moreover, ablation can be used to support immunotherapy.[39]

5 REHABILITATION

Scenario: At the rehabilitation center

STAKEHOLDERS

Patient – Receives rehabilitation services from providers.

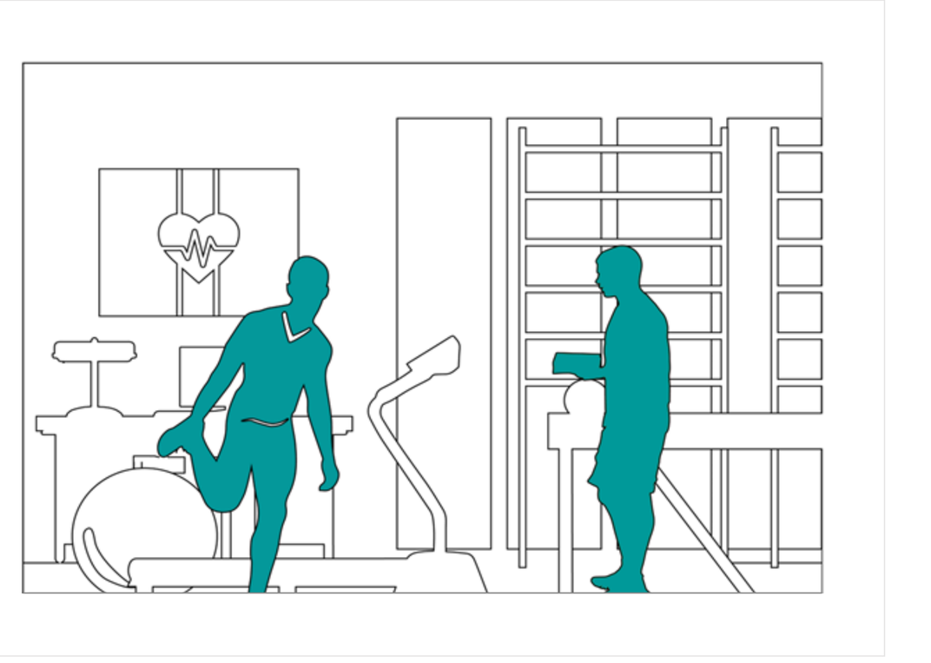
Family – Supports and encourages patient to follow the rehabilitation plan.

Rehabilitation therapist – Helps the patient to recover by providing personalized rehabilitation therapy.

Pulmonologist – Monitors the effectiveness of treatment and rehabilitation.

Medical device companies – Create innovative tech solutions that help patients to recover.

Nutritionist – Provides a healthy diet plan for the patient.



Patient undergoes rehabilitation to regain strength and endurance.

1 PAIN POINT: Treating lung cancer with radiation therapy or resection of the tumor may have consequences on the ability to breath properly.

SOLUTION: Process innovation

Pulmonary rehabilitation

Patients can benefit from pulmonary rehabilitation. It involves resistance and breathing exercises which help to improve breathing technique, relieve breathlessness, and improve endurance, essential for re-integrating them into former jobs.[40]

2 PAIN POINT: Even after extensive tumor therapy (e.g., surgery), patients can still be left with severe pain that might not entirely respond to common pain treatments.[41]

SOLUTION: Digitalization

VR for pain relief

Non-pharmacological adjuncts like VR have become an important option for effective pain management. Patient immersion in interactive virtual reality provides distraction from painful stimuli and can decrease an individual's perception of pain.[42,43]

SOLUTION: Process innovation

Music therapy

Music therapy in combination with appropriate analgesics can help to significantly lower the pain score in patients after lung cancer surgery.[44,45]

3 PAIN POINT: Sarcopenia and malnutrition are common in patients with lung cancer. This can influence the overall outcome negatively.[46]

SOLUTION: Process innovation

Optimized cancer nutrition

Cancer patients have an increased need of energy intake and especially protein intake to counter inflammation-induced sarcopenia. A balanced and special diet for lung cancer patients can have positive influence on the overall prognosis.[46]

SOLUTION: Process innovation

Sports therapy

Exercising regularly can help to maintain the functional respiratory volume in patients suffering from lung cancer and also regain lost muscle mass.[46]

4 PAIN POINT: Lung cancer patients often suffer from anxiety, depression and massive distress. Worldwide, receiving mental health help is often difficult within a reasonable time frame.

SOLUTION: Digitalization

Psychosocial rehabilitation

Social group psychotherapy can have a positive influence on the overall well-being and the clinical outcome. Digital formats can enable patients around the world to participate in social group psychotherapies if they don't have access otherwise.[47,48]

5 PAIN POINT: Patients may not take part in pulmonary rehabilitation due to lack of knowledge, perceived benefits, physical obstacles of patients and infrastructural difficulties.[49]

SOLUTION: Digitalization

Virtual rehabilitation

In regions with lack of trained pulmonary rehabilitation experts, remote options can enable patients to receive education and exercise training to improve health status. Additionally, a remote patient monitoring system connected with smart devices can enable the rehabilitation therapist to have real-time access to patient data.[50]

6 PAIN POINT: Patients might not be motivated enough to undergo rehabilitation.

SOLUTION: Process innovation

Gamified rehabilitation

Gamification can help motivate the patients by making the exercises more interactive and personalized.[51]

6 FOLLOW-UP

Scenario: At the hospital, in the doctor's room

STAKEHOLDERS

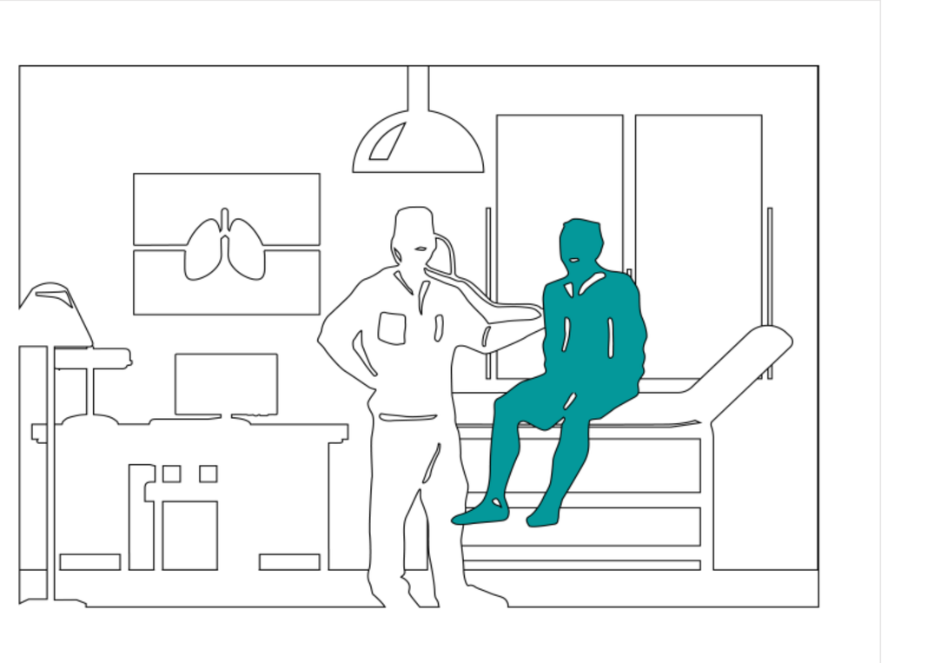
Patient – Patient is motivated to return to normal life and go for check-ups regularly.

Family – Helps and supports the patient adjust to the new life.

Pulmonologist – Monitors the patient's overall health and has an eye on potential relapse of the cancer.

Oncologist – Tracks cancer progression and continues to devise treatment plans.

Radiologist – Evaluates images (CT, MRI, etc.) in order to detect possible recurrences.



The patient goes for frequent check-ups after treatment for assessment of overall health and disease status, treatment side effects, and identification of signs of relapse.

1 PAIN POINT: Many lung cancer patients do not have access to a multidisciplinary care team.

SOLUTION: Digitalization

Online communication platforms

Communication platforms for experts of various specialties can help to provide more patients the best care with access to a multidisciplinary care team for integrated supportive care, even if some specialists are not physically present, for example in remote areas.

2 PAIN POINT: The overall outcome can be worse if patients don't feel integrated in the whole pathway.

SOLUTION: Digitalization

eHealth Patient Portal[i]

This allows patients to participate in the pathway, interact with their physicians and better communicate with their therapists, if they have access to all their health records and the latest medical information anytime and anywhere, enabling empowered, continuous and connected care to achieve better health outcomes.[52]

3 PAIN POINT: Not being able to discuss problems or adverse events during the intervals between follow-up schedules can negatively impact the patient.

SOLUTION: Digitalization

Electronic patient reported outcomes tool[j]

Patient outcomes management software such as Noona engage patients in their care with real time symptom reporting and monitoring, streamlined clinical workflows to promote evidence-based care, and access to rich data insights for better management and ongoing assessment over the course of care.[53]

4 PAIN POINT: Lung cancer survivors often experience poor cardiorespiratory fitness, malnutrition or sleep issues.[54]

SOLUTION: Sensing

Wearable biosensors

Wearables enable patients to monitor their vital values or sleep data in real time and adjust their physical activity level and nutritional intake appropriately.[55]

5 PAIN POINT: Fear of relapse is common in cancer patients, which can cause long-lasting traumatic disorders. Additionally, no social contacts understanding what the patients went through, can be exhausting.

SOLUTION: Process innovation & Digitalization

Lung cancer support groups

Patients can join the lung cancer patient community to share the concern, fear and information about recovering from the disease, which can help them cope physically, emotionally and mentally. A 24/7 helpline service that connects to a lung cancer expert and other healthcare professionals can be made available as often as needed, at no cost.[56]

SOLUTION: Digitalization

Cancer regrowth predicting tool

Based on certain prognostic factors like patient's age, gender, BMI, smoking status, the intensity of radiotherapy, and their tumor characteristics, AI can help in predicting the probability of recurring cancer in patients who already underwent the complete treatment pathway.[57]

Solution categories

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

[a]AI-Rad Companion (SHS): Several devices are planned and under development, not commercially available in all countries, and their future availability cannot be ensured.
[b]Digital Pathology and Syngo Carbon (SHS): Syngo Carbon consists of several products which are (medical) devices in their own right. Some under development and not commercially available. Future availability cannot be ensured. Siemens Healthineers is not the legal manufacturer of Concentriq® Dx. Any claims made for the product are under the sole responsibility of the legal manufacturer. Concentriq® Dx may not be commercially available in all countries.
[c]Biograph Vision Quadra (SHS) is not commercially available in all countries. Due to regulatory reasons, its future availability cannot be guaranteed.
[d]iVATS in the Hybrid OR (SHS): Some/all of the features and products described herein may not be available in the United States or other countries.
[e]SOMATOM go.Open Pro (SHS) is not commercially available in all countries. Its future availability cannot be guaranteed.
[f]RT Image Suite (SHS) is not commercially available in all countries. Its future availability cannot be guaranteed.
[g,h]Ethos & TrueBeam (Varian): Varian Medical Systems as a medical device manufacturer cannot and does not recommend specific treatment approaches. Specifications subject to change without notice. Not all features or products are available in all markets and are subject to change.
[h]TrueBeam (Varian): Product features described here relate to TrueBeam version 3.0.
[i]eHealth Solutions (SHS) consist of several products of ITH icoserve technology for healthcare GmbH – A Siemens Healthineers Company, Innsbruck, Austria. Products of eHealth Solutions are not intended for diagnostic purposes. The product offerings are not commercially available in all countries.
[j]Noona (Varian): Specifications and prerequisites are subject to change without notice. Noona is not available in all markets.

Website:
https://www.siemens-healthineers.com/innovation-think-tank

Sources:
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