Context and background of the survey

The objective of this survey was to assess the feasibility of a potential new Chalmers area of advance focused on global health challenges. The first part of the survey consisted of a short online questionnaire, targeting all Chalmers faculty members and other permanently employed research/teaching staff, and the second part consisted of in-depth interviews with key faculty members (suggested by their respective prefects).

Results from the online survey

We asked our colleagues about the health-related challenges they work with, their expectations from the new area of advance, and their preference for its name. A total of 207 Chalmers employees gave a positive reply to the survey, expressing their interest to participate in the new area of advance (raw data in the Appendix 1).

Figure 1. Participation (in % of total replies) of Chalmers employees from different departments in the online survey. 12 Chalmers research departments expressed interest, with quite even distribution.

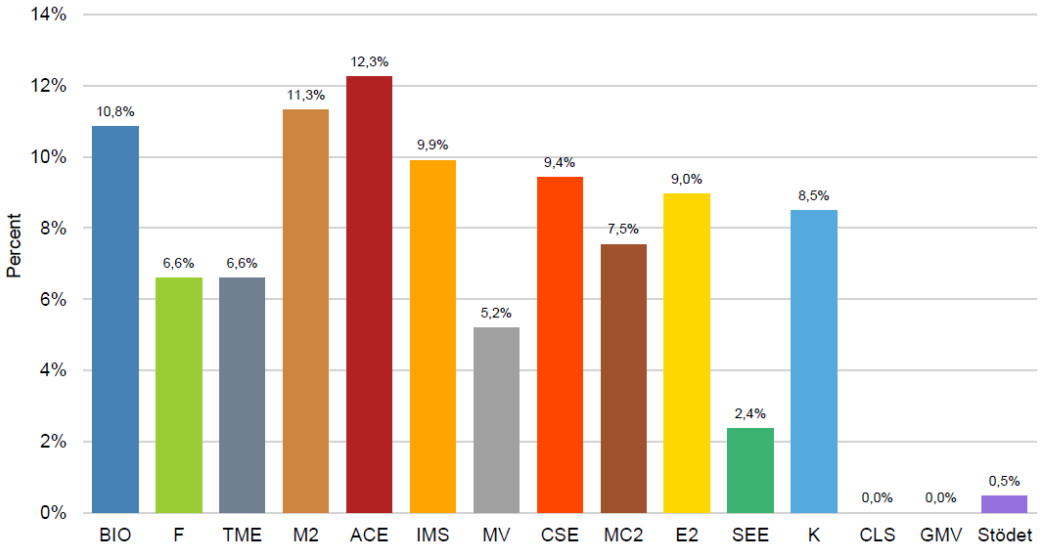

Figure 2. Types of appointments of Chalmers employees who replied to the survey.

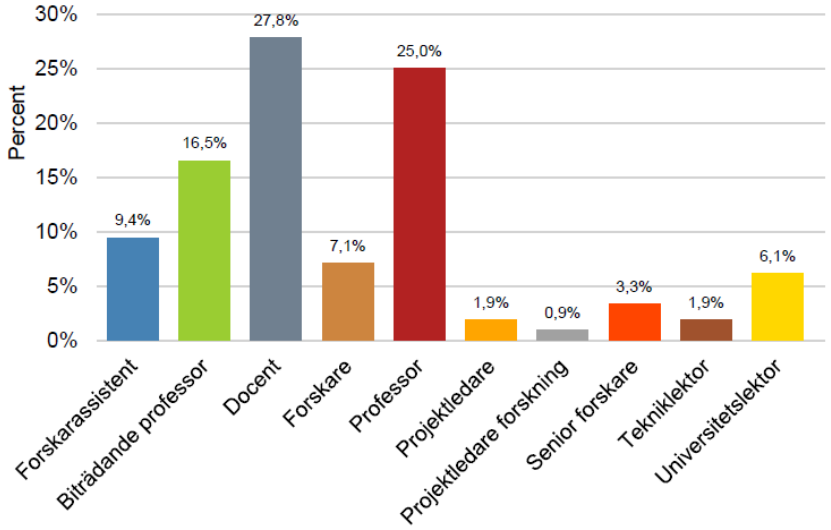

Figure 3. Expectations of Chalmers employees from the future area of advance, i.e. what activities they would like to be involved in.

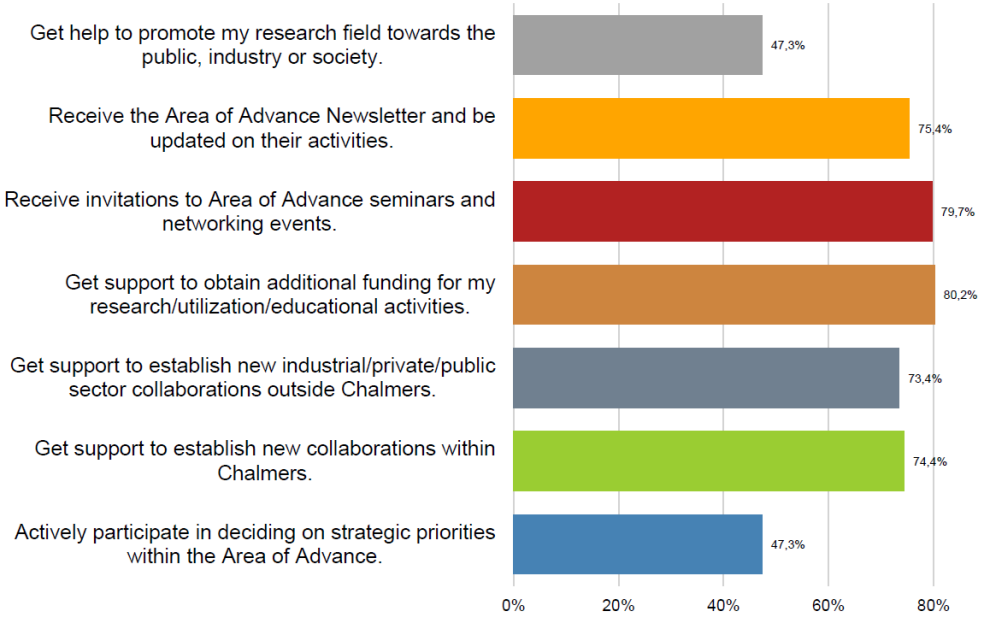

Figure 4. Overview of health-related challenges that Chalmers employees work with (and with to work with in the future) in the form of a word cloud. Font size is related to how many Chalmers employees mentioned a particular challenge in the survey.

Regarding the name of the future area of advance, the top suggestion was “Health Engineering” with 47 votes, followed by “Health” 19 votes, and “Engineering (for) Health, 18 votes. Most suggestions included the word “health”, and some other concepts that appeared frequently are “life science”, “science” and “technology”.

Results from in-depth interviews

A second phase of the survey was conducted as in-depth interviews with selected faculty members. All Chalmers prefects were asked to suggest key personnel from their departments involved in health-related activities these interviews. List of over 100 faculty members invited to these interviews is in Appendix 2. During the in-depth interviews, key health-related challenges that our researchers work with and wish to work with in the future were identified, as well as their collaboration landscape, and their opinions on how the new area of advance could assist them in reaching their objectives. What emerged from this interviews is that researchers from several different departments converge on some common challenges – which are largely in line with the word cloud analysis of challenges presented in Figure 4. Taking into account the outcome of the in-depth interviews and the online survey, we describe the main challenge-driven clusters below.

Challenge cluster: Digitalization, Big Data & Artificial Intelligence

Health- and healthcare-related emerging technologies and procedures generate and depend on large amounts of data. These datasets are very variable in type and size, they range from health monitoring devices, patient-generated data such as nutritional factors or follow-up on responses to treatments, data on patient flow and administration in hospitals, various types of diagnostics, ranging from personal biosensors to clinical imaging techniques, multi-omics datasets from clinical studies (genomics, and metagenomics, transcriptomics, proteomics, metabolomics), environmental surveys on air and water quality, etc. A major emerging challenge is to collect, compile, protect (data security and privacy) and analyze such data, and extract from it new knowledge to improve healthcare practices, prevention, personalized medicine, access of patients to advice or treatment, enable better patient stratification in hospitals and help with creating healthier lifestyles adapted to individual needs. Traditional statistical analysis is insufficient when it comes to analyzing these large and complex datasets. Chalmers holds some key competences across different departments (CSE, BIO, MV, M2, E2, SEE, ACE, TME) in machine learning/artificial intelligence and bioinformatics that can offer customized solutions to these challenges. The key external stakeholders that can be assisted by our engineering approaches are hospitals and other healthcare stakeholders (more efficient management of wards, more powerful and personalized diagnostics, facilitating data retrieval and analysis and making it user-friendly to clinicians), private sector stakeholders (patient feedback to facilitate development of new drugs and treatments), regional/governmental agencies that handle health and healthcare (enhanced overview of emerging trends and developments, data analysis for strategic planning) and finally patients themselves, who will have more direct access to their health-related data and healthcare records, enhanced contacts with care-givers, and will effectively be put in the “driver’s seat” when it comes to managing their own health. These digitalized solutions have to be adapted for empowering the increasingly aging population. Through digitalization, healthcare will become more personalized, from both the care-provider’s and patient’s perspective and Chalmers aspires to be a key technology driver in this process.

Challenge cluster: Infections, Antibiotics & Drug Delivery

One of the world-wide emerging challenges is the spread of infectious disease that can no longer be curbed with the existing antibiotic treatments. Development of resistance to existing antibiotics is aggravated by inappropriate use and non-optimal administration practices. While some regions of the world are currently more heavily affected than others, this is ultimately a global problem that cannot be contained locally. Effectiveness of drugs that are used to curb infections or treat chronic disease depends crucially on efficient

drug delivery systems. Here the main objective is to control the exact location in the body where the drug will be delivered and the rate at which a drug is released. At Chalmers, we are developing a broad front of new technologies that address these global challenges, present at different departments (primarily BIO, K, F, MV, MC2, IMS, M2). Regarding antibiotics and infections, there are three main lines of progress being developed at Chalmers. New technologies for rapid, precise and simple detection of bacterial infections will enhance diagnostics but also promote epidemiological studies on the spread of antibiotic resistance. Identification of new "drugable" targets in infectious bacteria and development of synthetic drugs holds promise of new families of "smarter" antibiotics, with a reduced risk of resistance. Finally, we are preparing for a post-antibiotic era by developing new materials with antibacterial properties. These efforts are aimed at providing antiseptic tools and environments for surgical treatments and nano-devices that can be safe for humans but specifically directed to kill bacteria using physical factors, replacing the chemical action of antibiotics. The key external partners for implementing our engineering approaches are hospitals and other healthcare stakeholders (testing of new diagnostic tools, sensors and antibacterial materials in the clinical setup) and the private sector stakeholders (pharma companies for joint exploration of new antibacterial drugs and healthcare provider companies for implementation of antibacterial materials, nano-devices and sensors of bacterial contamination). The main push at Chalmers regarding drug delivery involves new approaches for a directed and optimized cellular uptake, improving drug efficiency, and design of new materials for the delivery carrier systems that are optimized to gain spatiotemporal control of drug release. By tuning the permeability of the capsule material, drug release can be controlled to occur at a slow and steady rate, which is beneficial for patients with chronic disease. The drug carrier system can also be designed for release upon activation and this allows for fast and local drug delivery, which reduces potential systemic side effects. These new technologies are developed in partnership with other research institutes and pharma companies. With a broad range of innovative technologies, Chalmers aspires to make a key contribution to solving the global challenges related to infectious and chronic disease.

Challenge cluster: Prevention, Lifestyle & Ergonomics

Promoting heathy and safe lifestyles, devising safe procedures and building environments that support such lifestyles is the single most efficient way to ensure health and well-being of the human population. Chalmers has a very broad platform of expertise to contribute in many of those areas – where solutions often come from multi-disciplinary approaches. Our driving expertise in this area is spread across different departments, mainly at ACE, M2, IMS, BIO, E2, F. Chalmers is leading strong initiatives on building healthy and safe cities, including integrative ways of residing (adaptable for the needs of the aging population), safe and ergonomic workplace environments and procedures and safe and non-polluting transport solutions. A particular emphasis is placed on future health centers, where patients and care-providers will meet in dialogue-promoting conditions, empowering the patients to take a more active role in prevention and transfer some of the medical treatments to their homes. Chalmers also has very strong activities in curbing environmental pollution, with emphasis on clean air and water. We engineer materials and sensors intended for injury prevention, detection and rehabilitation. We also have top expertise in nutrition, where our researchers investigate the impact of diet on health and devise dietary strategies to prevent lifestyle-related diseases. A particularly relevant interdisciplinary challenge in this area is the future of interactions of humans with automation, both at home and the workplace. External partners and stakeholders for these activities are many and are varied. We collaborate with various regional/governmental agencies that handle the urban development, military, environment and healthcare. We also have a broad interaction interface with the

industries, including the automotive, maritime, sports equipment, biomass combustion, food, pharmaceutical, and construction. Chalmers is very active in this field both from the angle of providing specific engineering solutions and from the perspective of planning and implementing large-scale integrative interdisciplinary solutions.

Challenge cluster: Sensors & Diagnostics

Sensor technologies and diagnostic assays serve for clinicians to monitor and diagnose patient health conditions and play a central role in medicine. A crucial component in healthcare for optimal treatment and prevention is to detect disease at an early stage. Fast read-out technical solutions to detect the disease are the key for this. The development of new analytical tools that can provide fast and reliable read-out are used in guidance for medical treatment and clinical management decisions as well as in medical research to gain a better understanding of the cause of disease and a treatment strategy. In addition, engineering solutions for easy-to-use technology become more important to patients for self-diagnostics and care at home. Chalmers expertise within this field are mainly focused to the Department of E2, MC2, MV, K, F, and B, and span all from the development of new methodologies that find broad range of application for diagnostics to the design of new technologies aimed for direct implementation in clinical use. Here new detection schemes for biomarkers, pathogens, cancers, caries in dental care, neuropathies and genetic analysis can play an important role in the advancement of better diagnostic tests for a better healthcare. Some of the new technologies for direct clinical use where we have particular strengths involve new magnetic imaging based methods for monitoring brain activity and microwave technologies as pre-hospital diagnostic methods for assessment of triaging of trauma, stroke and sepsis patients, and for detection of internal bleeding, breast cancer imaging, bone imaging etc. The research and innovation at Chalmers in this area attract clinicians, academic partners as well as diagnostics and medtech companies to interact and contribute with the development of engineering solutions to many of the current healthcare challenges.

Challenge cluster: Clinical procedures, Surgery and Implants

Novel engineering solutions developed at Chalmers within this area are continuously translated into clinical practice for treatment of disease and improved healthcare. A key to the success for researchers at Chalmers within this area has been to work in close collaboration with physicians, with the mission to solve a wide variety of clinical problems. These activities mainly involve the Department of MC2, F, MV, CSE, IMS and E2. The activities involve everything from clinical research to providing engineering medtech solutions that directly assist the clinical work and include for instance new devices for brain imaging, tissue engineering solutions for clinical applications, new techniques for surgery and a multitude of different new type of implants. Chalmers has a very broad technology platform for engineering solutions for implants, spanning from the material/surface property design to tailoring implants to the needs of individual patients. New aspects in material design include doping the surfaces with drugs and fabricating the materials with in-built sensors. Development of implants for clinical needs involves engineering solutions directed to patients with disabilities such as hearing and balance. This is being addressed for instance by the design of bone conduction hearing devices. At Chalmers, highly integrated bionic limbs are being designed and fabricated to assist patients with motor disabilities. Groundbreaking work on mind-controlled implant prosthetics with treatment solutions for neurorehabilitation after motor impairment and neuropathic pain is built on using bioelectric signal acquisition and processing, machine learning, and virtual/augmented reality. Important research for children's healthcare involves development of monitoring devices to assist clinicians in quality assured ventilation of newborn infants in need of breathing support and new methods for battling deep-seated tumors based on hyperthermia. In close collaboration with physicians, Chalmers will continue to develop and integrate innovative engineering solutions to the clinical practice.

Challenge cluster: Health Care Management

An affordable and accessible high quality health care system is of great priority in a functional and healthy society. To provide this service to the society, a high level of competence in healthcare management is required. The new strategic documents set by the regional council indicate that healthcare management skills in the near future will be of great importance for assessing and driving towards the major goals in the sector: to provide for a closer proximity of care for the patients, a concentration of healthcare expertise and accessibility, digitalized forms of care and services and quality-driven healthcare business development. There are many aspects to be addressed in this societal shift of healthcare from hospitals to homes, such as who will be able to take responsibility of the collective knowledge within healthcare, how should norms and standards be developed for physical space of future care in homes and care in specialty clinics. There are also challenges to address considering healthcare in the postantibiotic era. For a well-functioning healthcare system, the organization and production involving flow of people through the system needs to relate to many different kinds of value parameters that ensure a good working environment. Healthcare accessibility is weighed against queue times at healthcare centers, and empowerment of patients is the main driver in this area: support of patients in home care using various apps, technical solutions to help patients to perform high quality home care while reducing the need for time spent with medical doctors. A shift in the field that is also addressed from the management perspective is to start viewing the patient as not only a client, but also a resource in the healthcare system. The patients provide great healthcare value e.g. as shown by improving cancer treatment where patients can function as support persons to one another. Hence for healthcare to function optimally, its design and management as a business is key. A high level of expertise in design and management of health care, including architectural design of healthcare physical spaces, is concentrated at Chalmers within the Departments of ACE, TME and E2. These researchers work in close collaborations with health care providers in the region, and regional/government agencies in charge of healthcare development.

Concluding remarks

This survey points to a strong interest of over 200 Chalmers researchers to work with global health challenges, and highlights our strengths and potential in several key areas. It also highlights our commitment to very closely collaborate with the regional and national stakeholders in the arena of health. These key stakeholders, such as hospitals, the VGR and industrial partners, should be involved in further profiling of this Chalmers area of advance, to achieve full complementarity and synergy of our activities. The new area of advance should be built as a strong and inclusive interdisciplinary and intersectorial platform for strengthening ongoing collaborations and promoting new integrative solutions for healthcare, where Chalmers expertise can be an important driver.