

The background is a vibrant collage of images related to research and innovation. It includes a central circular graphic with various icons: a stethoscope, a DNA helix, a rocket, a group of people, a laptop, a graduation cap, a magnifying glass over a person, a flask, and a person running. Surrounding this are circular insets showing people in various settings: two people standing against a green wall, a person working on a laptop, a person in a lab coat, and a person in a hard hat. The overall color scheme is light blue and white, with accents of orange, green, and purple.

**Research
Development
Office**

Research funding & External relations services

RESEARCH & INNOVATION FUNDING STRATEGY

Challenge Health and Medical Sciences

Erasmus MC
Universitair Medisch Centrum Rotterdam



STRATEGIC RESEARCH FUNDING AREAS TOWARDS CREATING RESEARCH AND INNOVATION HUBS



As an academic hospital, Erasmus MC is committed both to achieving a healthy population and to pursuing excellence in healthcare through research and teaching. To this end, we combine fundamental, translational, and clinical research with patient care and a range of teaching activities.

But how do we solve the major challenges we are facing? Accessibility and affordability of health and care? The rise in non-communicable diseases and mental illness? The spread of antimicrobial drug resistance and infectious disease threats?

Erasmus MC is committed to understanding health and disease in order to better predict who might fall ill and to prevent people from actually falling ill. But when people do fall ill, Erasmus MC wants to provide state of the art, precision medicine: deliver the right care at the right time to the right patient.

We believe that convergence for health and healthcare will lead to profound changes in traditional solutions in healthcare. We aim to change how we organize healthcare, from a reactive to a proactive approach. We need to develop novel and innovative solutions to promote overall health from the earliest moment in life, prevent or delay disease, and facilitate early detection of disease. In addition, we need target innovations that will improve disease diagnosis, prognosis, and treatment selection, leading to more effective and less invasive treatment.

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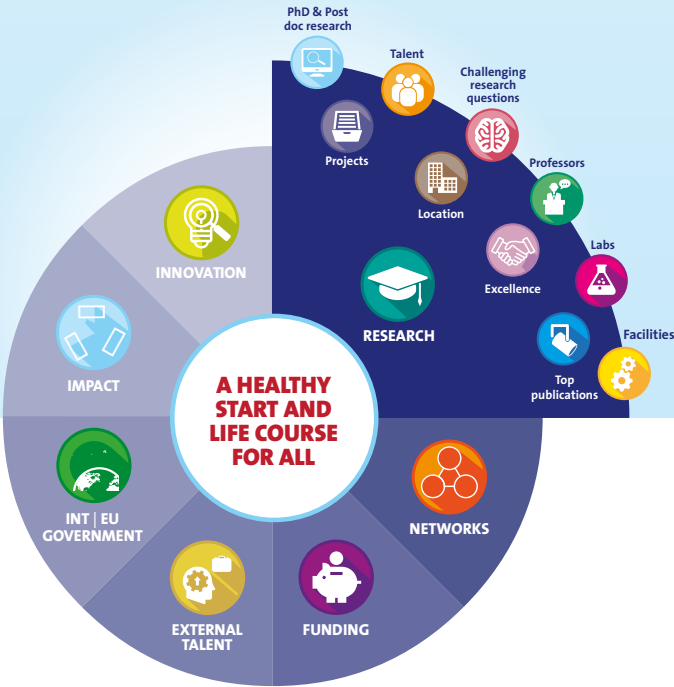
MAKE IT HAPPEN

To realize this, we need transdisciplinary collaborations, convergence between different fields and where better to start than with ourselves? Therefore, Erasmus MC has organized its research funding strategy into four transdisciplinary hubs from which we reach out into the world:

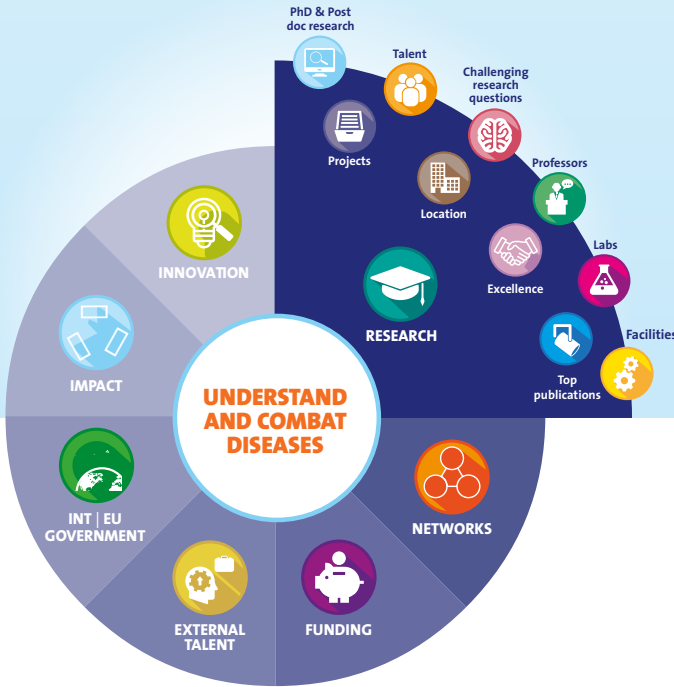
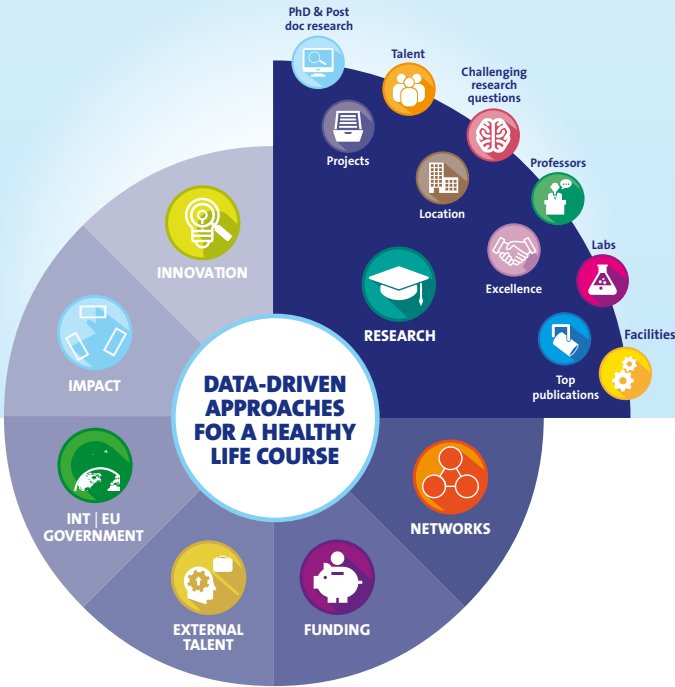
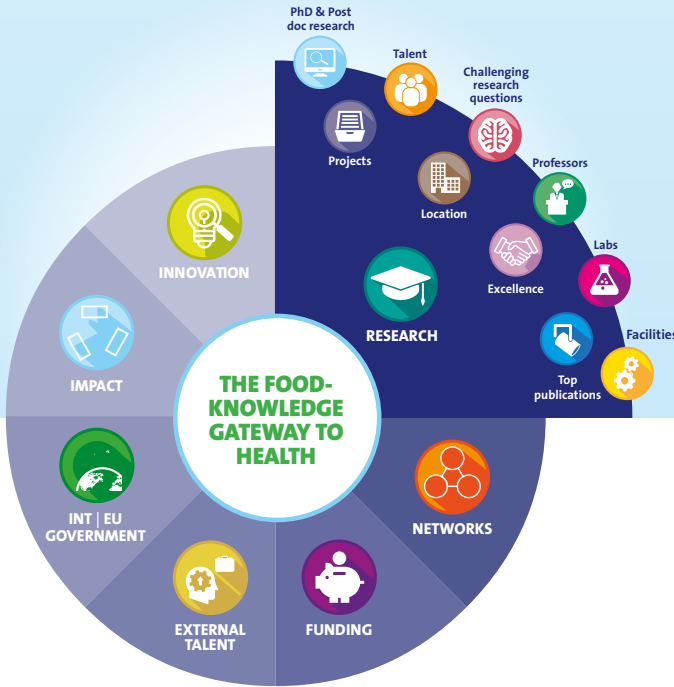
- A HEALTHY START AND LIFE COURSE FOR ALL
- THE FOOD-KNOWLEDGE GATEWAY TO HEALTH
- DATA-DRIVEN APPROACHES FOR A HEALTHY LIFE COURSE
- UNDERSTAND AND COMBAT DISEASES

To ensure sustainable healthy lives and promote well-being for all at all ages for current and next generations, aligned to the UN's Sustainable Development Goal 3 for 2030 there is a need to transform traditional health care into holistic integrative healthcare using a life course approach already starting at the preconception status continuing until death occurs. Ultimately, we are moving our focus from disease to health and from health to a healthy life course for all!

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A HEALTHY START AND LIFE COURSE FOR ALL



7

GRAND CHALLENGE

CITIZEN HEALTH AND WELLBEING

MISSION

A HEALTHY START AND LIFE COURSE FOR ALL

Evidence-based and context-driven child and parent care for all European citizens starting in Rotterdam by 2030

AREAS OF INTEREST & CROSS-SECTOR

Medical & Public Health Sector

Social Sector

Services Sector

Local & National Governments

Tech Sector

Consumer Sector

Food Sector

Behavioral Sector

R&I PROJECTS

Personalized context-driven approaches for a healthy pregnancy and childhood

Digital nutrition and lifestyle support tools for a healthy pregnancy and childhood

Translation into socio-economic standards & caregiving and welfare approaches

Better understanding of the impact of external factors on early child development before and after birth

Network medicine to understand the origin of diseases early in life

1 Bold, inspirational with wide societal relevance

Based on years of research, we know that health and risk of disease during life is also determined by the health status of the parents before conception, healthy intra-uterine growth and development, and health of the children during infancy and school-age years¹. Now that the rise in life expectancy for European citizens is slowing down and about 20% of their life course is associated with illness², early life offers a great window of opportunity to strengthen the foundation for a healthy life course for new generations and their parents. This requires focusing research and innovation (R&I) on the health of people rather than on diseases only.

There is a substantial body of evidence showing that nutrition, lifestyle and the use of medicine, alcohol, hard and soft drugs and tobacco by the parents before, during and after pregnancy has a serious impact on the physical and mental health of their child, not only at the start of life but during the entire life course. Other risk factors that negatively impact the development of a child before and after birth include socioeconomic status, parental health and early-life exposure to stress, physiological distress, and environmental health threats such as air pollution, climate change and endocrine disruptors. Interventions targeting these risk factors can prevent an unhealthy start and the associated development of diseases later in life for the new-born, while in parallel contributing to a better health of the mother and father.

Diseases known to be associated with health problems in the offspring of affected individuals, or even known to prevent a patient to become a parent, need special attention. In this context, the increasing parental age of first pregnancy and male infertility poses a growing challenge for Europe.

While the importance of parental health for the health of a new-born is widely acknowledged^{3,4,5}, many families in the EU are still devoid of effective prenatal, perinatal and child care^{6,7}. This current situation is further complicated by significant disparities in a healthy life and access to healthcare that are related to socioeconomic status.

2 A clear direction: targeted, measurable and time-bound

The challenges outlined above ask for evidence-based and precision, context-driven solutions. A network medicine approach considering genetic, biological, clinical, (psycho)social and environmental networks in parallel will enable the identification and understanding of the interaction of external factors with the development of health and disease at the start of life. This new knowledge will provide evidence that can be translated into interventions. By taking the context of the individual citizen into consideration, these interventions can be personalised and targeted towards specific challenges and needs. Rotterdam will serve as a front-runner region for Europe in studying the importance of a healthy start and developing and implementing evidence-based and context-driven interventions.

¹ <https://dohadsoc.org/wp-content/uploads/2015/11/DOHaD-Society-Manifesto-Nov-17-2015.pdf>

² OECD/EU (2018), Health at a Glance: Europe 2018: State of Health in the EU Cycle, OECD Publishing, Paris https://doi.org/10.1787/health_glance_eur-2018-en

³ Global Consultation on Child and Adolescent Health and Development. A healthy start in life. Geneva: World Health Organization; 2002

⁴ Stephenson J, et al. Before the beginning: nutrition and lifestyle in the preconception period and its importance for future health. Lancet. 2018;391:1830-1841

⁵ Fleming TP, et al. Origins of lifetime health around the time of conception: causes and consequences. Lancet 2018;391:1842-1852

⁶ <https://www.womenpoliticalleaders.org/moving-forward-maternal-health-europe/>

⁷ Barker M, et al. Intervention strategies to improve nutrition and health behaviours before conception. Lancet 2018;391:1853-1864

This city faces significant challenges having deprived areas that deal with a high prevalence of risk factors for an unhealthy start of life and associated high rates of perinatal morbidity and mortality⁸. The target of the Hub mission is that the majority of babies born in Rotterdam are provided with a healthy start through evidence-based preconception, perinatal and early childhood care by 2030, with the ultimate aim to improve health during the entire life course for the next generation of Rotterdam citizens by 2050. The Rotterdam best practices can be shared and adapted to local requirements throughout Europe, in this way enabling a healthy start for the next generations of European citizens.

3 Ambitious but realistic research & innovation actions

To reach the mission targets and provide a healthy start in life for all, research and innovation addressing the full knowledge chain is necessary. Insights from fundamental research on the impact of early life stressors on the development of life to more translational or clinical insights on how early life stressors undermine the physiological systems⁹, as well as better insights on effective implementation, and facilitation of integrated measures for poverty reduction, behavioural change and effective policy are essential. Translating knowledge-based insights into policy in a joint and integrated effort with local and national governing bodies is essential to reach the mission targets.

4 Cross-disciplinary, cross-sector and cross-actor innovation

Family life, pregnancy and birth are at the basis of society. This mission therefore asks for effective multi- and interdisciplinary approaches. It requires bringing together biomedical, clinical, epidemiological and social scientists, biomedical engineers, healthcare professionals, social caregivers, technology professionals including ICT, citizens, industry and national and local governments. They will need to work together across sectors including biomedical & life sciences, behavioural economics, sociology, consumer goods, media and so on. Population- and hospital-based cohorts with data and biomaterials will be at the core of cross-disciplinary research involving Artificial Intelligence as a key enabling technology.

5 Promote multiple, bottom-up solutions

The fact that a healthy start in life for all is truly at the centre of society makes that this mission can only be addressed by considering multiple elements simultaneously that each have their specific contribution and reinforce each other. Basic and translational research will result in innovation followed by implementation of evidence-based approaches. This will enable true societal valorisation of knowledge, i.e. bringing new solutions and interventions to patients and society, in this way stimulating e.g. positive behavioural change in (future) mothers and fathers.

⁸ Waelput AJM, et al. Geographical differences in perinatal health and child welfare in the Netherlands: rationale for the healthy pregnancy 4 all-2 program. BMC Pregnancy Childbirth 2017 Aug 1;17(1):254.
⁹ <http://developingchild.harvard.edu/wp-content/uploads/2010/05/Foundations-of-Lifelong-Health.pdf>

A HEALTHY START AND LIFE COURSE FOR ALL RESEARCH FUNDING LINES:



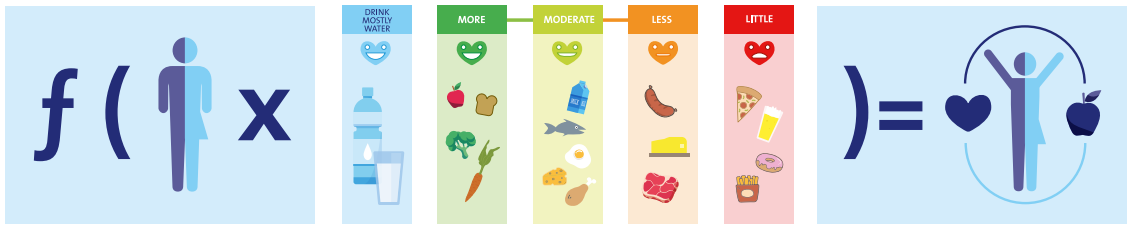
Integrated contextual healthy start approaches to improve health and well-being



How life course acts on genes and how genes act on life course



Healthy start for a healthy life course through data approaches



Healthy start for a healthy life course through nutrition approaches

THE FOOD- KNOWLEDGE GATEWAY TO HEALTH



GRAND CHALLENGE

CITIZEN HEALTH AND WELLBEING

MISSION

FOOD AND LIFESTYLE FOR A HEALTHY LIFE COURSE

Evidence based food and lifestyle interventions for all by 2030

AREAS OF INTEREST & CROSS-SECTOR

Medical & Public Health Sector

Agri Sector

Pharmaceutical

Service Sectors

Tech Sector

Living Environment

Food Sector

Behavioral Economics

Evidence based food and lifestyle interventions for a heterogeneous patient population

New standards and techniques to differentiate and assess food safety

Personalized nutrition and lifestyle approaches /tools

Understanding of the long-term effects of food intake on health

R&I PROJECTS

1 Introduction - the food-knowledge gateway to health

*"Unhealthy diets pose a greater risk to morbidity and mortality than does unsafe sex, and alcohol, drug, and tobacco use combined"*¹. The WHO states that a healthy diet helps protect against malnutrition in all its forms, and against Non-Communicable Diseases (NCDs) such as diabetes, heart disease, stroke and cancer². Changes from current to healthy diets are likely to substantially benefit human health, preventing approximately 11 million deaths per year¹. Against this background, there is **an urgent need for evidence based interventions** to prevent and cure disease.

Furthermore, food safety is an important issue: 23 million EU citizens fall ill each year due to food-borne diseases³. **Current standards for food safety do not differentiate between healthy consumers and patients with underlying conditions.** While both groups are heterogeneous, patients are generally much more vulnerable. What is harmless for a healthy consumer could be very harmful for patients. With the increasing population and the elevated demand for food products, coming from diverse geographic locations with diverse foodborne pathogens, the maintenance in its quality becomes a greater challenge. By the year 2030, the global food demand is expected to rise by 35%. A One Health approach is essential to mitigate food and environmental health risks.

Important complicating factors are that persistent social disparities exist when it comes to obesity, alcoholism and tobacco use⁴ and that individuals differ in their genetic risk for NCDs, and in their response to food patterns and pathogens (nutri-genetics). Major questions and challenges for the next decade include⁴: 1) the role of nutrition in the prevention, care and cure of NCDs; 2) the use of foods with high nutritional value

in care and cure; 3) assessment, prevention and cure of malnutrition in all its forms; 4) the promotion of healthy and sustainable diets across Europe; and 5) food safety in times of globalization, climate change and antimicrobial resistance.

2 A clear direction: targeted, measurable and time-bound

The mission is to **unlock the potential of food in preventing and curing disease**. The target is that by 2030, *evidence based food and lifestyle interventions during the life course to support optimal health* for both healthy citizens and patients, are developed, available, and ready to be implemented. In addition, by 2030 food safety standards should differentiate between healthy and vulnerable (patient) populations.

3 Ambitious but realistic research & innovation actions

To develop interventions and tools that improve health for a changing patient population as well as for healthy consumers, Research and Innovation (R&I) projects are needed to gain a thorough understanding of the relation between food and health across the full life course and **from molecule to population**. These R&I projects will ultimately deliver:

- 1 **Evidence based food and lifestyle interventions for a heterogeneous patient population**
- 2 **New standards and techniques to assess food safety for patients and healthy consumers**
- 3 **An understanding of the long-term effects of food intake on health**
- 4 **Personalized nutrition and lifestyle approaches and support tools to monitor nutritional status**

¹ [https://www.thelancet.com/journals/lancet/article/PIIS0140-6736\(18\)31788-4/fulltext?utm_campaign=tleatig&utm_source=hub_pag](https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(18)31788-4/fulltext?utm_campaign=tleatig&utm_source=hub_pag)

² <https://www.who.int/news-room/fact-sheets/detail/healthy-diet>

³ Adapted from: http://ec.europa.eu/research/bioeconomy/pdf/food2030_report_conference_2017.pdf#view=fit&pagemode=none

⁴ <http://www.oecd.org/health/health-at-a-glance-europe-23056088.htm>

To deliver on these questions and challenges, Research & Innovation projects are needed with a variety of approaches.

- a **Food for better health through nutrition approaches** - personalised nutrition to prevent malnutrition in relation to health and disease, and to support care and cure; randomized clinical trials on dietary regimes for patient groups.
- b **Food for better health through data driven approaches** - use of real world data through wearables and smart home devices and utensils; unlocking the human genome, microbiome and virome, and its' interaction with food; new insights from well-established longitudinal cohort studies; identification of (novel) biomarkers to assess malnutrition.
- c **One health approaches to implement health and well-being** - Combating antimicrobial resistance and (re-)emerging food-borne diseases across the globe. New techniques to prevent and predict food- or wildlife-borne disease outbreaks.
- d **How food acts on human biology and how human biology acts on food** - understanding the long-term health effects of diets, the interaction between food-microbiome-health and how biological processes such as stress affect and influence these relationships.

4 Cross-disciplinary, cross-sector and cross-actor innovation

Food is a big part of social life and social tradition. It can be a conscious or an unconscious activity, with temptations everywhere in parts of the world and shortages in other parts, both leading to low-quality diets. And, last but not least, it is very much a biological process. Too little is known about the effect of food

intake and food safety on our health and well-being in different stages of our life course, and on the effect of food intake on prevention, recovery and cure of diseases in different states of health and disease / patient population/vulnerable populations. Issues and problems connected with food safety, food security, and sustainable production systems qualify as a wicked dilemma. Ensuring safe, accessible, affordable, and nutritious food is increasingly difficult, especially in a global context. Central to this challenge is the development of a One Health strategy, and a new level of thinking and acting⁵.

To address all these questions in order to combat disparities and reach our target, interdisciplinary approaches are key. Research teams combining medical, biological, sociological, psychological, public management, programmers and ICT specialists, amongst others, are needed. Successful research strategies on a number of the challenges should include a citizen science approach.

5 promote multiple, bottom-up solutions

The fact that both food and health are right at the center of society, makes that this mission can only be achieved by addressing all these multiple elements simultaneously in a connected and coordinated effort. This requires multiple solutions for the European heterogeneous context and (patient) population from grassroots and bottom-up initiatives, to large scale interventions to establish new and widespread standards and interventions.

Erasmus University Medical Center is committed to **let actions speak louder than words** and work towards **unlocking the potential of food and food safety in preventing and curing disease.**

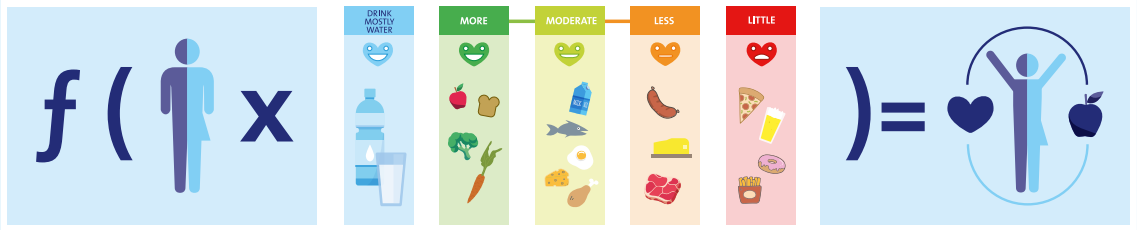
⁵ https://www.ncbi.nlm.nih.gov/books/NBK114498/#_appa_s72_



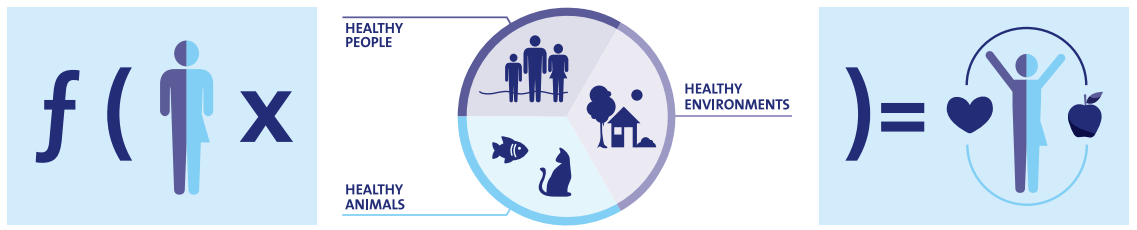
THE FOOD-KNOWLEDGE GATEWAY TO HEALTH RESEARCH FUNDING LINES:



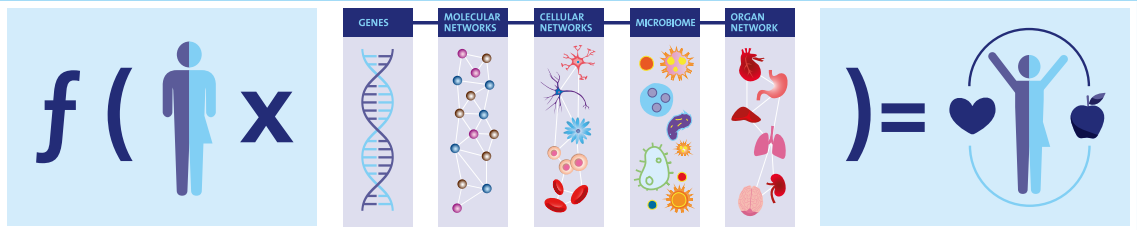
Food for better health through data-driven approaches



Food for better health through nutrition approaches



One health approaches to improve health and well-being



How food acts on human biology and how human biology acts on food

DATA-DRIVEN APPROACHES FOR A HEALTHY LIFE COURSE



GRAND
CHALLENGE

CITIZEN HEALTH AND WELLBEING

MISSION

DATA-DRIVEN APPROACHES FOR A HEALTHY LIFE COURSE

100% health intelligence-based
precision health and care by 2030

AREAS OF
INTEREST &
CROSS-SECTOR

Medical & Public
Health Sector Social Sector
Legal & Ethics Pharmaceutical
Sector Service
Sectors

Tech
Sector Consumer
Goods Food
Sector Behavioral Regulatory

R&I
PROJECTS

Novel
interventions
to prevent
diseases

Innovative
treatment options
to enable precision
health care

Innovative tools
for precision
diagnosis and
disease prediction

New
methodologies
to combine and
analyze data

Novel processes
for rapid
implementation of
digital solutions

1 Bold, inspirational with wide societal relevance

The vast amounts of data generated in healthcare provide a wealth of information for systematic analysis to improve healthcare. Such health intelligence based on 'real world information' combined with data from clinical trials allows the development of data-driven, individually tailored, evidence-based strategies for prevention, diagnosis, and treatment of disease. These strategies, once developed, have the potential to realize a significantly healthier world population with lower costs and fewer side-effects than the standardized regimes currently available.

2 A clear direction: targeted, measurable and time-bound

The target is that by 2030, precision strategies for prevention, diagnosis and treatment are evidence-based through health intelligence. For this purpose, different healthcare data sources need to be disclosed and linked. Variations in treatment across the EU are significantly reduced, while individual tailoring of prevention, diagnosis, and treatment is increased.

3 Ambitious but realistic research & innovation actions

Innovative development areas such as artificial intelligence, machine learning, and Big Data analytics provide a platform for the Health arena to realize goals that were unimaginable only a few years ago. Harnessing these developments for healthcare means creating innovative methods applying such developments to the intricacies of human development, health, and disease.

Big data and machine learning are extremely useful for finding associations and thus for prediction of outcomes, but more research is required to exploit these data sources and techniques for understanding causal relations, which are necessary for precision preventive interventions and treatments. Solutions are needed to deal with huge amounts of data for health intelligence as well as to translate outcomes of data analytics into digital tools that can be applied in health and care settings. Deciphering mechanisms of disease through health intelligence opens avenues to designing innovative diagnosis and treatment methods, enabling precision medicine. Correlating disease incidence with data collected years earlier can, for instance, uncover early biomarkers of disease and even genetic linkages or predispositions.

Yet to enable such innovative research, infrastructure must be adapted and developed to allow combined analysis of data from various sources. Actions will need to be undertaken to address interoperability, common standards, data quality and accessibility.

4 Cross-disciplinary, cross-sector and cross-actor innovation

A highly-developed, linked knowledge base and digital solutions enabling analysis of immense datasets are fundamental to myriad types of healthcare research and will become increasingly important as the drive for precision medicine demands analysis of more and more individual subgroups, for which larger and linked datasets are needed to derive meaningful results. At the same time, the need to keep healthcare costs within bounds will demand innovative implementation of precision medicine solutions. Addressing this target requires harnessing and integrating the combined skills and expertise of medical researchers, IT professionals, software developers, healthcare providers, experts in legal and ethical practicalities, economists, (local) governments, patients, and the general public. Strong multi- and interdisciplinary approaches will be needed for implementation of digital solutions

to provide automated mapping of individual patient characteristics onto precision medicine analytics, enabling cost-effective medical strategies. Moreover, these data-driven approaches can be used to develop patient-centered healthcare which empowers individual patients to optimize their own health care according to their personal preferences.

5 Promote multiple, bottom-up solutions

Creating data-driven approaches to enable a healthy life course will demand that we piggy-back healthcare applications onto innovative developments in more fundamental areas, such as the development of artificial intelligence, extreme-performance data analytics, data management, and linking tools. “Privacy by design” and regulatory requirements are core to the analysis of medical data and implementation of digital solutions to medical problems and should occupy a central role from the very start of this mission. These elements will assemble to provide trustable, safe, user-friendly and cost-effective tools and technologies which allow a vast array of applications which enable evidence-based, precision medical solutions to prevention, diagnosis, and treatment of disease, resulting in a healthy life course for all.

**DATA-DRIVEN APPROACHES FOR A HEALTHY LIFE COURSE
RESEARCH FUNDING LINES:**



A healthy life course through predictive data-driven approaches



A healthy life course through preventive data-driven approaches



A healthy life course through precision data-driven approaches

UNDERSTAND AND COMBAT DISEASES



GRAND CHALLENGE

CITIZEN HEALTH AND WELLBEING

MISSION

UNDERSTAND AND COMBAT DISEASES

Integrated understanding of disease mechanisms to improve health, from prediction and prevention to detection and treatment

AREAS OF INTEREST & CROSS-SECTOR

Medical & Public Health Sector Social Sector Legal & Ethics Pharmaceutical Sector Service Sectors

Tech Sector Consumer Goods Food Sector Behavioral Regulatory

R&I PROJECTS

New techniques for precision diagnostics, monitoring & treatment

Advancing patient care and improving quality of life

Understanding linkages between NCDs and IDs

Trans-disciplinary research and collaboration

Convergence NCD (incl. mental health) and multi-morbidities

Network medicine: Unravelling the role of contextual & genetic risk factors

Tackling transmission and control of disease vectors

1 Bold, inspirational with wide societal relevance

Reducing the impact of non-communicable diseases (NCD) and infectious diseases (ID) is considered one of the major challenges for sustainable health in the 21st century. At present, NCDs – which encompass most forms of cancer, diabetes, cardiovascular disease, osteoarthritis, chronic respiratory conditions, (rare) genetic and neurological diseases, as well as mental health conditions – are the leading cause of death worldwide with about 41 million mortalities every year¹. Nearly 80% of NCD deaths occur in low- and middle-income countries², but the impact of NCDs on Europeans is equally alarming: together, the five major NCDs (diabetes, cardiovascular disease, cancer, chronic respiratory diseases and mental disorders) account for an estimated 86% of premature deaths and 77% of the disease burden in the European Region^{3,4,5}. Most individuals aged 45 years and older will develop a NCD during their remaining lifetime; indeed, many will develop multiple NCDs (multi-morbidities)⁶.

In addition to the most common NCDs, there are about 6000 rare diseases, that, collectively, affect around 30 million European Union citizens. These diseases are often chronic and life-threatening⁷ and can be associated with considerable health care costs⁸.

Worldwide, infectious diseases (IDs) cause at least 5 million deaths/year⁹. Most occur in low-income countries where pneumonia, HIV/AIDS, tuberculosis, and malaria are still prevalent. The incidence of IDs in high- and middle-income countries has fallen dramatically over the last century. However, recent outbreaks of emerging and re-emerging diseases worldwide, such as severe acute respiratory syndrome (SARS), measles, avian and pandemic influenza, and zika virus, demonstrate the continuous challenge and urgency of controlling IDs. Based on future temperature projections across the world researchers¹⁰ mapped where the mosquitoes that transmit diseases like dengue and Zika might travel if climate change continues unchecked. Based on their worst-case scenario projections, the researchers believe as many as a billion people could be newly exposed to these illnesses within the century, especially in major urban centers in Europe, the United States and China¹¹.

¹ <https://apps.who.int/iris/bitstream/handle/10665/272596/9789241565585-eng.pdf?ua=1>

² https://www.who.int/nmh/publications/ncd_report_full_en.pdf

³ WHO. 2017. Fact sheets on sustainable development goals: health targets. Non-communicable Diseases.

⁴ <http://www.euro.who.int/en/health-topics/noncommunicable-diseases/noncommunicable-diseases/fact-sheet-on-sdgs-noncommunicable-diseases-sdg-target-3>

⁵ WHO. 2016 Action Plan for the Prevention and Control of Non-communicable Diseases in the WHO European Region. <http://www.euro.who.int/en/health-topics/non-communicable-diseases/pages/policy/publications/action-plan-for-the-prevention-and-control-of-noncommunicable-diseases-in-the-who-european-region-20162025>

⁶ Licher S., Heshmatollah A., van der Willik K.D., Stricker B.H.C., Ruiter R., de Roos E.W., Lahoussel E.W., Koudstaal P.J., Hofman A., Fani L., Brusselle G.G.O., Bos, D., Arshi B., Kavousi M., Leening M.J.G., Ikram M.K., Irfam M.A. 2019. Lifetime risk and multimorbidity of noncommunicable diseases and disease-free life expectancy in the general population: A population-based cohort study. PLOS Med 16(2): e1002741. <https://doi.org/10.1371/journal.pmed.1002741>

⁷ Licher S., Heshmatollah A., van der Willik K.D., Stricker B.H.C., Ruiter R., de Roos E.W., Lahoussel E.W., Koudstaal P.J., Hofman A., Fani L., Brusselle G.G.O., Bos, D., Arshi B., Kavousi M., Leening M.J.G., Ikram M.K., Irfam M.A. 2019. Lifetime risk and multimorbidity of noncommunicable diseases and disease-free life expectancy in the general population: A population-based cohort study. PLOS Med 16(2): e1002741. <https://doi.org/10.1371/journal.pmed.1002741>

⁸ <https://www.eurordis.org/about-rare-diseases>

⁹ http://oecdobserver.org/news/fullstory.php/aid/3337/Rare_diseases:_A_hidden_priority.html

¹⁰ Numbers calculated based on WHO statistics report 2017 to illustrate – sum of TB, malaria, HIV, hepatitis, influenza

¹¹ <https://journals.plos.org/plosntds/article?id=10.1371/journal.pntd.0007213>

¹² <https://www.npr.org/sections/goatsandsoda/2019/03/28/707604928/chart-where-disease-carrying-mosquitoes-will-go-in-the-future?t=1554978641825>

Both NCDs and IDs can have risk factors of either environmental or intrinsic (genetic) origin, and these can interact to strengthen each other. The development of NCDs is associated with a cluster of common risk factors, including ageing, alcohol and tobacco use, unhealthy diet, physical inactivity, metabolic risk factors (e.g. elevated blood pressure, obesity or hyperglycemia), and environmental factors, such as urbanization, air pollution, and chemical exposure (e.g. endocrine disruptors, asbestos, chromium VI). Major risk factors for the development of IDs include ongoing (unplanned) urbanization, population growth, increased international travel and migration, animal husbandry and intensive farming practices, socio-economic circumstances and environmental pollution and climate change. Additionally, low vaccination rate is becoming an important risk factor for the (re)emergence of some IDs. This (re) emergence of IDs is exacerbated by an increase in antimicrobial resistance (AMR) and health-care associated infections (HAI).

In addition to these environmental and genetic risk factors, NCDs and IDs may cluster with each other as well. In 2012, 15.4% of cancer cases worldwide had an infectious origin¹². Individuals infected with the human papillomavirus (HPV), *Helicobacter pylori*, and Hepatitis B and C viruses have an increased risk of developing cervical cancer, gastric cancer and liver cancer, respectively. In addition, patients suffering from (multiple) NCDs are generally more susceptible to infections. For example, diabetes has been shown to increase the severity of emerging, endemic diseases such as tuberculosis and malaria, and interferes with tuberculosis treatment, threatening infection control^{13,14,15,16}. Yet despite this clustering, prevention and management research almost always focusses exclusively on a single disease.

In order to combat diseases and create better health for everyone, it is crucial to deepen our understanding of the main causes, risk factors and mechanisms underlying NCDs and IDs, and where they overlap. This information is crucial to develop prevention and treatment strategies tailored to the individual patient (precision medicine) in order to provide optimal care with minimal side effects at reasonable costs.

12 Plummer M, de Martel C, Vignat J, Ferlay J, Bray F, Franceschi S. Global burden of cancers attributable to infections in 2012: a synthetic analysis. *Lancet Glob Health* 2016; 4: e609-16

13 Van Crevel R, van de Vijver S, Moore DAJ. The global diabetes epidemic: what does it mean for infectious diseases in tropical countries? *Lancet Diabetes Endocrinol.* 2016

14 Danquah I, Bedu-Addo G, Mockenhaupt FP. Type 2 diabetes mellitus and increased risk for malaria infection. *Emerg Infect Dis.* 2010;16:1601-4

15 The Lancet Diabetes Endocrinology. Diabetes and tuberculosis—a wake-up call. *Lancet Diabetes Endocrinol.* 2014;2:677

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2 A clear direction: targeted, measurable and time-bound

The Hub mission is to integrate understanding of disease mechanisms into health care to improve health and well-being for all: from prediction and prevention to detection and treatment at reasonable costs and in a patient-oriented manner. This will ensure healthy lives and promote well-being through the entire life course.

By 2030, we intend to contribute to the United Nations Sustainable Development Goal aiming at reducing premature mortality rates due to NCDs by 1/3 (baseline 2015)¹⁷ as well as reducing the burden of NCDs, improving quality of life and advancing mental health. For IDs, the 2030 target is to reduce the number of infected individuals and deaths caused by AIDS, neglected tropical diseases, tuberculosis and malaria, as well as to develop effective interventions to combat IDs, including hepatitis, water-borne diseases (e.g. norovirus), influenza, yellow fever, mumps, measles, and zika virus).

17 <https://www.un.org/sustainabledevelopment/development-agenda/>

3 Ambitious but realistic research & innovation actions

Achieving these mission targets will require trans-disciplinary collaboration and synergy of fundamental and translational research. Novel insights regarding individual environmental and genetic factors and their interaction will provide the holistic understanding needed to advance prevention and treatment of IDs and NCDs. Drivers of (re)emergence, spread and transmission of infectious diseases must be unraveled. Additionally, ensuring healthy lives and promoting well-being of all individuals will demand innovative approaches, novel vaccines and medicines, and technological tools for early detection of diseases. Designing more efficient disease interventions and prevention strategies will be of utmost importance, to ensure the best outcomes for the patient, at the lowest costs and in a patient-oriented manner.

Continued commitment to basic science will advance our understanding of these diseases, launching novel practical and clinical interventions using value-based healthcare approaches to reduce the impact of these diseases on patients and society.

Recent advances in artificial intelligence (AI), including machine learning and big data analysis, have opened new horizons in the detection and/or management of diseases and enable the development of new theories, innovative strategies and tools for diagnosis and/or intervention. For instance the integration of various omics technologies (in the X-omic project) has the potential to further our understanding of the mechanisms underlying NCDs, which can ultimately result in an earlier diagnosis and an earlier and more accurate intervention.

Mining and analysis of real world data collected from different sectors and disciplines will identify novel diagnostic biomarkers, profiles, and leads for prevention strategies and/or treatment interventions that may not have been discovered in standard clinical trial settings. Indeed, the study of metabolism at the global or “-omics” level is a rapidly growing field that has the potential to have a profound impact upon medical practice.

An approach which integrates genetic, metabolic, clinical, social and environmental networks is needed to identify and understand the origins of NCDs and IDs. Further identification of intrinsic and extrinsic risk factors that are relevant for NCDs and/or IDs will also be crucial and provide novel insights that will lead to the development of vaccines and medicines, better diagnostics, and innovative, safe, and effective interventions to prevent, detect, diagnose, treat, and ultimately eradicate these diseases.

In addition, we will need to educate citizens and health care professionals and increase general public awareness on prevention measures and on optimal treatment interventions tailored to the individual patient (precision medicine).

4 Towards convergence innovation through cross-disciplinary, cross-sector and cross-actor research

To achieve a significant decline in the number of (severely) affected individuals and reduce the impact of NCDs and IDs on individuals and society, novel transdisciplinary strategies are needed. Erasmus MC will invest in the development of a common framework for defining and improving our understanding of multi-morbidities, in order to develop evidence-based strategies for multi-morbidities in health care systems.

Strong cross-disciplinary and cross-sectoral collaborations are crucial for understanding and managing public health risks at this interface and improving global health. To fully cover the complexity of this problem, we need to maintain and advance our position as a top research institute and hospital in key medical areas, such as cancer research and treatment, as well as built bridges between different research fields, including e.g. virology, immunology, public health, nano-/micro-biology, psychiatry, oncology, epidemiology and technology.

Innovative insights regarding medical technology must be leveraged with comprehensive understanding of how diseases function within the human body to launch new strategies for medical research. For example, novel imaging technologies enable early, accurate diagnosis, which in turn enables localized treatment using minimally-invasive techniques, avoiding the side-effects which are associated with the more traditional systemic and/or invasive treatments.

There is a need for trans- and interdisciplinary research and convergence to understand diseases and their interlinkages, leading to new forms of prediction, prevention and precision therapeutics. Cardiovascular disease (CVD) and cancer are the two leading causes of death worldwide. Although commonly thought of as two separate disease entities, CVD and cancer possess various similarities and possible interactions, including a number of similar risk factors (e.g. obesity, diabetes), suggesting a shared biology for which there is emerging evidence.¹⁸

Understanding the possible link between immune system activation and depression might help explain what many observational studies have reported: depression is more common in patients with type 2 diabetes, rheumatoid arthritis, and coronary artery disease — all of which involve chronic inflammation — than it is in people in the general population.¹⁹

Several studies have reported an association between osteoarthritis (OA) and cardiovascular disease (CVD). This might indicate that OA and CVDs share risk factors or pathophysiological processes. On the other hand, it might also indicate that OA directly or indirectly causes CVDs or, reversely, that CVDs cause or worsen OA. Understanding the exact nature of how AS and OA are linked might lead to new biomarkers and common treatments for these diseases in subgroups of patients²⁰

As mentioned above, approximately 15.4 % of worldwide cancers are attributable to viral infections. Unraveling the infectious cause has led to interventions that may reduce the risk of developing certain tumors. These include preventive vaccines against HBV and HPV, HPV-based testing for cervical cancer screening, anti-virals for the treatment of chronic HBV and HCV infection, and screening the blood supply for the presence of HBV and HCV. Additional research to identify other oncogenic viruses in human cancer may lead to further understanding the etiology and pathogenesis and offer opportunities to develop novel methods for therapeutic and prophylactic intervention.²¹

¹⁸ <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4800750/>
¹⁹ https://www.health.harvard.edu/newsletter_article/infection-inflammation-and-mental-illness
²⁰ <https://www.sciencedirect.com/science/article/pii/S1521694218300433>
²¹ <https://www.ncbi.nlm.nih.gov/pubmed/24008290>

Engagement of the scientific and clinical community at all levels is required in order for the European population to benefit from novel insights and discoveries, to be translated into new digital or technological tools for prevention, diagnosis and prognosis, and into new treatment modalities. Additionally, collaborative involvement of all sectors, including health, ICT, education, agriculture, transport, and finance, is required to reduce the risks that are associated with IDs and NCDs and to promote the development of prevention or treatment interventions to prevent and control these diseases.

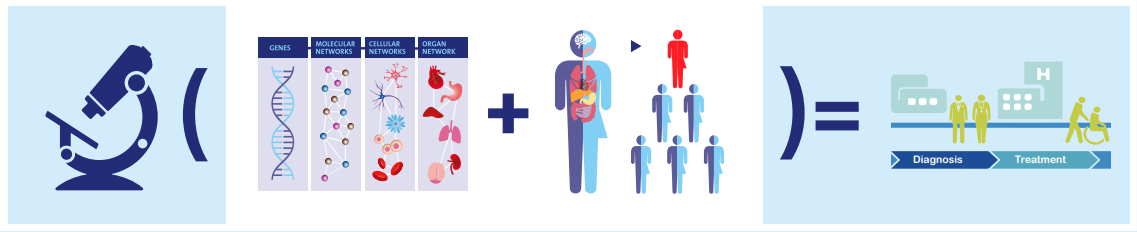
Human well-being and better care of individuals should be ensured through prevention of risks and mitigation of potential and/or existing health hazards originating from socioeconomic status, lifestyle, the human-animal-environment interface, and/or interactions between mental & physical health. This requires an interprofessional cooperation of, amongst others medical, clinical laboratory and social scientists, health insurance companies, health care professionals, veterinarians, industry, international bodies, charities and other non-profit organizations, patients, citizens, and (local) governments to develop appropriate and personalized interventions.

5 Promote multiple, bottom-up solutions

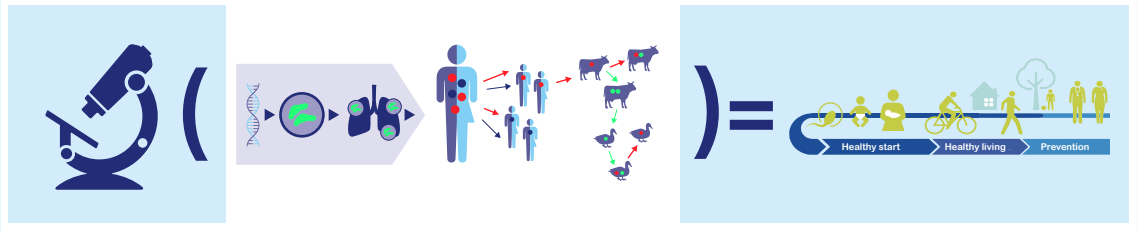
Given the vast number of factors influencing a person's health status during the entire life course, a large number of different actions are needed. From very fundamental projects resulting in new knowledge or development of new tests and diagnostics, to personalized and evidence-based lifestyle interventions, to highly-innovative grassroots projects which aim at developing new technologies in co-creation with centers of expertise, patients and stakeholders, to the development of new public health policies, and more.

To reduce the number of diseased persons and the number of premature mortalities caused by NCDs and IDs, multiple factors need to be considered simultaneously, as each of these factors have their own specific role and yet also influence response to other factors. This system approach generating holistic knowledge will ultimately lead to efficient prevention of NCDs and IDs, and the development of innovative interventions for patients and society. This will promote human well-being and health, leading to improved health for all.

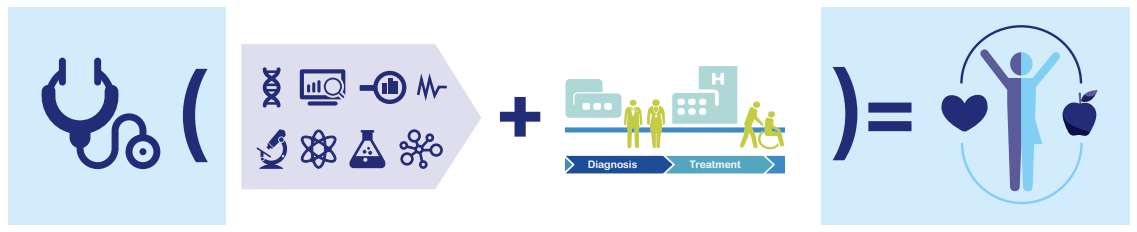
UNDERSTAND AND COMBAT DISEASES RESEARCH FUNDING LINES:



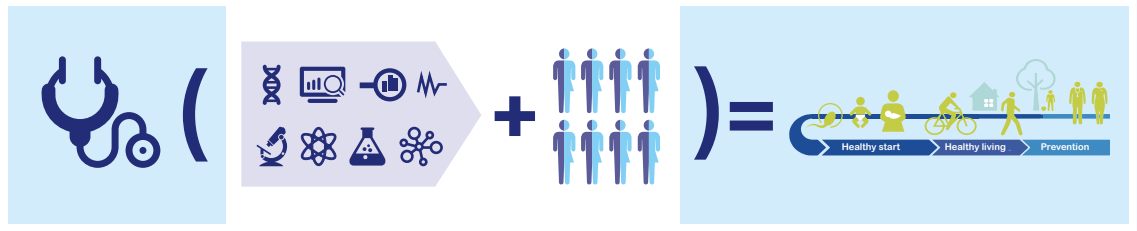
Understand & Unravel Non-Communicable Diseases (incl. Rare Diseases)



Understand & Unravel Infectious Diseases



Novel technologies for early diagnosis, precision treatment and advanced therapeutic approaches



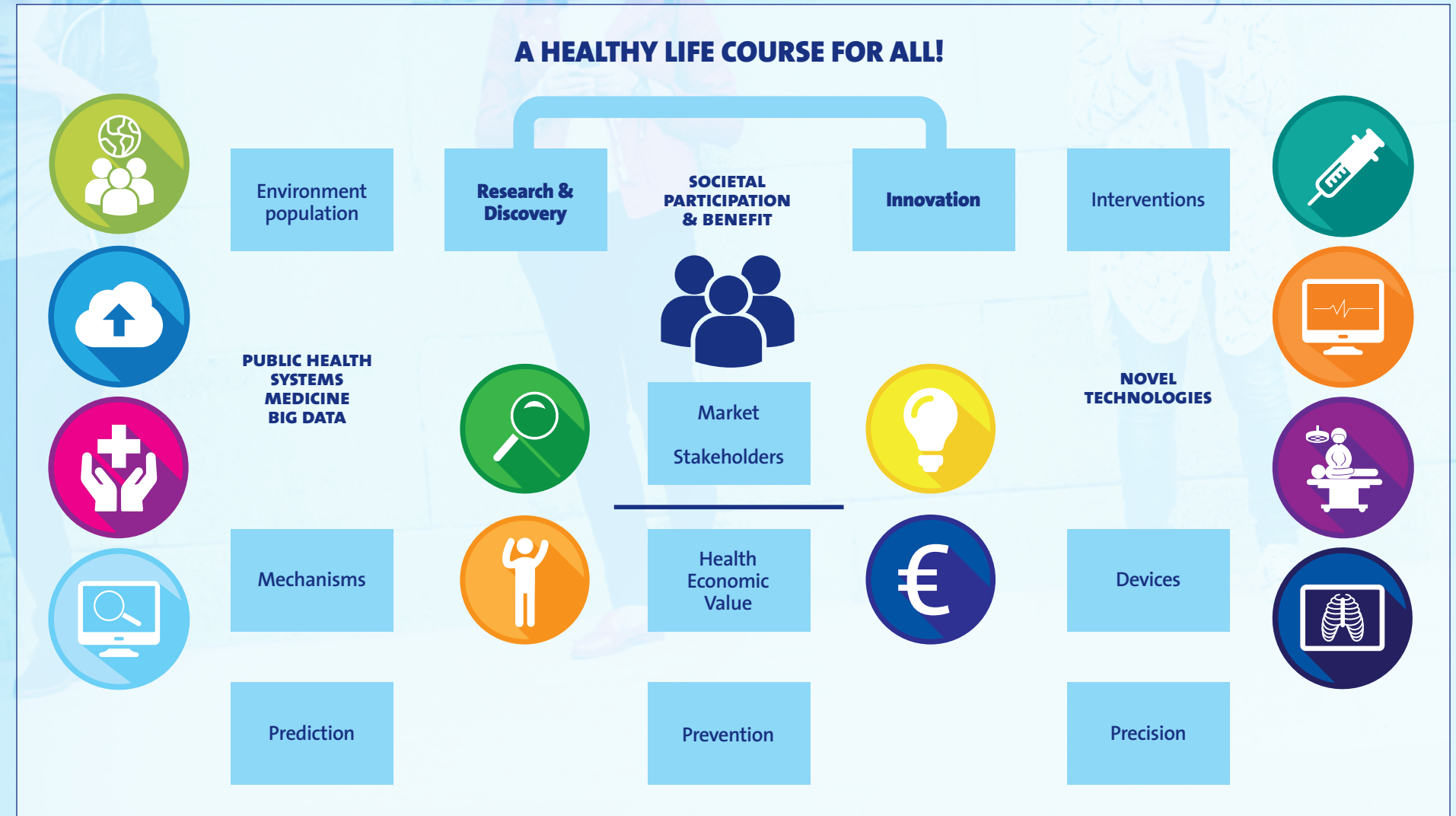
Early detection tools for optimal prevention

THE IMPACT WE WANT TO MAKE: 'A HEALTHY LIFE COURSE FOR ALL!'

Erasmus Medical Centre wants to enable health and a healthy life course for all!




We are using transdisciplinary approaches to develop strategies for prediction, prevention, and precision medicine that can be employed to solve current as well as emerging health challenges. It is how we impact the lives of healthy citizens and patients through our networks and collaborations.

We are an academic hospital with the DNA of Rotterdam, an academic hospital that walks the talk.



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