

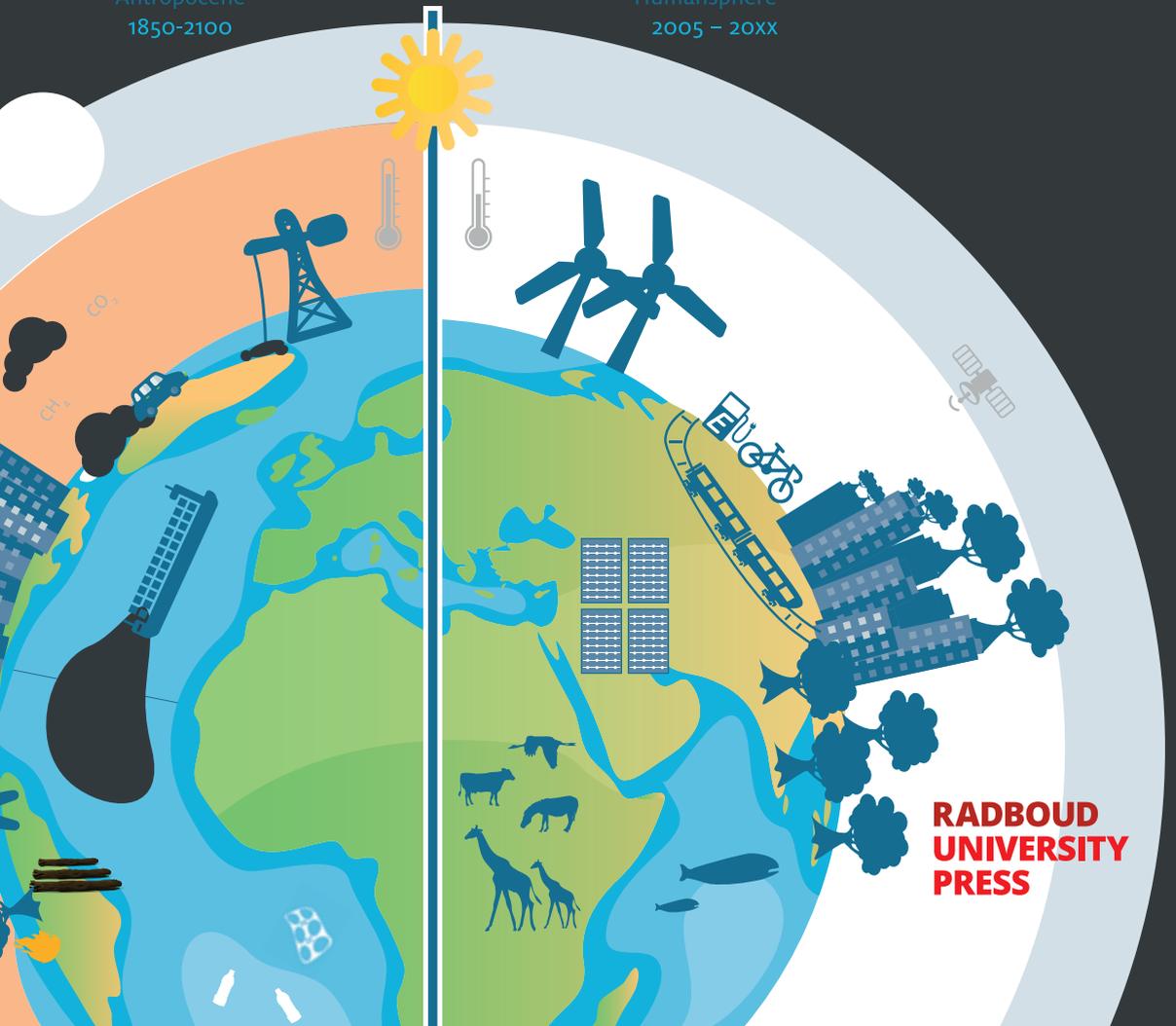
Kees van Laarhoven

# Human and Planetary Health

The urgency to integrate into One Health

Antropocene  
1850-2100

Humansphere  
2005 – 20XX



**RADBOD  
UNIVERSITY  
PRESS**

**“Man surprises me most  
about humanity.  
Because he sacrifices his  
health in order  
to make money,  
then he sacrifices money  
to recuperate his health...”**

attributed to the Dalai Lama

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# Preface

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**IT'S CLEAR** Even the strongest optimist can no longer deny that the atmospheric temperature has risen, oceans are polluted with plastic debris and healthcare consumption is rocketing in such a way that even the richest countries in the world will soon not be able to supply.

It's clear that groups of people prefer to look away from this, thinking the situation is hopeless and will inevitably soon deteriorate. It's clear that some groups try to point their finger at industrialised countries but their governments and politicians are not capable of finding ways to address this, nor are they very successful in coming to execute international agreements to solve some of these challenges.

It's more than clear, and especially distressing, that the attitude of administrators will not lead to a timely solution to these vital threats. It is mostly clear that all the aforementioned attitudes will not soon result in any solution. To me, it's clear. And I am more optimistic than most, as the human species has repeatedly demonstrated the ability during history to find solutions for seemingly intractable problems, and ultimately overcome them with great success. I am not an optimist, detached from daily reality, but a medical scientist, involved in patient care and in training programmes for young doctors and PhD students, while also running a surgical department at a university hospital.

---

I, too, read the daily news, see threatening climate changes, overlook the rapidly growing public debate and the demand for more money for healthcare and finally started to wonder how we got this far. I started to wonder, first of all: what's true and what's not? I started to look for reliable literature dedicated to these problems: medical literature, environmental studies, policy reports of the WHO and others, economic analyses, statistical calculations and trends, socio-economic observations, religious arguments and regulations. It was a long journey through over a thousand publications, hundreds of hours of discussion with experts and a long-lasting search for answers. I was inspired by the 2018 WHO call for multi-sectoral approaches to improve planetary health as well as global human health<sup>40</sup>. It was a call for a One Health approach, defined as<sup>41</sup>, "One Health is an integrated, unifying approach that aims to sustainably balance and optimise the health of humans, animals, plants and ecosystems. It recognises that the health of humans, domestic and wild animals, plants and the wider environment (including ecosystems) are closely linked and interdependent. The approach mobilises multiple sectors, disciplines and communities at varying levels of society to work together to foster well-being and tackle threats to health and ecosystems, while addressing the collective need for clean water, energy and air, safe and nutritious food, taking action on climate change, and contributing to sustainable development."

Taking it from there, important milestones are to be achieved within the 17 Sustainable Development Goals (SDGs)<sup>42</sup>. SDGs are defined as, "a collection of seventeen interlinked objectives designed to serve as a shared blueprint for peace and prosperity for people and the planet, now and into the future"<sup>43</sup>.

Going through a vast body of knowledge of public health and connecting this with knowledge from my medical/surgical background, I want to share my science journey with you, since it can have a happy end. By acting sensibly and combining efforts from all sectors, problems will be solved and a better world will be the heritage of our children.

During this journey, I hope to convince you that time hasn't run out. There's still a way to get out of this disastrous spiral and there's still time left to achieve a much better situation. Moreover, it is my opinion that doctors can no longer stand aside and just observe how and in which direction discussions are going, since we are the people who must have the courage to speak out and take responsibility. With all contributors, we feel a strong commitment to take the initiative in this. After all, as medical professionals and scientists, we are the experts of science in transition and we need to show the courage not only to speak up but also to take responsibility for action.

This is not just a book to give hope but a sincere attempt to show a safe way out; an affordable way, an achievable way. I will first show that prevention is superior to curing and that the latter is not just true for medical problems but also for environmental or energy-related problems. I will then convince you that pointing the finger at other countries, other people, other tribes and other religions will in no way safeguard this unique planet that is so lonely, floating in a cold and incomprehensible universe. At the same time, I will help you to realise that, for instance, the Covid-19 pandemic and the Russia-Ukraine war, again, have shown that there are boundaries to a makeable world and that the disparities

in good fortune, prosperity and social security between high, middle and low-income countries are painfully tangible.

At the same time, this demands a relentlessly stoic attitude in order to make it work.

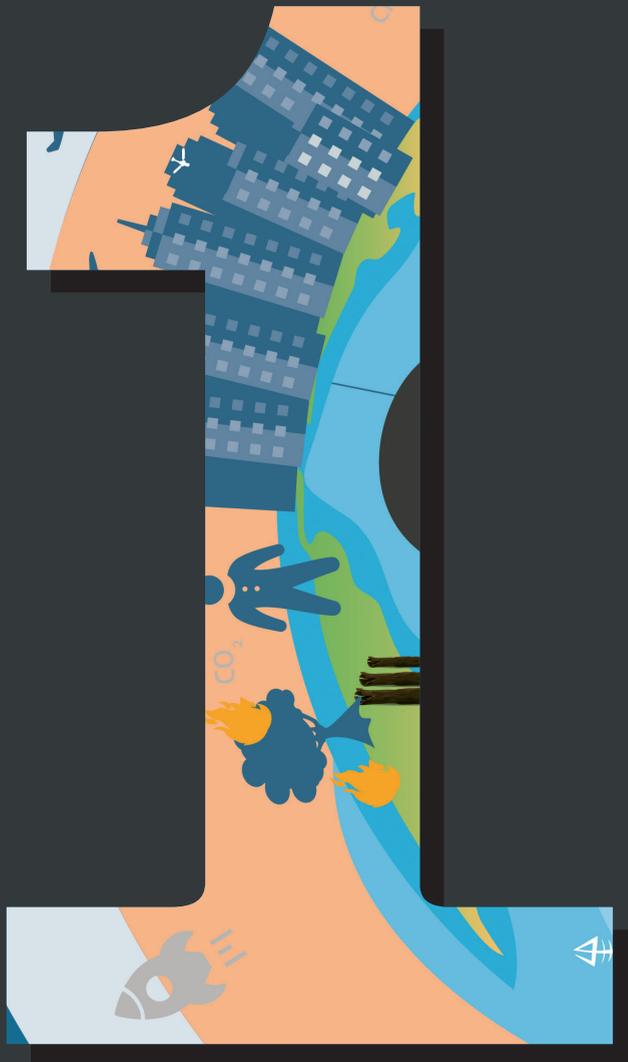
I am convinced that when you go through these sometimes scary but always fascinating facts and figures, you come to the same conclusion as we did: We can do this, we must do this and we will do this. After all, it's clear what is happening!

This book gives direction to the future of the world of health systems. It's written from the perspective of a medical doctor, someone who is active in the daily care of patients. Being a surgeon, obsessed with affording top clinical care but also seeing things from the perspective of integrative health and seeking answers to questions like, 'what's important for my patients?', I see chances, opportunities and meaningful obligations to fulfil. But, as a medical professional, I also realise that temporary disease relief does not make patients nor the world healthier in the long run. Personally, I feel a strong medical and societal responsibility to conceptualise how health systems should be redesigned to make them sustainable. I encourage my professional colleagues to interfere with public debate and policymaking. Healthcare professionals, as knowledge authorities, should be much more involved in this public debate.

This book was written not only for healthcare professionals but also for hospital board members, health policy makers and stakeholders in industries allied to health (e.g. the food, environmental and mobility industries). Therefore, not just a medical journey was conducted, but

various other perspectives were sought out to fully comprehend the origin and possible solutions of health systems in order to arrive at a substantiated concept to redesign disease care towards an integrative health system. In other words, a contextual journey was made, putting contemporary health issues and our health system service in environmental, economic and socio-cultural perspective<sup>44</sup>. This was done, first, by exploring in subsequent chapters where the major health issues originated from. Why did these health issues arise and why did the system evolve the way it did? Where are we heading? The final chapters conceptualise how health and care should develop and is very much aware of the fact that health systems are connected to other sciences and industries. As such, a multi-sectoral approach is described that may give direction to regional/national health plans. By connecting the main health issues of today with medical evidence, as well as with global Sustainability Development Goals and multi-sectoral actors, such a multi-sectoral approach to Integrative Health becomes tangible.

Part



# **The Inheritance**

Chapter



# Challenges to human health

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**IT'S** here, in today's daily practice, where this journey began by questioning which main healthcare issues are at stake, both now and in the near – and more distant – future. How did these health issues evolve? Which environmental, economic and socio-cultural explanations are there? And, if we can understand the root causes, can we redirect them, using a fundamental approach? Can we evade merely following trends in a reactively operating healthcare system, by changing from just trying to 'do things right' towards 'doing the right thing'? Once you have travelled this journey with me, I hope it will become clear: we, as medical professionals and policymakers, need to change perspectives and, from all sectors, we see that change is already happening.

So, the question arises whether the traditional healthcare system worldwide should be one of the biggest industrial sectors. Should humankind's main focus be on caring for disease or on creating a safe and healthy living habitat? To cite the Dalai Lama, "Man surprises me most about humanity. Because he sacrifices his health in order to make money, then he sacrifices money to recuperate his health..."<sup>45</sup>.

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## The global burden of disease

In the 21<sup>st</sup> century, the world is facing diverse and complex health challenges, including rapidly spreading infectious diseases – like the recent COVID-19 pandemic – in addition to well-known health threats, like multimorbidity and the co-occurrence of lifestyle-related diseases. Looking at today's healthcare system, we recognise a predominantly reactive system which is trying to solve new medical problems with technical innovations without paying sufficient attention to their causes and backgrounds. It allows diseases to spread, which results in an ongoing increase in healthcare consumption globally. In this book, in order to emphasise the differences, I will refer to our current healthcare system as 'disease care', as opposed to a new model which is more focused on an integrative approach towards health problems.

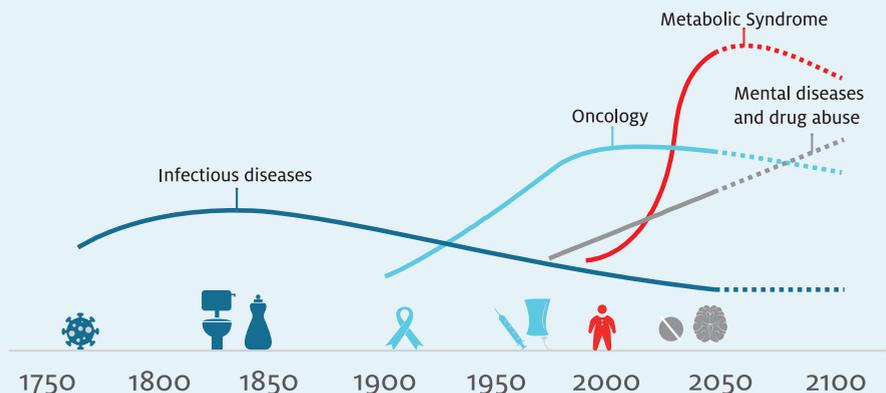
In order to comprehend today's complex health challenges and their concomitant high demands on care, reviewing the progress of understanding medical conditions over the past 150 years is important. As a consequence, the medical field has evolved into a high-tech medical interventionist science. Many medical students will recognise a feeling of fascination when they hear stories about the first patients being anaesthetised by ether, chloroform and nitric oxide, as early as 1845. Compared to these days, patients were arguably brave to undergo surgery, dentistry or obstetrics. Others may have encountered a similar feeling of fascination hearing about Joseph Lister, a professor of surgery in 1860 in Glasgow, who introduced asepsis in surgery, or the captivating story of Sir Ian Fleming, who discovered penicillin, in 1920. Understanding the concepts of hygiene, infection prevention and the treatment of infection were major knowledge break-

throughs and, together with the upcoming field of anaesthesia, an era of interventional medical science in the 20<sup>th</sup> century was opened.

Surgeons, in their daily practice, searched to push boundaries in surgery. Early radical resections of oesophageal or pancreatic cancers were known to have many complications. Surgeons who, in the 1960s, carried out the first cardiac surgeries on patients anaesthetised in ice baths, in times the heart-lung machine did not exist. Surgery, especially in the second half of the 20<sup>th</sup> century, was a unique place to be. And not only the surgical field but also the medical field made immense progress.

For infectious diseases and epidemics, we need to go back further, to the 17<sup>th</sup> and 18<sup>th</sup> centuries. At that time, epidemics around the world, like the Black Death, smallpox, typhus and malaria, were the main health problems. Later on, and following economic changes, like these of the Industrial Age and urbanisation in Europe in the 19<sup>th</sup> and first half of the 20<sup>th</sup> century, rises and falls of other infectious diseases like cholera, tuberculosis, intestinal infections, influenza, and pneumonia were the main challenges to the medical professions<sup>49</sup>.

In 2018, the Burden of Communicable Diseases in Europe (BCoDE) study reported an overall decrease in infectious diseases in high-income countries (HICs) over the last century but warned for outbreaks of (re-)emerging diseases worldwide, like severe acute respiratory syndrome (SARS), the Middle East respiratory syndrome (MERS), measles, avian and pandemic influenza, and others, like the Ebola and Zika viruses<sup>50</sup>. Until then, influenza was responsible for the highest disease burden in terms of disability-adjusted life



**Figure 1.1** Rise and fall of diseases in the Industrial Age

*Predictions of the rise and fall of diseases are based on current epidemiological developments, under the assumption that no new preventive or disease-modifying strategies are being developed.*

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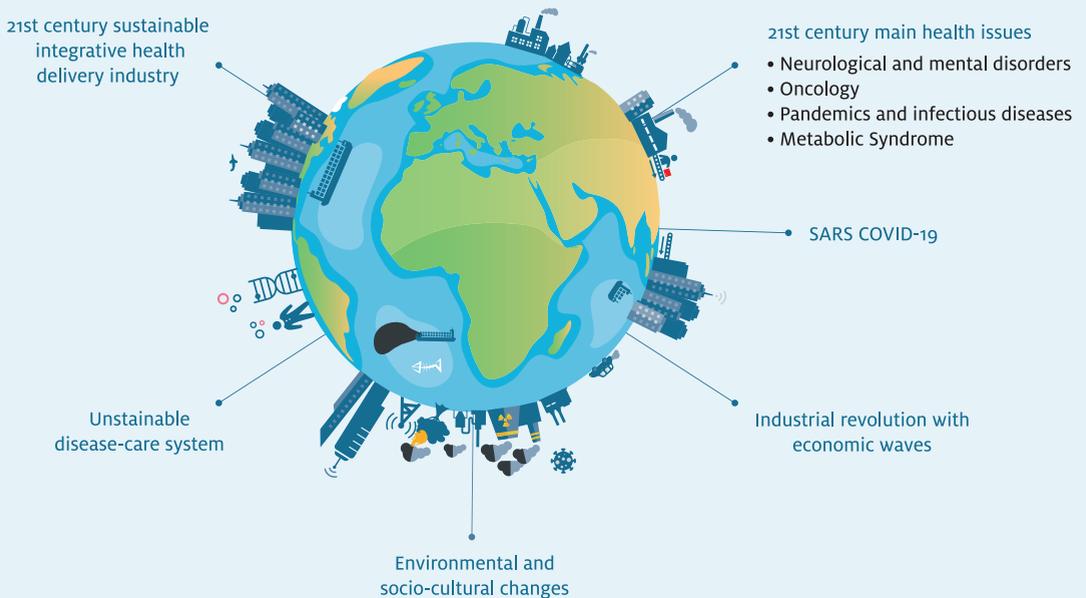
years (DALYs). With the still-evolving COVID-pandemic that emerged towards the end of 2019, a new chapter has been written.

Humankind has been coping well with communicable diseases, resulting in more infants and children living longer, but, during the last century, communicable diseases were replaced by non-communicable diseases (NCDs), from which large groups suffer for decades of their lives. These transitions have had a tremendous impact on our disease care systems.

Gradually, and with the improved control of infections in the 20<sup>th</sup> century, especially in affluent Western societies, a rise was seen in cardiovascular diseases, diabetes mellitus, cancer, respiratory diseases and other chronic lifestyle-related diseases (Figure 1.1). In today's early 21<sup>st</sup> century, 41 million people each year die from NCDs, as reported by the WHO, which is equivalent to

71% of all deaths globally<sup>51</sup>. 77% of all those deaths occur in low and middle-income countries (LMICs)<sup>52, 53</sup>. Four major modifiable risk factors are responsible for these new pandemics: tobacco use, physical inactivity, the harmful use of alcohol and unhealthy diets.

Otherwise, many health improvements, like eradicating many infectious diseases and high-tech interventions – for instance, in cancer treatment, cardiovascular disease and traumatology – were accomplished through hard work and intelligent endurance<sup>49</sup>. Health improvements that resulted in a globally increased life expectancy and a tenfold increase of the global population from one billion (1800 AD) to nearly 10 billion people in 2050. The multifaceted nature of all these progressions explains why population growth, disease and health are so closely related to ecological, economic and socio-cultural conditions.



**Figure 1.2** Factors of influence on the current disease-oriented care systems in the 21<sup>st</sup> century  
*The main health issues in the 21<sup>st</sup> century are related to economic developments in the Industrial Age. Unsustainable health systems face serious threats in terms of affordability and accessibility, urging a new, more integrative approach to the health delivery industry.*  
 © CJHM van Laarhoven

And the symptomatic disease care system has long been ideal and attractive, as it endeavoured us to explore and learn from the malfunctioning human body and mind. But, while knowledge increased, disease care consumption also increased, and we long took this for granted and, so far, insufficiently questioned its durability or necessity.

As a paradox, from a demographic point of view, this increased and untenable consumption can be explained by the success of the modern disease care system. Mackenbach<sup>49</sup> explained this very well by correlating the high prevalence of NCDs with treatment in Western societies. I quote, “When we stop to think about what exactly happened to these diseases, this is not difficult to understand. The incidence of a disease is the number of new cases arising in the population over a particular period of time, whereas the prevalence of a disease is the number of existing cases present in the population at one point in time. The long-term decline of infectious diseases has been mainly a matter of declining incidence, which has led to a lower prevalence of the disease. On the other hand, the rise of NCDs was not only due to rising incidence but also to a treatment-related declining case fatality and thus, to longer disease duration. The combination of more new cases occurring and the longer duration of the disease led to a substantially higher prevalence”<sup>49</sup>. And this, at least partly, explains the observations of the long-lasting periods of over 30 years that elderly populations have had to endure disease during their lifetime, as well as the substantially increasing higher disease care consumption.

## **Sustainability of the current healthcare model**

Nowadays, NCDs, lifestyle-related diseases, oncology and mental health are among the main health issues (Figure 1.2). Over the past half-century, we have sailed away, systematically, from a healthier world. 50% of people over 50 years of age have one or more chronic diseases and, importantly, they live in bad health for an increasingly longer period of time (30 years for men and as many as 40 years for women). Life-span is often stretched far more than the healthy lifespan, which is defined as the total number of years without diseases and impairments. Globally, one in three adults suffers from multiple chronic conditions<sup>54</sup>.

With our present lifestyle in obesogenic living environments, demands on disease care consumption will overburden its capacity. Disease dominates health, and present generations – the baby boomers, X and Y – face long periods of unhealthy ageing. And, with an expected growth of the world population from the eight billion we have now to 10 billion in 2050, population overgrowth will stretch care consumption even more, making the health system one of the biggest industries in the world, in terms of the numbers of professionals working in healthcare (Figure 1.3). With these efforts, health gain diminishes, whereas costs will increase further, making the 20<sup>th</sup> century disease care model no longer sustainable.

## **Disease-oriented care costs**

Just how big is disease care consumption in terms of costs, and what are the prospects? The average worldwide expenditure on the traditional healthcare system is 10% of GDP, being the highest in the United States of America, at

### Health Expenditure as Share of Global GDP



**Figure 1.3**

Expenditure in Global Domestic Product on disease care

Data presented up to 2018 as data during the COVID-19 pandemic are considered less representative<sup>55, 56</sup>.

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nearly 17%, and lowest in low-income countries, at around 4%<sup>57, 58</sup>. The average disease care spending per capita varies hugely across countries, ranging from 20 international dollars (Int\$) in Madagascar to 11,000 Int\$ in the United States of America (550 times higher)<sup>59, 60</sup>. However, prospects roughly foresee a doubling of costs within the next 20 years. With today's high levels of medical knowledge and technological possibilities, an increase in life expectancy results in higher disease rates.

An increased life expectancy of 10%, together with a population growth of up to 10 billion people in 2050, will lead to a further increase in disease care expenditure, from 10% to 15% of GDP<sup>57</sup>. It is, therefore, very unlikely that the present disease-oriented care systems will be sustainable for future generations. The problem is twofold: experiencing an increase in the global disease burden, together with the increase in disease care consumption.

In high-income, Western society, the increased life expectancies of the present older generation,

the baby boomers (those born between 1946 and 1964), burden the system most. We may wonder, how come we have never been further away from 'healthy ageing'? Considering the discrepancy between modern knowledge and disease prevalence, the disease-oriented care system underperforms as a system in terms of cost efficiency and disease/health ratios<sup>61</sup>. According to data from the World Bank, a pattern of diminishing returns (on expenditure) is seen: the increases in life expectancy will slow down, while expenditures continue to increase. Proportionally, the highest gains in life expectancy are achieved in poor countries with low baseline levels of spending<sup>62</sup>.

### Health inequalities

On the other hand, disease-oriented care systems are not capable of affording enough care at a basic level for everyone. Health inequalities exist in all countries, mainly between different social-economic groups, including, for example, gender inequities with structural cutbacks on the well-being of girls and women.

In addition, the latest Lancet Commission on Global Surgery reported that five billion people do not have access to safe, affordable surgical and anaesthesia care<sup>63</sup>. But surgery and anaesthesiology are fundamental components of disease-oriented care, representing around 30% of the global burden of disease<sup>64</sup>. Surgery is required at all ages and for a broad spectrum of diseases, from congenital anomalies and traumas, to infectious and malignant diseases, as well as chronic diseases like inflammatory bowel disorders, or osteoarthritis in the elderly.

Unmet needs are greatest in Sub-Saharan Africa and South Asia. As of 2020, 47.6% of people living in Sub-Saharan Africa faced the risk of catastrophic expenditures due to surgery, while this percentage was only 1.5 for HICs<sup>65</sup>. The majority of Sub-Saharan Africa resides in areas within two hours of a major hospital, supposedly capable of carrying out lifesaving – so-called ‘Bellwether’ – procedures (caesarian delivery, laparotomy and treatment of open fractures)<sup>66</sup>. However, 8% of the population lives outside such a two hour travel zone. The post 2015 SDGs for surgery and anaesthesia – that it is accessible, available, safe, timely and affordable – are unmet in LMICs. Development of safe, essential, life-saving surgical and anaesthesia care in LMICs has stagnated or even regressed, and case-fatality rates are still high for common, easily treatable conditions.

### Health, well-being and human development

Human health is difficult to define and numerous definitions are available. As Labonté and Ruckert rightly argue, the definitional contest on how we understand ‘health’ is essential for gathering the right and diverse types of evidence for it<sup>67</sup>. By defining health in terms of the absence of disease and building health interventions based on

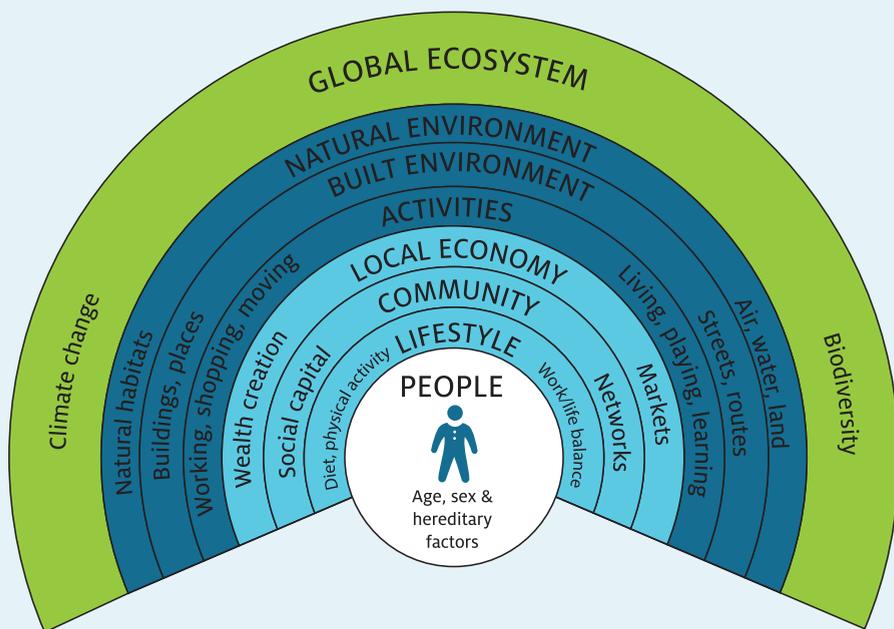
the ‘primary outcomes’ as death and disease, we disregard the very important psychological and social components of health. Whereas the elderly generations carry much morbidity, they may find themselves in a positive well-being state.

The (adapted) Dahlgren-Whitehead model<sup>68</sup> is often used to better understand the main determinants of population health, initially a report on policies and strategies to promote equity in health, but later used in a broader context. The model (Figure 1.4) places individuals at the centre, with various layers of influences on health surrounding them, such as individual lifestyle factors, community influences, working conditions and environmental conditions. The model helps to explore the relative influence of determinants like ecological change and economic influence on different health outcomes.

The Human Development Index (HDI) is another helpful instrument as it combines human health and well-being with socio-cultural and economic aspects. It includes human capabilities as a criterium for development. The HDI takes into account three key dimensions, each having its own indices<sup>69</sup>:

- A long and healthy life; measured by life expectancy
- Access to education; measured by expected years of schooling of children at school-entry age and mean years of schooling of the adult population
- A decent standard of living; measured by Gross National Income per capita, adjusted for the price level of the country

Despite increased disease rates, quality of life, as measured by the Human Development Index, has increased globally<sup>70</sup>.



**Figure 1.4** Main determinants of population health  
Adapted Dahlgren Whitehead model<sup>68</sup>.

Recently, the United Nations Development Programme (UNDP) has experimented with the Planetary pressures-adjusted Human Development Index (PHDI) as a new indicator of human development<sup>71</sup>. This new index adjusts the HDI for pressures on the planet and includes four dimensions (21 indicators) that display the interactions between people and ecosystems. Dimensions include 'human development', 'energy systems', 'material cycles' and 'transforming our future'<sup>71</sup>. More concretely, PHDI is the level of human development adjusted by the CO<sub>2</sub> emissions per person and per capita footprint. When there are no pressures on the planet, the PHDI equals the HDI.

### The concept of the Anthropocene

Trying to comprehend the last century's human health developments, as well as the ecological and economic influences on it, the concept of the Anthropocene may be useful. It was postulated as a recognisable era that redirects everything that is within the global biosphere. In 2000, the term Anthropocene was coined by Paul Crutzen during the International Geosphere-Biosphere Programme<sup>72</sup>. This term tried to comprehend the growing awareness in the community of Earth System Sciences that human activities were fundamentally changing the ecosystem<sup>73</sup>. The Earth System Science community focuses on a broad spectrum of planetary processes, like global changes to the climate and biosphere. And,

as Steffen and colleagues demonstrate, typical conditions of the Holocene, here defined as the last 11,700 years of earth's history, truly differed from those of the last three centuries<sup>73</sup>. And although still disputed as a genuinely new era, in proposing this new term, Crutzen and Stoermer<sup>72</sup> indicated the onset of the Anthropocene as, "the latter part of the 18th century, when data retrieved from glacial ice cores show the beginning of a growth of atmospheric concentrations of several greenhouse gases, in particular CO<sub>2</sub> and CH<sub>4</sub>." The authors linked these global physical effects of human activities to the onset of the Industrial Age.

Looking back, it is therefore not a coincidence that the economic changes due to the Industrial Age, the ecological changes observed in the last two centuries and societal changes, as seen in the Anthropocene, come together and are jointly responsible for 21<sup>st</sup> century human health issues, as well as planetary health burdens.

Before we discuss the ecological and economic influences, we will first explore the four main 21<sup>st</sup> century health issues in the next chapter.

### Key points

- The **global burden of disease** and today's **disease-oriented care** costs make the current healthcare system unsustainable.
- Technical advances and medical progress in healthcare have created higher life expectancies and an **increased global disease care consumption**.
- **Safe and affordable healthcare** is not available for all and **health inequalities** still play an important role.
- Economic changes due to the Industrial Age, and the ecological changes observed in the last two centuries, come together in the **Anthropocene**.
- The Anthropocene represents the human hand in huge changes in **planetary health**, which, in turn, impacts on our own **human health**.

Chapter



# The major human health issues

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### **Obesity as a creeping pandemic, amplifying the metabolic syndrome and other non-communicable diseases**

40-60% of the global population is overweight and, depending on the geographic area, up to 30% is obese (BMI >30). Being overweight is importantly related to most metabolic syndrome related clinical manifestations, like diabetes mellitus type 2 and cardiovascular disease. But it is also strongly correlated to many forms of cancer, to anxiety and depression and to disturbances of the immune system.

An astonishing picture arises when we overview global, and especially western societies' weight changes in time. Whereas in 1975, 80% of the global population had either a normal weight or was underweight, this was reduced to 60% in 2015 and is expected to go down further, to 40%, in 2030 (Figure 2.5).

In the 2017 Global Burden of Disease analysis, high BMI was associated with 4.72 million deaths and 148 million disease adjusted life years globally<sup>19</sup>. Obesity is therefore increasingly contributing to the global burden of disease.

Early onset obesity, from 20-39 years of age, is related to six years of reduced life expectancy and a reduction of 15-20 years to a healthy life.

For obese DM type 2 patients, converting from antidiabetics to lifestyle interventions are most successful in the normalisation of weight and blood sugars and saves billions in costs. Effective early treatment – and prevention – of obesity and being overweight has the potential to essentially improve future human health. Treatment options vary from personalised lifestyle and socio-psychological interventions (e.g., on stress or sleep deprivation), remediate medication or, as a last resort, bariatric surgery.

Whereas the World Health Organisation has defined obesity as a genuine disease, today's disease care systems usually defer treatment until secondary complications occur. Apart from that, current disease care systems have proven to be unable to successfully combat the obesity epidemic.

Rather, a combination of individual interventional approaches, like lifestyle interventions, medication and surgical treatment are needed to endure a sustained obesity reduction<sup>31, 32</sup>.

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**IN** this chapter, the major health issues of the 21<sup>st</sup> century are outlined by reflecting on past epidemiological developments. Focus lies on four of the top global diseases in both HICs and LMICs, including: (I) neurological and mental disorders, (II) oncology, (III) pandemics and infectious diseases (IV) and metabolic syndrome. Maintaining the traditional distinction between communicable (infectious) diseases and non-communicable diseases (NCDs), this book uses the term 'non-communicable diseases' for diseases such as obesity and other clinical manifestations of metabolic syndrome, various forms of cancer and mental disorders. Nowadays, NCDs have exceeded the burden of infectious diseases in most countries.

However, it should be noted that such NCDs can also be conceptualised as communicable, as the spread of aforementioned diseases is often a product of globalisation, including trade liberalisation, market integration and the rise of transnational industries. These aspects of interconnectedness and transmission among the human population will be highlighted in this chapter but will further be discussed in depth in the next chapters.

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## Top four 21<sup>st</sup>-century human health issues

### I - Neurological and mental disorders

Neurological disorders are a leading cause of disability and one of the leading causes of death<sup>74</sup>. Almost one in three people worldwide will have a neurological disorder at some stage in their life, with the most common causes being cerebrovascular disease (stroke), migraine, Alzheimer's disease and other dementias or drug addiction. Although there is great variation of neurological diseases globally, in the past thirty years, the absolute number of deaths from all neurological disorders has increased, especially in LMICs. As the worldwide population grows older, ageing is one of the factors that explains the growth in disabilities related to neurological disorders<sup>75</sup>. But, in addition to ageing, lifestyle factors – such as unhealthy diets, lack of physical exercise as well as environmental factors, such as air pollution – are also strongly related to the growth of neurological diseases like Alzheimer's disease<sup>76,77</sup>.

In 2019, 35 million people were reported to have substance abuse addiction, with only one in seven of people who were addicted receiving appropriate treatment<sup>78</sup>. Substance use (opioids, cocaine, amphetamines, cannabis and other pain killers), directly and indirectly, has been responsible for 11.8 million deaths in 2017<sup>79</sup>. Half of them were aged under 50, and over 350,000 people died due to overdose. This amounts to one in five deaths globally. Indirect pathways include secondary infections like hepatitis and

HIV, premature deaths due to injury or suicide and indirect systemic effects on cancer development, cardiovascular disease, strokes and diabetes. Combined smoking, alcohol and drug use is an important risk factor, causing 11.4 million premature deaths annually<sup>79</sup>.

In 2017, more than one billion people globally (around one in seven people) were affected with either a mental disease or a substance use disorder, causing 7% of the total global burden of disease, as measured in Disability Adjusted Life Years (DALYs, years that people are living with a disability), and 19% of all years lived with disability<sup>80</sup>. Among the many different mental disorders, globally, 280 million people are estimated to be diagnosed with depression, 45 million people with bipolar disorders, 24 million with schizophrenia and 57 million people with dementia<sup>81</sup>. In LMICs, 75-85% of the population with mental disorders do not receive proper treatment. In addition to these disconcerting epidemiological developments, the numbers of individuals with substance abuse issues is increasing rapidly, indeed reaching endemic proportions. About two-thirds of the DALYs from mental and addictive disorders are caused by anxiety and depression and/or alcohol and drug use. And importantly, the impact of mental and addictive disorders is often underestimated<sup>82</sup>. Together, mental, neurological and substance use disorders constitute the top four health issues of the 21<sup>st</sup> century, with an increase of 41% between 1990 and 2010<sup>83</sup>.

### **Parkinson's disease and our environment**

Several lines of evidence indicate that Parkinson's disease is the fastest growing neurological condition in the world. The term 'Parkinson's pandemic' has even been coined. This growth is only partially explained by ageing.

After correction for ageing, Parkinson's disease continues to grow fast. This means that factors other than ageing also contribute to the rapid worldwide growth of Parkinson's disease and various lines of evidence incriminate toxic substances in our environment.

Recent reports confirm that air pollution currently continues to contribute to causing Parkinson's disease. A second line of evidence is that farmers have a markedly increased risk of developing Parkinson's disease. The condition is also more common in rural areas compared to urban environments, and people living in the immediate vicinity of farmland have an increased risk of developing the disease. One very likely explanation is that pesticides may contribute to causing Parkinson's. Many pesticides – for example, paraquat and rotenone – are known to be very toxic to the substantia nigra, which is the key area that is being damaged in the brains of people with Parkinson's<sup>13</sup>. A further environmental factor is trichloroethylene, a widely used solvent in industry, but also in many household products. Trichloroethylene is also very toxic to

the substantia nigra, and people living in areas contaminated with trichloroethylene have an increased risk of developing Parkinson's disease.

Finally, it should be noted that factors such as head traumas also increase the risk of developing Parkinson's. On the other hand, several protective factors should be mentioned, including leading an active lifestyle and keeping a Mediterranean diet. Taken together, these lines of evidence indicate that the risk of developing Parkinson's disease, to a large extent, can be brought under control, both personally and at a societal level. We all need to take responsibility in creating a safer and healthier living environment in order to dam this Parkinson's pandemic from developing further<sup>11-13</sup>.

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## II - Oncological diseases

Worldwide, cancer is a leading cause of death, accounting for almost 10 million deaths (around 18% of the total global annual deaths) in 2020 and 19.3 million new cancer cases. The global cancer burden is expected to grow to 28.4 million cases in 2040, which is a further 47% rise from 2020<sup>84</sup>. In 2020, the most frequent new cases of cancer were breast, lung and colorectal cancer (each around two million new cases/year) and the most common causes of death due to cancer were lung, colorectal and liver cancers. Since 1950, an era of 70 years started, during which tremendous progress has been achieved in radical surgery, chemotherapy, radiation therapy and the more recently, promising immune therapeutics. These procedures have immensely improved the life expectancy of oncological patients<sup>85</sup>. The combination of an increase in both the incidences and the survival rate has resulted in a strong rise in cancer prevalence, with cancer becoming more and more a chronic condition. However, advances in cancer treatment have been slow, and part of the increased survival results from earlier detections of cancer, for example, by population screening. Multiple causes underly the increase in cancer diagnoses. Here again, there is the effect of the ageing of populations (particularly in western countries). But, in addition, there are more preventable causes, such as the obesity pandemic and continued difficulties for population groups in accessing adequate healthcare<sup>86</sup>.

## III - Pandemics and infectious diseases

Since the 1950s, we have been heavily engaged – and increasingly successful – in treating endemic infectious diseases like smallpox, polio and leprosy and in the eradication of guinea worm disease and in fighting river blindness<sup>87, 88</sup>.

Infectious diseases have been among the leading causes of death and disability for centuries, and today they again form a growing threat to human health due to the continued (re-) emergence of new, old and modified infectious disease epidemics. Infectious diseases are responsible for around 25% of the annual global death rate of 56 million people<sup>53</sup>. Although the infectious disease burden for children under the age of 10 declined by 57.5% between 1990 and 2019, and for adolescents aged 10-24, by 18.7%, infectious diseases remain highly concentrated among the younger age groups<sup>51, 81</sup>. Additionally, over one billion people are affected globally by so-called Neglected Tropical Diseases (NTDs) and 1.7 billion need preventive treatment every year, according to the WHO<sup>89</sup>. NTDs are responsible for significant mortality and morbidity rates, with approximately 200,000 deaths and 19 million DALYs lost every year<sup>89</sup>. People living in developing countries suffer especially severely from the burden of infectious diseases, with children being most affected, both in terms of morbidity and mortality<sup>90</sup>.

In 2015, Member States of the WHO pledged to end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases by 2030, and to combat hepatitis and other communicable diseases. A year before this declaration, these specific diseases were still responsible for 4.3 million deaths (7.5% of the total number of deaths/year) worldwide<sup>91</sup>. Additionally, these diseases add significant morbidity to people via chronic illness, disability, stigma, and even exclusion from society<sup>92</sup>.

Due to worldwide vaccination programs for children under five, mortality from infectious diseases has decreased from 6.5 million child

### **Lifestyle and cancer**

The prevention and treatment of cancer is among one of the greatest challenges of healthcare in the 21<sup>st</sup> century. The incidence of cancer is still increasing, while we can prevent almost a third of cancer diagnoses through a healthier lifestyle. Thanks to earlier detection and improved treatment, the number of cancer survivors is steadily increasing. This growing population of cancer survivors is facing the direct and indirect consequences of disease and treatment. Supportive lifestyle counselling can benefit the quality of life and prognosis of this population.

About 30 years ago there was consensus that, besides smoking, lifestyle did not play a major role in the aetiology or treatment of cancer. We know now that about 30-50% of common cancers can be prevented by being physically active, eating healthy and maintaining a healthy body weight<sup>8</sup>.

Based on massive evidence, an independent panel of experts from the World Cancer Research Fund/the American Institute for Cancer Research formulated guidelines for cancer prevention. It has been firmly established that better compliance with these guidelines is indeed associated with a lower risk of most prevalent cancers. Cancer survivors are advised to adhere to these cancer prevention guidelines and it is recommended to start a healthy diet and adequate exercise as early as possible, preferably before starting treatment.

Unfortunately, studies on the role of lifestyle before, during and after cancer treatment are currently unable to formulate specific guidelines per cancer type, stage and treatment. However, evidence suggests that, in general, lifestyle-related factors – like diet, dietary supplements, physical activity, sleep, alcohol and smoking – are associated treatment outcomes. Promoting a healthy lifestyle does not only prevent morbidity and mortality, but also improves quality of life, social participation and reduces health care costs.

Some call a cancer diagnosis ‘a teachable moment’ for changing one’s lifestyle. That sounds encouraging, but the reality teaches that, even after a cancer diagnosis, most patients do not adhere to lifestyle advice. Changing to a healthy lifestyle over an extended period of time is notoriously challenging; it requires knowledge about what is healthy, but also coordinated and integrated action from various professionals from different disciplines and sectors of society. Together, these should focus on the availability of healthy choices and facilitate access to physical environments for active ways of life. Promoting sustainable lifestyle changes should be a key priority of our healthcare system, as well as society as a whole for the near future.

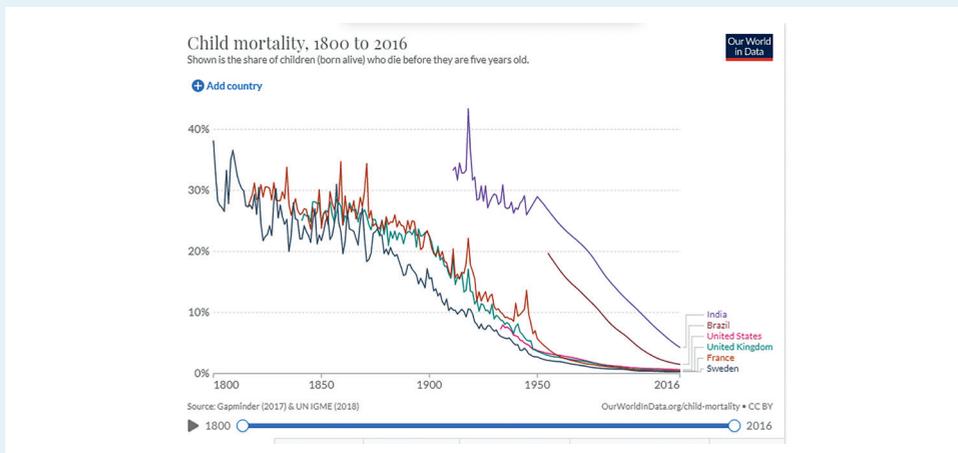
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deaths in 1990 to 2.4 million in 2017<sup>93</sup>. UNICEF estimated that vaccination saves two to three million children from deadly diseases each year<sup>94</sup>. The proportion of children (born alive) that die before the age of five is displayed in Figure 2.1. This sharp decrease in the mortality of under-fives is mainly attributable to the large public health campaigns, and which also includes programs on sanitation, safe drinking water, safe living environments and safe traffic. As a result of immunisation programs, deaths from measles, which is a major contributor to child death, have declined globally by 73%, between 2000 and 2018, accounting for 23.2 million saved lives<sup>95</sup>. The COVID-19 pandemic, however, has halted the progress on immunisation coverage. In 2020, for example, 23 million children missed out on life-saving vaccines due to severely limited access<sup>95, 96</sup>. Today, the likelihood that a child below the age of five will be fully vaccinated with the recommended vaccines is less than 20%<sup>97</sup>.

Recently, SARS-COVID-19 has acted as an unexpectedly strong new health threat. Although the pandemic seemed to be largely under control, up to now, in 2023, new variants have emerged in various regions worldwide.

The pandemic era of COVID-19 did turn the tables, both in disease care and in society. Whereas modern society showed relative efficiency in handling and containing large epidemics like AIDS and EBOLA, COVID-19 has overwhelmingly undercut the worldwide economy and severely disrupted disease care systems<sup>98</sup>.

Between January 2020 and July 2022, the official death toll of COVID-19 cases was estimated to be 6.9 million. However, more recent studies suggest that the impact of the COVID-19 pandemic may have been three times higher (18.2 million excess deaths) than official records state<sup>99</sup>.



**Figure 2.1** Child mortality under five

*Child mortality sharply decreased after 1950. The main reasons are vaccination and large public health campaigns in many countries. Gapminder.org (2021). Retrieved 29 August 2021, from <https://www.gapminder.org/data/documentation/gd005/>.*

Recent studies have also shown that the COVID-19 pandemic has had a major impact on mental health, like anxiety and depression, and on various sources of stress<sup>96, 100</sup>. For example, research has shown that the COVID-19 pandemic coincided with an increased level of stress experienced in patients with Parkinson's disease, which, in turn, led to further aggravation of their motor and nonmotor symptoms<sup>101</sup>. An additional 'hidden sorrow' of the COVID-19 pandemic has been the lack of physical activity, which was the inevitable consequence of the lockdowns to mitigate the risk of becoming infected. As we indicated before in this chapter, this lack of physical activity, in turn, has many deleterious health consequences. And finally, many individuals who were grounded at home because of the COVID-19 pandemic were faced with social isolation, which, in turn, may well have had a negative impact on their health.

Physical activity, healthy food and other lifestyle promoters act as strong measures of primary prevention against infectious diseases. The COVID-19 pandemic has learned that other secondary preventive measures like face masks, distancing, lock downs, and mass vaccinations are powerful.

The estimated extra COVID-19-related disease care costs worldwide for 2019-2020 were 3.5 trillion USD<sup>102</sup>, for that which it is possible to calculate<sup>103</sup>. Economic losses are not measurable, but the calculation of all national financial support programmes (including EU, WHO, UN etc.) surpasses 16 trillion USD<sup>104, 105</sup>, which is 90% of the worldwide annual GDP.

Although COVID-19's impact on the economy is large, the numerical mortality number is low. Compared to the mortality figures for pandem-

ics like the Spanish flu of 1918-1920 (40 million) and the pest of the Middle Ages (70 million), as well as the First World War (15 million) and the Second World War (66 million deceased; 2.6% of the global population), the COVID-19 pandemic counted only six million deaths out of a total global population of eight billion people (by mid-March 2022), which amounted to 0.68% of the total global population, which is far less than those listed above<sup>106</sup>.

Before the outbreak of the COVID-19 pandemic, Harari stated in his book *Homo Deus*<sup>107</sup> that, historically, every three to five decades, an epidemic or world war was to be expected. With respect to COVID-19, he was absolutely right. Although it could be perceived as a possible side effect, this pandemic did not refrain authoritarian world leaders from starting a supra-regional new war<sup>108</sup>. Following this hypothesis – and combined with the progress we have shown in handling and containing potential large epidemics like AIDS and Ebola – COVID-19 can be seen as having been a less severe pandemic, as far fewer deaths occurred due to the virus than those involved in world war, for example.

As with previous newly emerging respiratory pathogens, natural immunity, immunity gained through vaccination or, most probably, a combination of these, will decrease the global burden of COVID-19 in the future. Meanwhile, COVID-19 mutations or new viruses may, in the future, result in new pandemics. And, apart from viral pandemics, bacterial multi-resistance and gross surface water contamination with multi-resistant bacteria will likely remain major infectious health threats.

## NARRATIVE

### Natural epidemics and pandemics

The mother of all pandemics, the black plague or the 'Black Death' invaded Europe in 1347 and, with four waves altogether, lasted until 1800. By 1353, already one-third of the European population had died from it, and there were up to 70 million deaths worldwide. In large regions whole populations were eradicated<sup>1-3</sup>. Between the 15-17<sup>th</sup> century, in a 300 year period, approximately 55 million died due to the so called 'Columbian exchange' diseases – smallpox, measles, syphilis, typhus, etc. Between 1918-1920, the Spanish influenza flu infected one-third of the European population and approximately 40 million people died, giving rise to regional mortality rates varying from 2-20%. No other infectious disease has ever claimed so many lives in such a short epidemic period worldwide ('The 1918 influenza pandemic', <https://virus.stanford.edu/uda/>). In comparison, in a 40-year period, the HIV/AIDS pandemic has been responsible for 36.3 million deaths (1980-2020). Epidemiologically, several broad categories of pandemic threats are to be distinguished.

First, the group of extreme pathogens that have a high potential of causing true global severe pandemics. These pathogens transmit efficiently between humans, with sufficient long asymptomatic infectious periods that facilitate the undetected movement of infected persons. Examples are the pandemic influenza viruses (2009) and SARS-COVID viruses. The impact of the H1N1 Influenza pandemic of 2009 showed

the overall impact pandemics can have on healthcare systems, but also on animal health, agriculture, education, transport, tourism and the financial sector<sup>9, 10</sup>.

The second group of pathogens only presents a moderate global threat as they have not a sustained human-to-human transmission, but could, as a result of mutation or adaptation, become more efficient. Examples are the Nipah virus and the H5N1 and H7N9 influenza viruses. The H5N1 Bird Flu, via natural mutation, might become more contagious, more virulent and less treatable, leading to a case fatality rate as high as 60%, with over a billion fatalities.

The third group of pathogens (e.g. Ebola, Marburg and Lassa) merely have the potential to cause (inter) regional epidemics, with limited risk of global spread as they show a slower pace of transmission and high early detection and containment probability<sup>1, 9, 20, 21</sup>.

Infectious diseases, epidemics and pandemics have different preventive leverage points. Whereas primary prevention fails once large-scale infections have become prevalent, very specific secondary prevention measures are effective and the backbone of infection control.

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Our contemporary infectious concerns therefore are on new viral epidemics, for instance, fights against zoonoses and the rise of multi-resistant bacteria.

Related to this, and perhaps a cause of this problem, is a fundamental component of today's disease care: antimicrobial therapies. For the last eight decades, antimicrobials have served as the backbone of modern medicine, facilitating organ transplantations, surgeries and chemotherapy<sup>109</sup>. Antibiotics are vital in both agricultural, veterinary and human clinical settings to prevent and treat diseases. However, the misuse and over-use of antimicrobials has made many microbes immune to current drugs, causing antimicrobial resistance. Many antibiotics and antivirals that would normally limit the growth of microbes, and therefore curb the spread of infectious diseases have now resulted in an emergent worldwide epidemic, as the emergence and spread of drug-resistant pathogens continues to threaten the capacity to treat common infections, leading to alarming global spreads of multi and pan-resistant bacteria, the so-called 'superbugs'. Accordingly, The WHO has declared anti-microbial resistance (AMR) to be one of 'the top 10 global public health threats facing humanity'<sup>110</sup>. Such a trans-border health threat demands cross-sectoral governance arrangements<sup>111</sup>.

Not only multi-resistance in bacteria, but also, for example, drug-resistant viruses like HIV (HIVDR) have emerged. In Sub-Saharan Africa, over 50% of newly diagnosed infants with HIV carry a drug-resistant strain of the virus. And similar problems are seen in tuberculosis (TB), with the emergence of resistance to last-resort TB drugs, as well as the emergence of drug-resistant para-

sites and difficulties in treating and controlling malaria, for example<sup>110</sup>.

Antibiotics, antiviral and antifungal agents encompass a broad spectrum of natural or (semi-) synthetic chemical substances for inhibiting growth or killing microbes. And antibiotics, as well as antibiotic-resistant bacteria, can be distributed widely in the environment, like in surface water, ground and drinking waters. There have also been increased concentrations in surface waters of other pharmaceuticals, like lipid-lowering agents, antidiabetics, psychotropic drugs, painkillers and contraceptives<sup>112</sup>. Apart from the immensely positive impact of the pharmaceutical industry on people's lives, the pharmaceutical industry will need to move towards more sustainable production, in terms of cleaner production and waste reduction, but also in regulating pharmaceutical promotional activities and rationalising pharmacotherapy and physician's prescribing habits<sup>112, 113</sup>.

In the same line of thinking, we consider microbiota in human health and how they affect the development and function of all organ systems. Microbiota in humans adapt, evolve and protect against pathogenic microorganisms and toxins. We know that lifestyle factors, genetic composition and interpersonal variation, diets, drugs and antibiotics, as well as environmental exposures, affect the human microbiome composition and influence physiological and psychological human health<sup>114</sup>. Disturbed gut microbiota or dysbiosis and many chronic conditions, mostly NCDs – like allergies, autoimmunity and gastrointestinal disorders, but also obesity, diabetes and cardiovascular diseases – have been correlated. Genetics, lifestyle and diets, environment and microbiota

interact and influence human health. The 'One Health' and 'Eco-health' concepts embrace this concept and study the relationship between microbiota and the environment.

#### IV – Metabolic Syndrome

Among the diseases that are associated with the dominant lifestyle, or with 'civilisation' in general, metabolic syndrome is a rising star. Examples include obesity, diabetes, and cardiovascular diseases, but also parts of the growth in neurodegenerative disorders like Alzheimer's disease or Parkinson's disease, and many others<sup>115</sup>. And, globally, the awareness has grown that these profound changes in diet, as well as in physical and mental lifestyle in recent history are responsible for this development. Over the course of six to eight generations, since the early Industrial Age, our lifestyle has changed gradually. However, during the last three decades, these gradual changes have led to the profound effect of a true pandemic of obesity. Only recently, around the year 2000, did the term 'metabolic syndrome', defined as a 'pathologic complex condition characterised by abdominal obesity, insulin resistance, hypertension and hyperlipidaemia', has become widely accepted. Modern understanding of the ongoing epidemic of chronic disease involves a spectrum of late manifestations of slow progressive metabolic dysfunctions that find their (wide range of) origins early in life. In this chapter, we will concentrate on lifestyle-related metabolic syndrome, leaving aside those that are genetically inherited.

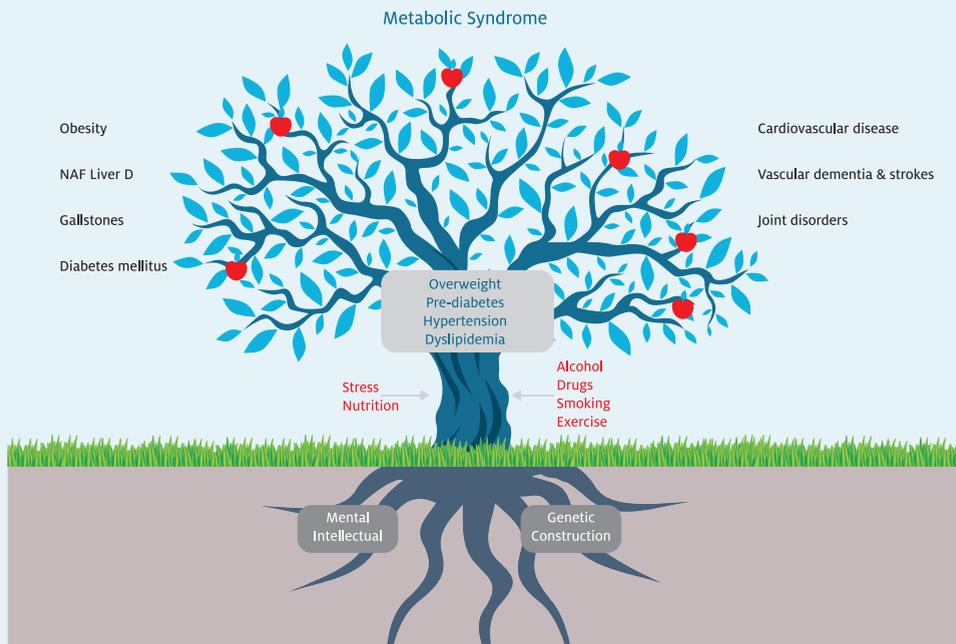
If we imagine human life as a tree of life, we are all born with some genetic construction and mental and intellectual capacity: our roots (Figure 2.2). During our youth – our tree trunk – we become influenced by external factors like

stress, nutrition and varying habits, like the use of alcohol, smoking and drugs, and lifestyle habits like physical exercise.

In early adulthood, imagined as the main branches in the tree of life, we may become overweight. But, more often, pre-diabetes, dyslipidaemia and hypertension may develop.

Often in middle age, after we have already been exposed to multiple external factors, the first typical metabolic syndrome-related diseases like diabetes, gallstones or (non-alcoholic) fatty liver disease may present themselves. Later, and at varying ages, as we see in the present baby boomers' generation, sequelae like cardiovascular disease, strokes, dementia, osteoporosis and joint arthrosis follow<sup>116</sup>.

Not only is the metabolic syndrome a silent killer in middle and senior age, it also leads to significant exposures to foetuses in utero, making new-borns more vulnerable to early onset obesity and degenerative diseases later in life<sup>115</sup>. This rapid nutritional transition can contribute to a metabolic mismatch between environment and brain, bringing about epigenetic changes. Natural protection by scarcity during foetal life stands in contrast with the relative abundance of calories later in life, which results in a predisposition for childhood fat deposition, glucose intolerance and metabolic syndrome, known as the 'thrifty phenotype' theory by Hales and Barker<sup>117</sup>. This interplay between genes and environment is shown to alter human biology, which may lead to metabolic syndrome in later stages of life. Congruently, transgenerational epigenetic inheritance is possible, transferring predisposed susceptibility to later generations.

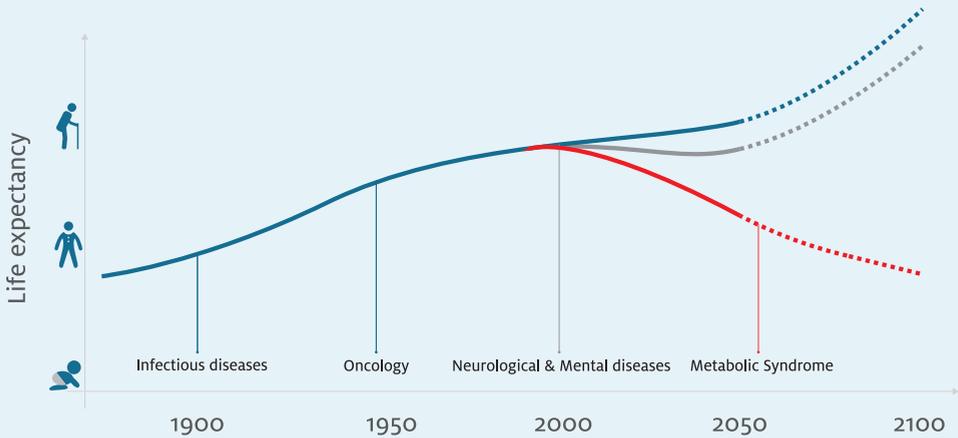


**Figure 2.2** The tree of life metaphor of the Metabolic Syndrome  
*Tree of life metaphoric overview of the metabolic syndrome, with root factors, early life environmental influences, early adulthood preclinical conditions and lifestyle-related diseases leading to the metabolic syndrome.*  
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With successful conquests of many communicable diseases (and despite COVID-19), metabolic syndrome has become the world's major health threat, largely driven by unhealthy dietary and physical patterns<sup>118</sup>. In 2020, about 3% of children and 5% of adolescents had metabolic syndrome, equating to respectively, around 26 and 36 million individuals<sup>119</sup>. While it started as a typical 'Western' lifestyle trend and an urban-related disease complex, it gradually spread across the world. Two basic forces are at play here, the increase in high calorie-low fibre food and a decrease in physical activities due to mechanised labour, motorised transport and sedentary life.

These two forces drive this slow, silent and often late recognised disease<sup>120, 121</sup>. That said, the focus here should not only be on the behaviour of individuals as global forces, including economic development and global trade, have brought unhealthy lifestyle options to the global market, pushing the nutrition transition towards diets which are high in salt, saturated fat and sugars.

Therefore, not individual lifestyle interventions on a personal level but a multi-system approach to the living environment will answer the complex question of untreatable individual metabolic syndrome diseases.



**Figure 2.3** Relative impact of Metabolic Syndrome on life expectancy

Various disease groups have had a major impact on life expectancy. With the improvement of treatments of infectious and oncological diseases, gradually our life expectancy increased. However, effects of neurological and mental diseases, and especially the metabolic syndrome have a negative impact on life expectancy. Out of 58-61 million annual deaths, a significant proportion is metabolic syndrome related<sup>122, 123</sup>.

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Three specific characteristics of metabolic syndrome deserve special attention. First, whereas the syndrome usually develops in adolescence and early adulthood, clinical manifestations of metabolic syndrome-related diseases usually arise in middle age, making it a silent killer and difficult to recognise early (Figure 2.3). Secondly, obesity, as one of the metabolic syndrome's most evidently related diseases, is often transmitted through the generations, leading to long-term health problems, both for parents and children. Third, a syndemic effect is seen in obesity, in combination with severe immunological or infectious diseases, as recently shown in the case of the COVID-19 pandemic<sup>31</sup>. This syndemic or synergistic effect of a combined pandemic of two disorders deserves consideration, as many statistics show that obese patients are much

more a risk of incurring severe COVID infections and mortality.

As metabolic syndrome is the new upcoming pandemic, we will explore the four most prominent diseases that fall within it: obesity, diabetes mellitus, cardiovascular diseases and non-alcoholic fatty liver diseases.

### Obesity

Obesity is usually a chronic, progressive disorder leading to poor health, unwarranted stigma and increased mortality. In the 2017 Global Burden of Disease analysis, high body-mass index (BMI) increased by 37% between 2007 and 2017 and by 127% between 1990 and 2017, one of the highest rates of increase among the risk factors assessed<sup>19</sup>.

Apart from environmental factors – such as food intake, basic metabolic rate, culture and physical exercise, and summarised as an obesogenic environment (Figure 2.4) – genetic factors – for example, POMC, Leptin-receptors and MC4R obesity genes – can predispose people to obesity. Hormones like Ghrelin, which has a positive effect on obesity, and secretin, which has a negative effect, also play important pathophysiological roles in developing obesity<sup>124</sup>.

High BMI accounted for 4.72 million deaths (8.7% of global annual deaths) and was the fourth leading risk factor for mortality, with further increases predicted. Furthermore, obesity is causally related to malignancies of the oesophagus, colorectum, liver, biliary tract, pancreas, uterus, ovary, kidney and thyroid.

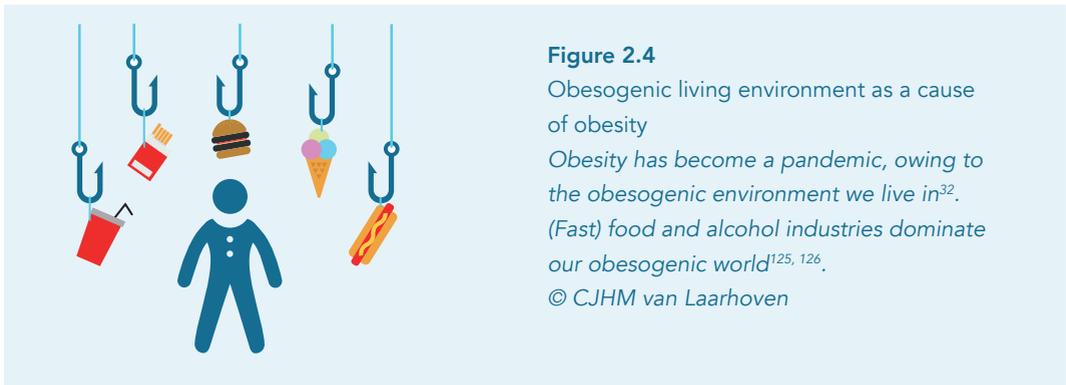
Since the 1960s and 70s, when famine deaths globally were the main health concern, the number of people facing daily hunger has gradually decreased to 800,000 in 2000<sup>127</sup>. Although famine has increased enormously again due to COVID-19, with 135 million people facing acute daily hunger, nowadays, more people worldwide are overweight than underweight<sup>66</sup>. Obesity has become the biggest non-communicable endemic disease worldwide (Figure 2.5).

## Diabetes mellitus type 2

Diabetes mellitus type 2 is another important clinical manifestation of metabolic syndrome. The number of people with diabetes mellitus rose from 108 million in 1980 to 462 million (6.28% of the world's population) in 2017, with the highest increases in LMICs<sup>133, 134</sup>. In 2019, deaths directly caused by diabetes were estimated at 1.5 million<sup>133</sup>. Diabetes is a major cause of blindness, kidney failure, heart attacks, stroke (two- to three-fold increased risks), peripheral neuropathy and lower limb amputation, especially due to vascular inflammatory damage<sup>135</sup>.

## Cardiovascular disease

A third important manifestation is the group of cardiovascular diseases. According to the Global Burden of Diseases, Injuries, and Risk Factors study (GBD) 2019<sup>136, 137</sup>, cardiovascular diseases were the underlying cause of death for 18.5 million people (approximately one-third of all deaths globally in 2019). More than six million deaths occurred among individuals aged between 30-70 years, making cardiovascular diseases an important and common cause of premature death among young and middle-aged deaths<sup>136, 138</sup>.

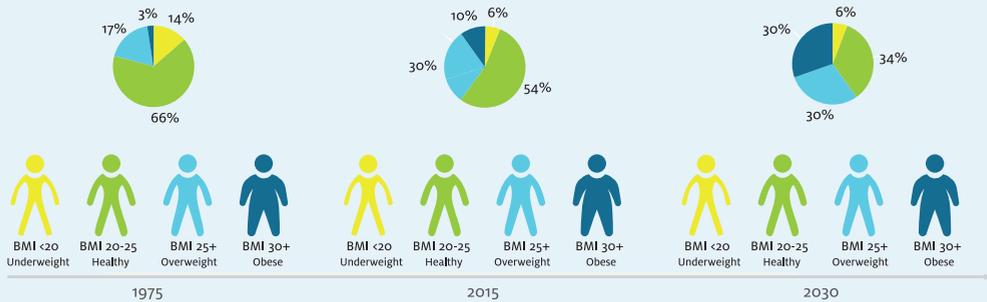


**Figure 2.4**

Obesogenic living environment as a cause of obesity

*Obesity has become a pandemic, owing to the obesogenic environment we live in<sup>32</sup>. (Fast) food and alcohol industries dominate our obesogenic world<sup>125, 126</sup>.*

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**Figure 2.5** Global weight changes over time

Since 1975, weight distribution has been increasingly dominated by overweight and obesity<sup>31, 128-132</sup>.

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### Non-alcoholic fatty liver disease

A fourth clinical manifestation is that of non-alcoholic fatty liver disease (NAFLD). NAFLD is important to consider as its incidence and prevalence are increasing along with the global epidemic of diabetes mellitus type 2 and obesity<sup>139</sup>. NAFLD considers a range of conditions which are caused by a build-up of fat in the liver (140). The global prevalence of NAFLD is estimated to be 25%, increases with age and is largely influenced by lifestyle habits<sup>139</sup>. Although NAFLD does not cause any direct harm, it can lead to serious damage to the liver and increased risks of high blood pressure and kidney disease<sup>141</sup>. People that already have diabetes are at an increased risk of developing heart problems. Besides having a large economic burden, NAFLD also results in a lower quality of life<sup>139</sup>.

### Lifestyle-related causes for the metabolic syndrome

Many factors, like unhealthy food, alcohol, smoking and drug consumption, reduction of physical

activity, stress and psychological disorders are related to the development of the metabolic syndrome. Many of these factors are independent risk factors for disease and mortality.

For example, alcohol is found to be a leading risk factor for the global disease burden and a preventable risk factor in developing metabolic syndrome. It is the seventh avoidable risk factor for premature death, morbidity and social harm<sup>126</sup>. In 2016, alcohol, with 2.8 million deaths, accounted for nearly 10% of global deaths in the age group 15-49 years<sup>125</sup>. With 9% attributable DALY for men, and 2% for women, alcohol was associated with far more health loss for men.

Tobacco use, another preventable risk factor for developing metabolic syndrome, is responsible for eight million people each year worldwide<sup>142</sup>. While smoking prevalence and its related morbidity has been high in HIC in the last decades, smoking prevalence is now falling in most of these regions, but prevalence will increase in

LMICs when economic prosperity grows. At present, worldwide, one in four men (over 900 million people) are daily smokers, with 80% of them living in LMICs. About half of them, 500 million people (6.4%), are expected to die prematurely due to continued smoking. The epidemic of tobacco deaths will progress globally, and demographics show that in global areas where tobacco industries succeed, alcohol and (fast) food industries follow shortly<sup>143</sup>. Especially, combined smoking, alcohol and drug use is an important risk factor, causing 11.4 million premature deaths annually<sup>79</sup>.

As a last example, stressful experiences are well-known to be correlated to the development of psychiatric disorders like bipolar disorder, anxiety and depression. Moreover, McEwen, in 2017, showed how stress could lead to parasympathetic/sympathetic imbalances, systemic inflammation and impaired glucose regulation, thus attributing to the development of various clinical manifestations of the metabolic syndrome<sup>144</sup>.

It may be concluded that seemingly straightforward lifestyle interventions (like healthy diets, smoking cessation and physical exercise) have little effect, unless rooted in a supporting healthy living environment. The current reactive disease care system, however, focuses on curing disease, be it either cholecystectomy for gallstones, medication for diabetes, bariatric surgery or cardiac bypass surgery. It merely relieves symptoms and defers the progression of disease. Even classic examples of successful treatments, like cholecystectomies, now turn out to have mediocre results, as nearly half of all symptoms that gallstone patients persist, as they are related to more complex diseases within the metabolic syndrome<sup>145, 146</sup>.

## **Bariatric surgery**

The bariatric surgery case is a good example of how health care has developed in disease care. Traditionally, surgery has often provided the first answer to emerging medical problems without claiming definite solutions. For instance, already in the Middle Ages, by treating infections by abscess drainages, teeth extractions, or amputations, provisional solutions were offered. And nowadays, in traumatology, surgeons may restore the body's integrity (almost) completely. However, with more complex conditions, like cardiovascular disease or oncology, temporary relief of symptoms or delaying progression is the only result surgeons can offer. In times of the new pandemic of obesity, bariatric surgery is another early and convenient surgical solution. However, like in previous situations, we still need to search for a more multi-systemic approach to decrease the behaviour that leads to obesity. Instead of accepting such a high prevalence, a multi-systemic approach is needed to alter the living environment and prevent individuals from becoming tempted by unhealthy lifestyles. Using the tree of life metaphor, as referred to earlier (Figure 2.2), disease care picks the apples without making efforts to support or strengthen the tree or prevent the diseases from occurring (Figure 2.6).

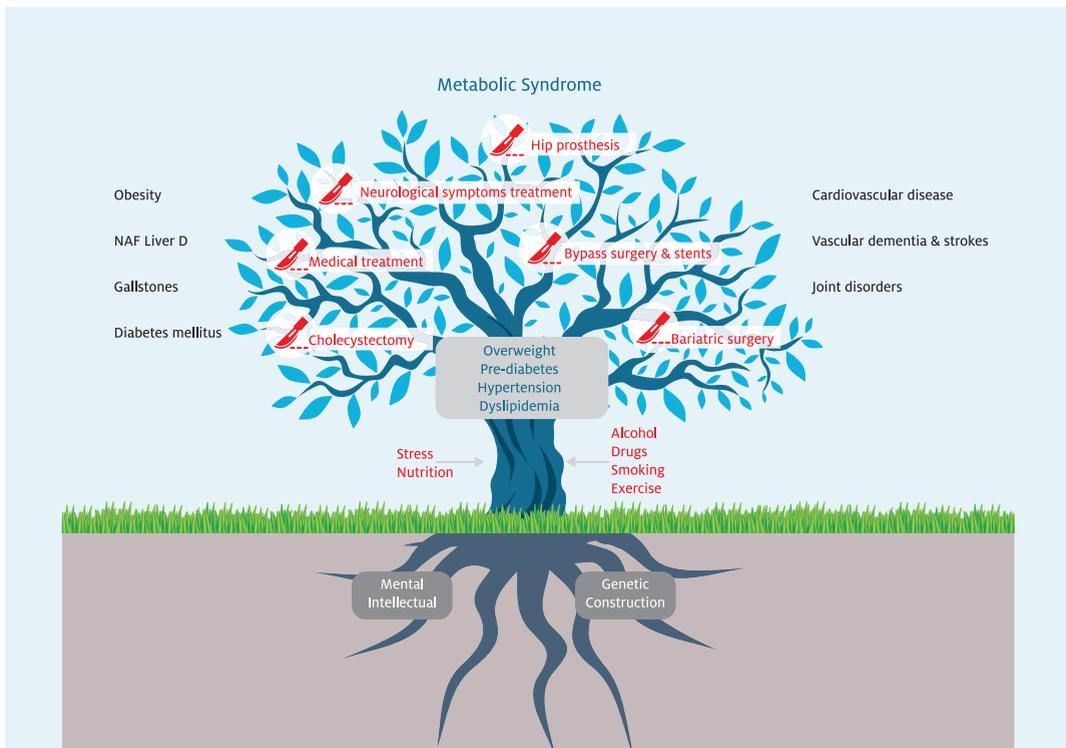
In conclusion, it is at least noteworthy to appreciate the discrepancy between extremely developed technological disease care systems, on the one hand, and diseased Western populations on the other. From a more global perspective, it is furthermore astonishing how such high-tech facilities are not available to most people in low and middle-income countries. It shows the misfit of our disease care systems and questions global disease care sustainability. These issues should

not be regarded in isolation but rather as being embedded in the global economic and ecological context.

The question at stake is how human health will develop globally. In general, data shows that life expectancy has increased overall, with more equality in life expectancy among countries. In particular, child and maternal mortality rates have decreased, and antismoking campaigns and vaccination programmes as inputs for ‘better health’ have been successful, though to differing degrees<sup>147</sup>. This, together with the increase

in the Human Development Index, which points to more years in good health, access to education and decent standards of living, encourages optimism<sup>60, 148</sup>.

Despite this reassuring data, human health has most recently come under increasing pressure from metabolic syndrome. This raises the question of why we, as disease care institutions, limit ourselves to symptomatic disease care. Although it is our primary responsibility to deliver and innovate the best possible care, it does not keep us from the responsibility to promote health as well.



**Figure 2.6** Disease-care system; picking apples from the tree of life

*Interventions of the current disease care system can be seen as akin to picking apples from the tree of life; no fundamental solution is given, as causes interacting with roots or trunks are not addressed.*

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### **Bariatric surgery and the imperfection of the surgical fix Obesity and metabolic syndrome, too big of an enemy to fight with a scalpel**

Twelve years later, Mrs Jansen is being referred to a bariatric clinic with a request for a gastric bypass operation. She is now 47 years old, has gained weight since the birth of her third child 10 years ago and, at 110 kg, her body mass index is 35 kg/m<sup>2</sup>. Her husband, as well as her children, are also overweight. Two years before referral she also developed diabetes mellitus type 2 and is facing mental stress. Without success, she has tried multiple times to lose weight, which only increases her stress levels. Together with her general practitioner, she has decided to undergo bariatric surgery, as this will relieve both her obesity and her diabetes mellitus type 2.

The overweight epidemic is fuelled by the wide availability of energy dense foods and reduced physical activity. Obesity is a risk factor for diabetes mellitus type 2, hypertension, hyperlipidaemia and cardiovascular disease. The epidemic also affects children. The WHO estimates that around 17.6 million children under five years of age are obese – out of the 678 million (2.6%) who are overweight – and that trend is rapidly increasing. Obesity is costly and accounts for 2-6% of total health care costs in developed countries.

Lifestyle change (less food, more exercise) is arguably the cornerstone in the fight against obesity. Continuous adherence to healthier behaviour is daunting for most and failed dieting attempts to lose weight contribute to the risk of future weight gain.

The Ghrelin hormone decreases significantly after bariatric surgery, for a prolonged period, and a reduction of excessive weight loss in years after surgery is seen<sup>27</sup>.

While effective in the short term, the question is whether bariatric surgery should be our answer to the epidemic of obesity. There is a practical reason to doubt it – the magnitude of the problem simply exceeds surgical capacity. Moreover, it is questionable whether surgery really should be the answer to the behavioural problems which underly the metabolic disease epidemic. This is a clear example that our reactive approach to health and disease is outdated and that prevention is key<sup>37</sup>.

**Professor Dr Joost Drenth,**  
*Department of Gastroenterology and Hepatology, Amsterdam University Medical Centre, the Netherlands*

### Key points

In considering the main health issues of this era, we distinguished four major domains. These four areas are strongly intertwined to our modern way of life and to our disease care systems, which are unable to provide sustainable answers.

- **Neurological and mental diseases:** Dementia, Parkinson's disease, stress, anxiety and depression, as well as substance use disorders (alcohol, drugs, smoking) became one of the top four health problem in the 21<sup>st</sup> century.
- **Oncology** has been the main focus of disease care in the second half of the 20<sup>th</sup> century and, due to radical surgery, radio and chemotherapy, and new immune therapy, the oncological five year survival has improved up to 50%, but causative treatment is still pending.
- **Pandemics and infectious diseases:** Infectious diseases became more under control after the understanding the concept of asepsis, and the invention of penicillin and the introduction of vaccination programs. New infectious problems, like zoonoses (influenza, SARS/MERS, Ebola), the mass multi-resistance of bacteria and antibiotic groundwater pollution make infectious diseases one of the top four health issues.
- The **metabolic syndrome**, with its so-called 'diseases of civilisation' – obesity, diabetes mellitus type 2, (non-alcoholic) fatty liver disease, cardiovascular disease, hypertension, dyslipidaemia and other age-related diseases like sarcopenia and osteoporosis – is at the top of disease care consumption.

Chapter



# Challenges to planetary health

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### **The El Niño cycles, volcanic eruptions and the human hand**

Up to the 1950s, natural influences on climate change like the solar cycles, the El Niño cycles and strong volcanic eruptions were more important than the human influence on climate. Since then, a slight global temperature decline occurred, due to a dramatic increase of cooling aerosols from the post-war industrialisation in the Western world and some major volcanic eruptions that temporarily diminished solar activity.

For a long time, we have wondered whether current climate change is caused by human actions in the Anthropogenic era, or whether a natural wave movement is the cause of climate change. There is now a broad consensus on the impending disruption of the ecosystem, stating that this disruption has its origins in the economic developments of the last three centuries, but especially since the 1980s<sup>22</sup>.

Globally, there is a growing awareness of these issues, as well as a willingness to replace fossil fuel energy sources with renewable energy, such as wind, water and solar energy. Certainly, making the energy industry more sustainable seems to be a good first step in the energy transition, in which companies take responsibility for the environment. Internationally, ESG (Environmental, Social and Corporate Governance) is becoming an increasingly important assessment method for investors.

The question that arises is therefore whether we as humans should continue to exhaust the earth's resources, in particular fossil raw materials, both in terms of the depletion of raw materials and the disruption of the climate. Moreover, this short-term strategy, aimed at economic growth, appears to be a boomerang of the highest order, as climate change itself disrupts human health. Not only does human behaviour led to climate change, pollution and resource depletion. In turn, climate change itself results in direct and indirect demonstrable damage to human health.

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# HISTORICALLY,

we have always fantasised about the vulnerability of our world through the invasion of aliens, the 'big bang' of a massive meteorite impact or natural atmospheric changes, like ice ages. Nowadays, the threat comes from within. One species, humankind, has been able to become dominant over all other living species. On the one hand, human intelligence has enabled us to survive, multiply, develop natural resources, harvest any needs we might have and make nearly every other living obey. But on the other hand, other parts of our working brain are not balanced with our perceptions and demands of long-term sustainability.

Major ecosystem changes in ancient times have been the work of nature itself and, with hindsight, they were containable from the earth's perspective. New eco balances were re-established in climate, as well as in biodiversity. Today's ecosystem derangement, however, finds its origin in the economic developments of the last three centuries, namely, the Industrial Age. Especially since the 1980s, changes in our environment, the earth's natural ecosystem, have been accelerating, with major implications for populations' health<sup>22</sup>. If, for example, we compare the dinosaur extinction and the near whale extinction, differences become clear.

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## NARRATIVE

### Dinosaur extinction and whale hunting

Dinosaur extinction in the Cretaceous-Paleogene was the work of nature itself and, with hindsight, although very impressive and always most appealing to the imagination, it was containable from earth's perspective. A new eco balance was re-established, and dinosaur extinction can be regarded as part of a continuous natural evolution in which flora and fauna species become extinct.

In the Anthropocene, one of the other largest mammals on earth nearly became extinct, and this time it was not nature, but humankind-driven.

The commercial hunting of whales (whaling), started by the Basques in the 16<sup>th</sup> century, and became increasingly important during the Industrial Age. Many countries in Europe – for example, Norway, Iceland, the United Kingdom and the Netherlands, as well as countries like Canada, the United States of America, Russia and, in Asia, Japan and Korea – were involved in this trade. In the 19<sup>th</sup> century, urged on by an increased demand for whale oil, advanced pelagic whaling techniques developed, like ship-anchored harpooning and factory ships with slipways, making whaling extremely efficient. Since 1860, a rapid extinction of these largest of mammals occurred and, by the late 1930's, more than 5,000 whales were killed annually.

The World Wide Fund for Nature reported that 90% of all northern half whales were

killed by human activities, either through whale hunting, as cetacean by-catch (the incidental capture of non-target cetacean species like dolphins, porpoises and whales), ship collisions, or by noise pollution from large ships.

The International Whaling Commission (IWC), established at the International Convention for the Regulation of Whaling (ICRW) in 1946, ordered, in 1986, a moratorium to temporarily forbid all commercial whaling. Norway, Iceland and Japan did not agree to the moratorium. Until today, discussions around national sovereignty and ownership, but also about cetacean intelligence, suffering during hunting and the rapidly approaching extinction of some whale species, continue.

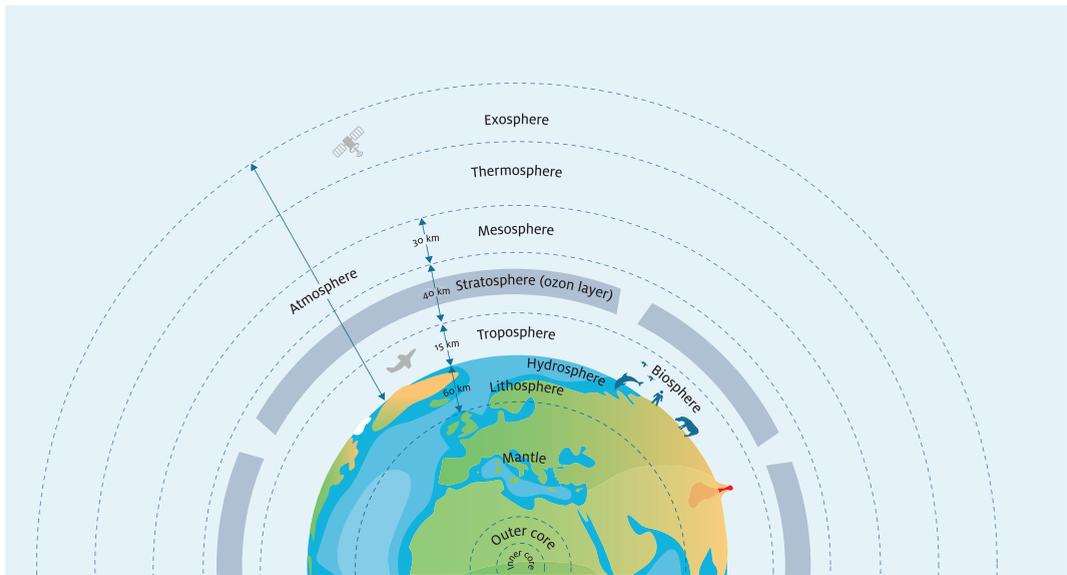
In 2010, the IWC met with 88 member states and proposed a compromise to lift the 24-year-old ban on commercial whaling. Parts of the proposals consisted in banning whaling in the Southern Ocean, and which was declared a whale sanctuary, banning all commercial whaling and allowing only commercial whale catching by indigenous peoples.

The total numbers of whales (all species) was reduced from 2.56 million (1890) to 800.000 in 2001, recovering to 1.7 million whales nowadays. How impressive and powerful this short-termed era of the Anthropocene is<sup>17, 18</sup>.

Today's impending new ecosystem derangement is different in four ways: it is mankind-driven, larger parts of the ecosystem are involved, its higher velocity prohibits adaptation and human intellectual power outweighs the absorbance and recovery capacity of the ecosystem. In other words, the planet is losing.

Today, the powerful influence of the Anthropocene is evident – the larger the human population in the Anthropocene, the more it alters earth's ecosystems and will impact its own human health. Increasing living standards in developed and rapidly developing countries results in the accelerated conversion of natural land to agriculture or urban areas. For instance, by biotic homogenisation (the loss of biodiversity due to a process of increasing similarity over time between

two or more spatially distributed ecological communities), these Anthropogenic processes greatly alter plant and animal communities, thereby changing the transmission patterns of the zoonotic pathogens (any disease-producing agents, like viruses, bacteria or other microorganisms) they carry<sup>149</sup>. And these changes present new challenges as novel pathogens spill over from wildlife to humans, and vice versa. Pathogens invade natural areas and novel host species are transmitted to new continents or islands. Animal populations increase or decrease as land-use changes and regional climates become warmer and wetter or drier. This a typical example of environmental interconnectedness that ultimately threatens human health and demands a different approach to healthy living and health care delivering services<sup>150-153</sup>.



**Figure 3.1** Apple peel ecozone

The apple peel ecozone consists of 35 kilometres of the earth's solid crust (Lithosphere) and the Troposphere, the lower part of the atmosphere, of about 15 kilometres. The hydrosphere contains oceans, rivers, ice and all other fresh water supplies.

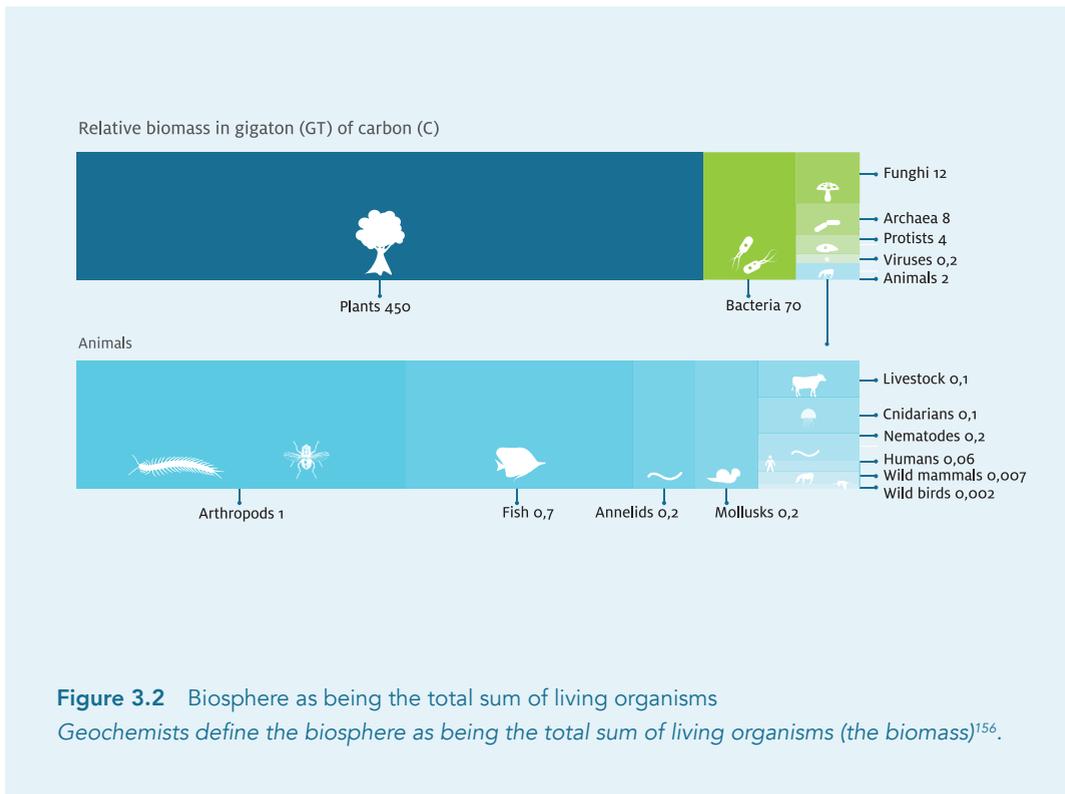
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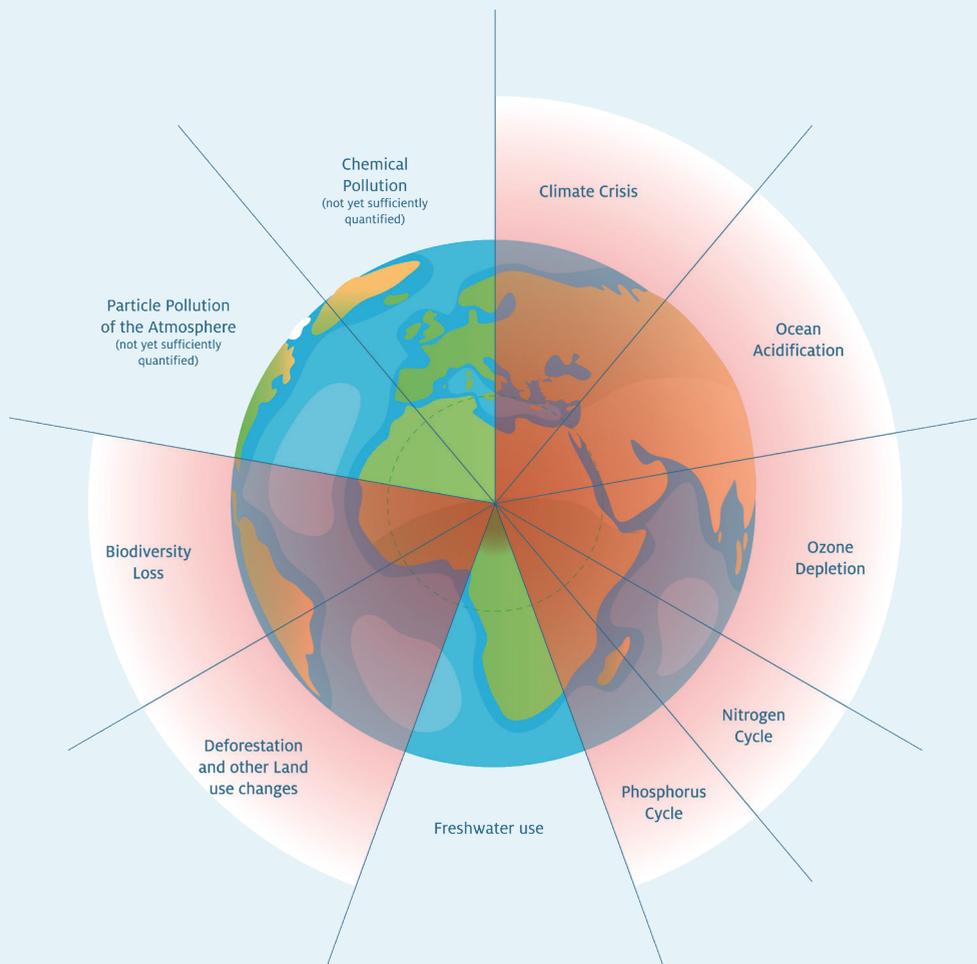
In later chapters, the effects of environmental change on human health will be described. But first, in this chapter, a brief description of the ecosystem itself is described. This explanatory chapter is important as it helps us understand how nature interacts with human health and uncovers the complex interactions at play. The major planetary health issues at stake will be discussed in the next chapter.

### Biosphere, Atmosphere, Lithosphere, Hydrosphere

The biosphere is defined as all organisms within the earth's system, enclosed in an 'apple peel' of about 50 km (Figure 3.1). Imaging this thin living zone enclosed between the earth's molten core and mantle, with a radius of roughly 6343 kilometres and an endless universe makes us realise how unique the biosphere is. This apple

peel ecozone, with a depth of only 35 kilometres of solid crust, a height of 15 kilometres of troposphere and a volume of roughly 25.5 billion  $\text{km}^3$ , is the essential living zone harbouring all known organisms, including mankind. The apple peel zone relates to the concept of the Earth's Critical Zone<sup>154, 155</sup>. And becomes even more interesting when we realise how much biosphere volume each person of today's global population of eight billion people has at their disposal or, rather, which they should conserve. Dividing 25.47 billion  $\text{km}^3$  by eight billion people would render a personal biosphere of 3.184  $\text{km}^3$  per person. Such a personal biosphere means a personal area of five  $\text{m}^2$  to live in and to nurture. Five square meters, with, vertically, a biosphere of 50 kilometres of the troposphere and solid crust and all that's within it. This is not much!





**Figure 3.3** Theoretical concept of the state of imbalance of planetary boundaries  
*In 2020, according to the theoretical concept of Planetary Boundaries, six out of nine boundaries were supposed to be endangered: climate change (1), ozone depletion (2), nitrogen and phosphorus cycles (3), biodiversity loss (4), deforestation and other land use changes (5), and oceanic changes (6). Although still controversial, all changes are considered to be manifestations of humankind's activities, driving the earth into a new state of imbalance<sup>158</sup>.*

The biosphere is estimated to contain between 10-14 million species. All inhabitants of this unique ecosystem – flora and fauna – contribute to the balance of the build-up and consumption of all organic material (or biomass), the basis for all living species (Figure 3.2). Humanity, so far, is the only species that intervenes in this ecosystem balance in such a way that it is severely being disturbed and causing changes which threaten to become irreversible.

Historically, we have always fantasised about the vulnerability of our world through the invasions of aliens, the ‘big bang’ of a massive meteorite impact or natural atmospheric changes, like ice ages. Nowadays, that threat comes from within. One species: mankind, has been able to become dominant over all other living species in this small ecozone. Tragedy shows that, on the one hand, our human intelligence has enabled us to survive, outgrow numerically, develop natural resources and sophisticatedly harvest any needs, as well as being capable of making nearly all other living obey. But, on the other hand, other parts of our way of thinking, like materialism, ambition, short-term vision and greed, are not balanced with our perceptions and demands of long-term sustainability.

### Planetary health and planetary boundaries

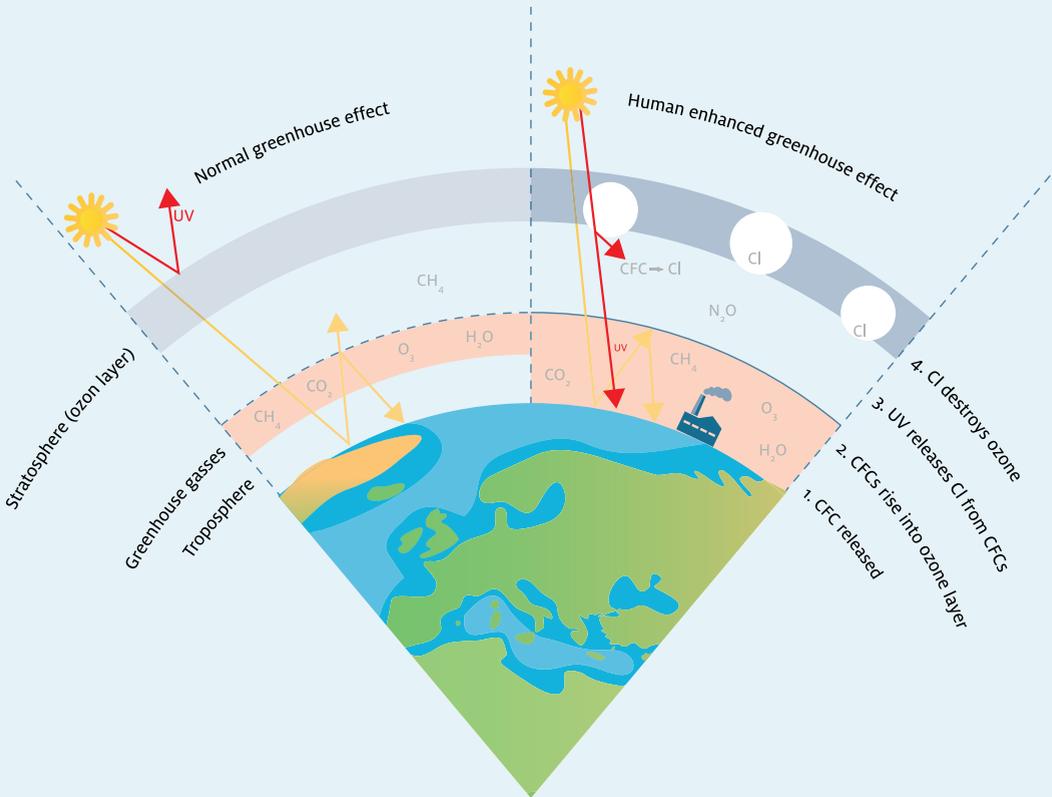
Planetary health has earlier been defined as: “The health of mankind and the state of the natural ecosystem to which mankind’s health is dependent”<sup>157</sup>. For instance, gross changes in temperature, a global shortage of drinking water and biodiversity loss will also have major impacts on the health of mankind (Figure 3.3).

The theoretical concept of planetary boundaries was introduced in 2009, in *Nature*, by Rockström

et al.<sup>158</sup>. The authors described the global ecosystem as a system with nine boundaries in which mankind should navigate cautiously in order to secure sustainable use of planetary resources and maintain that ecological balance. Exceeding a boundary is regarded as destructive to the earth system, posing threats to humans, animals and the planet. The planet’s ecosystem has a strong resilience and the ability to adapt to climate change but globally, regions vary in their vulnerability to exposure<sup>159-163</sup>. Although true evidence of climate change is still controversial, many important changes are considered to be manifestations of mankind’s activities.

According to the latest Intergovernmental Panel on Climate Change (IPCC), the global surface temperature was 1.09 [0.95 to 1.20] °C higher in 2011-2020 than in 1850-1900, which is directly related to the Industrial Age<sup>164</sup>. Warming over land (1.59 [1.34 to 1.83] °C) was stronger than warming over the ocean (0.88 [0.68 to 1.01] °C)<sup>165</sup>. And climate change records surpassed every other year. As reality shows, among the last three warmest decades, this decade has been the warmest ever recorded<sup>166</sup>. The 2022 IPCC report warned that the world would reach the 1.5 °C level within the next two decades, driving high risks of biodiversity decline and increasing mortality, species extinction and loss of livelihood<sup>165</sup>. So far, 30 years of energy and climate policies have not reduced the global emission rates of greenhouse gases, the main driver of temperature rise.

National commitments, as agreed under the Paris Agreement, are unlikely to limit global warming to 1.5 °C, even if supplemented by stricter objectives of emissions reductions after 2030<sup>167</sup>.



**Figure 3.4** Greenhouse gases effects

Normally the earth absorbs radiant energy from the sun. It subsequently reflects some of the energy as light and radiates the rest back into the atmosphere as heat. Natural greenhouse gases in the troposphere (water vapour (H<sub>2</sub>O), carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O) and ozone (O<sub>3</sub>)) absorb thermal infrared energy coming from the earth's surface and delay its transmission into space. In a normal situation, they maintain an average temperature on the earth's surface of around 15°C.

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## Greenhouse gases effects and ozone depletion

Large-scale agriculture, deforestation and industries using fossil resources (wood, oil, gas, coals, peat, etc.) have greatly changed the concentration of most of the greenhouse substances, like CO<sub>2</sub>, N<sub>2</sub>O and CH<sub>4</sub> and have changed the earth's climate by retaining heat in the lower atmosphere (Figure 3.4)<sup>168, 169</sup>.

In the pre-industrial era, the Holocene, concentrations of greenhouse gases were more or less constant but, since the beginning of the Industrial Age (1750), humankind has produced more greenhouse gases than the natural turnover can handle. This is especially true for carbon dioxide (CO<sub>2</sub>) production through the combustion of fossil fuels and deforestation. To illustrate, at present, 25 of the biggest multinational industrial companies are responsible for 50% of CO<sub>2</sub> emissions worldwide<sup>170, 171</sup>. Secondly, the increase of methane (CH<sub>4</sub>) through the agricultural activities of livestock, rice cultivation and the fossil-fuel industry is significant and a dominant factor in this greenhouse effect. Additionally, atmospheric methane is also increasing significantly due to the recent onset of the melting of permafrost in Siberia.

Apart from the humankind-induced greenhouse effect by natural gases, unnatural chemical products like Chlorofluorocarbon (CFC) propellants play an important role in affecting the ozone layer. Although CFC propellants were banned by the Montreal protocol<sup>172</sup> in 1989, this ozone effect is supposed to last into the second half of the 21<sup>st</sup> century. Both effects, greenhouse gases and ozone destruction, are dominant factors in atmospheric temperature changes.

## Key points

The influence of the Anthropocene on today's ecosystem derangement is unprecedented. Humankind-driven disruptions involve larger parts of the ecosystem than ever before and its high velocity prohibits adaption in any form.

- Humankind has become dominant over all living species in the ecozone and intervenes in the ecosystem balance in such a way that it causes **irreversible damages** to the ecosystem.
- Nine boundaries are distinguished within which humankind should navigate cautiously to secure a **sustainable use of planetary resources** and maintain an ecological balance; they define humankind's 'safe operating space'. Currently, six out of nine planetary boundaries have been crossed.
- Since the beginning of the Industrial Age, humankind has produced **more greenhouse gases** than the natural turnover can handle.

Chapter

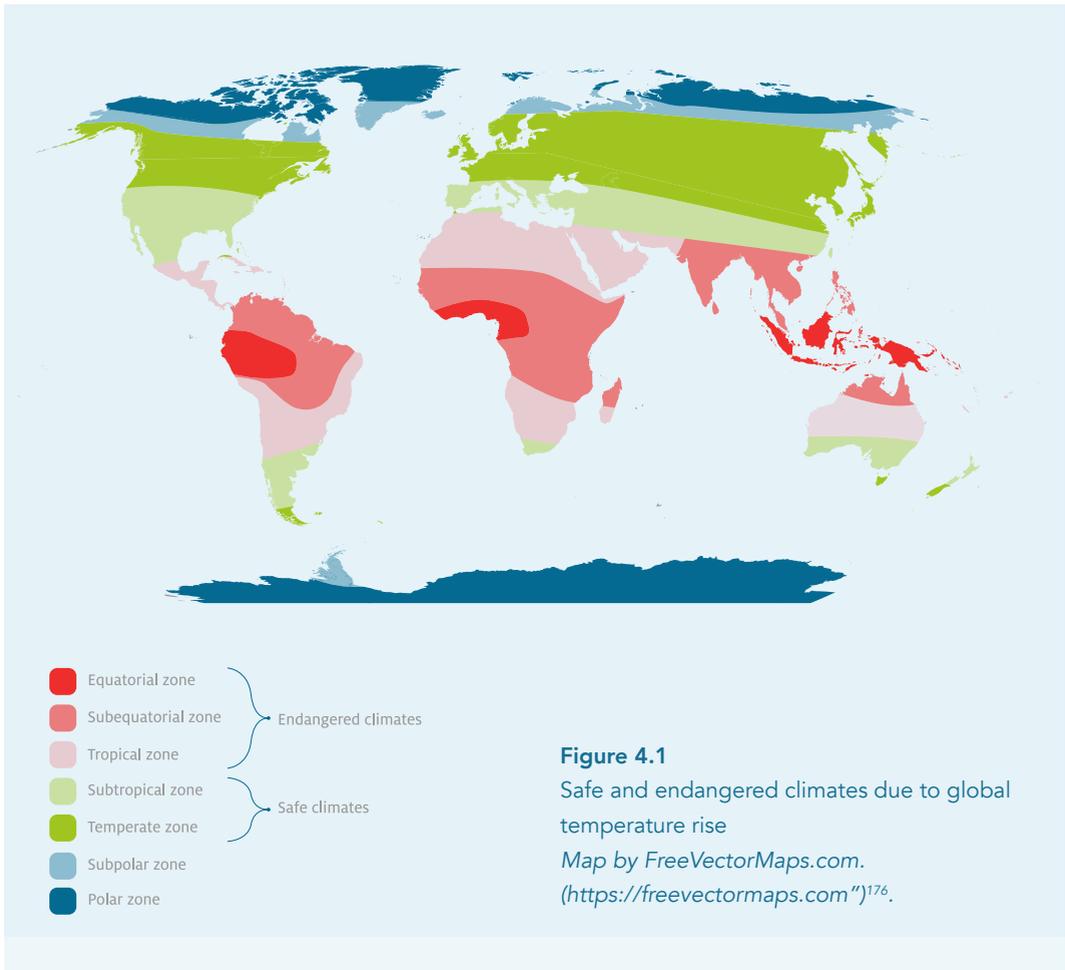


# Major planetary health issues

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**THE** world is facing a triple planetary crisis: climate change, pollution and biodiversity loss<sup>173</sup>. Each of these three planetary crises threatens various planetary boundaries. Realising that at least six out of nine planetary boundaries are already endangered (Figure 3.3), which of these important boundaries are also relevant to human health in the 21st century? In this chapter, we will explore the possible relationship between planetary and human health disruptions. Comprehension of this strong interdependency will urge us to think differently about health systems in another – more integrative – way. In further chapters, the integration of prevention and disease care will be coupled with a more sustainable living environment.

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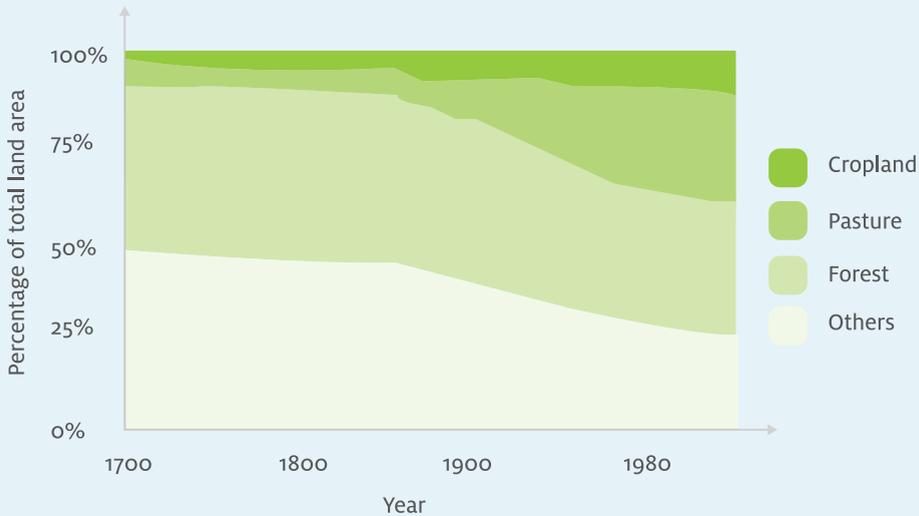


**Figure 4.1**  
 Safe and endangered climates due to global temperature rise  
 Map by FreeVectorMaps.com.  
 (<https://freevectormaps.com/>)<sup>176</sup>.

### I - The climate crisis and ozone depletion

With the IPCC global surface temperature rise of 1.09 degrees in mind, climate change is one of the main drivers of environmental change and will globally affect all people with the specific effects of stratospheric ozone changes and extreme weather conditions<sup>4, 174</sup>. The Lancet Countdown developed a 'Tracking Progress on Health and Climate Change' to provide an independent, global monitoring system of indicators across five domains<sup>175</sup>. Authors concluded that the observed trends in climate change demonstrate an unacceptably high level of risk for the future health of populations across the world.

The effects of heat stress differ across global regions, owing to local variations in climate response, population density and living conditions<sup>177</sup>. The analysis of Sun et al. shows that the frequency and intensity of heat events is increasing, especially in tropical and (sub)equatorial regions (geographic perspective) and developing countries (national perspective) (Figure 4.1). Metropolises in low-income countries and in tropical and (sub)equatorial zones are most vulnerable to natural disasters, climate excesses and the related spread of diseases. Meanwhile, temperate climate zones, like the subtropical and temperate zones, will turn into relatively safe havens.



**Figure 4.2** Land distribution changes in time  
*Natural forests have decreased globally by 25% and only 35% of all land is still unaffected or wild<sup>180</sup>.*

## II – Deforestation and other land use changes

Deforestation, defined as the clear-cutting, partial logging or deliberate burning of forests (or accidental fires), is one of the biggest issues in the change of global land use. According to the Botanic Gardens Conservation International, of the 58,497 registered tree species globally, 17,150 species (30%) are nominated as ‘threatened’<sup>178</sup>. For this, agriculture, logging and livestock farming, but also climate change and extreme droughts, are held responsible. Whereas selective logging may seem attractive, the way it changes a dense, closed and wet forest into a more open, dry cultivated forest leads to increased flammability, especially in changing climates with prolonged periods of heat and droughts.

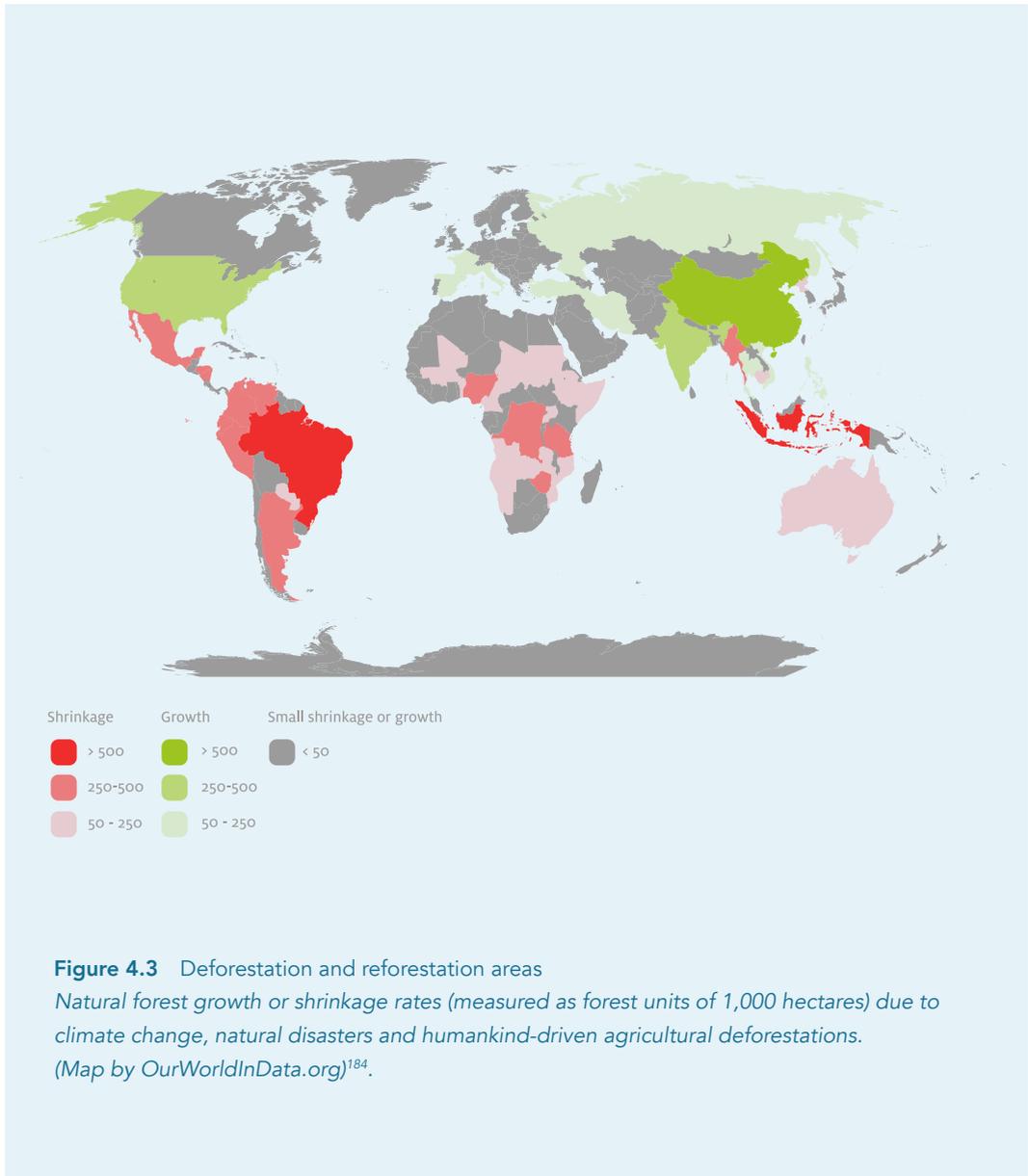
Since 1850, 40% of the total forest area has been deforested, with most of it (30%) being converted into cropland or pastureland purposes. Nowadays, only one quarter of the world’s land – instead of half in the pre-agricultural ages – is covered with forest (Figure 4.2). To put this data in perspective, never before did the human living environment cover almost half of all habitable land (in 2018, it covered five billion out of 10.6 billion hectares). Similarly, never before was 14% of the planet occupied with urban and built-up land<sup>179</sup>.

The United Nations Food and Agriculture Organisation (FAO) has estimated that 1.3 million square kilometres are still being deforested annually, mainly in the tropics. The main reason this is happening is because of slash-and-burn agriculture by small-scale farmers (South East Asia, Africa and South America) and the rubber tree

and palm oil industries<sup>181</sup>. Of most concern are the recent mass forest fires in Siberia and California, as they have been happening in what are usually considered safe climates, the temperate and subtropical zones (Figure 4.1). Record-breaking levels of air pollution due to forest fires have led to serious health issues.

### Effects on deforestation and quality of forests

Forests are one of the top three main absorbing resources in the carbon cycle and other biomass homeostasis. They absorb more CO<sub>2</sub> from the atmosphere than any other system, harbouring roughly two-thirds of terrestrial plant biomass and a substantial fraction of global soil carbon<sup>182</sup>



**Figure 4.3** Deforestation and reforestation areas  
*Natural forest growth or shrinkage rates (measured as forest units of 1,000 hectares) due to climate change, natural disasters and humankind-driven agricultural deforestations. (Map by OurWorldInData.org)<sup>184</sup>.*

(Figure 4.3). Forests worldwide absorb 8.8 billion tons of CO<sub>2</sub> annually by photosynthesis, which equals about one-third of the total production of greenhouse gases by humans. Deforestation undermines the self-balancing function of CO<sub>2</sub> absorption by decreasing its carbon sequestering capacity. Additionally, when trees are burned, CO<sub>2</sub> is released into the atmosphere, thus adding to the greenhouse effect.

Tropical trees perform most of the world's photosynthesis, at 60%. However, plants, animals, microorganisms and fungi in these ecosystems also respire a similar amount back to the atmosphere, the so-called 'neutral carbon cycle balance'<sup>183</sup>. A small proportional change in CO<sub>2</sub> absorption or emission can result in a large shift. In the near future, tropical forests may lose much of their carbon absorption capacity due to the negative effect of climate change on the remaining forests.

### III – Ocean acidification and other water-related changes

Next to climate crisis and deforestation, today we are more and more exposed to water-related changes. First to consider are the oceans, which cover around 71% of our planet and play a crucial role in weather and climate-induced greenhouse gas patterns. Oceans harvest the phytoplankton, which is, next to global forests, the main atmosphere CO<sub>2</sub> cleaner. Oceans also play an important role as food larders. And more and more, oceans form our transport highways and play a role in the supply of oil, gas and wind energy<sup>185</sup>.

### Ocean chemical pollution and acidification

Besides these effects, oceans have become the sewer for all kinds of biological and chemical waste, making them more acidic and thus resulting in changes in their natural nutrient composition. The accumulation of mainly nitrogen and phosphorus nutrients has been related to climate change, loss of phytoplankton, biodiversity loss and algae growth<sup>186</sup>. Moreover, protective calcified exoskeletons of sea life and coral reefs are dissolving due to the increased acidity<sup>187</sup>.

### Seawater plastic pollution

Awuchi et al. studied the impact of plastic pollution on the sustainability of the seafood value chain<sup>188</sup>. Authors estimate that about 1.1-1.8 million metric tons of plastic waste enter the world's oceans from coastal communities every year.

As an interaction with climate change, oceanic coastal flooding, surges and hurricanes occur more often, especially in (sub)equatorial areas and other areas like the temperate zone of the south of the United States of America<sup>164</sup>.

### Sea level rise and flooding

Rivers play an essential role in the global water cycle due to their unique high flow capacity. Rivers drain 75% of all the earth's land surface water and harbour and disseminate unique flora and fauna. Mankind has always been very dependent on rivers and lakes by establishing agricultural settings, villages and cities in fertile river valleys near seacoast river mouths and coastal deltas. Since the 20<sup>th</sup> century, more than 50% of the world's population has lived within 60 km of the coast. Normally, the net effect of the evaporation of water from oceans its replenishment by rivers is balanced. However, due to global warming effects, especially glacier melting, sea

levels are rising. Prospects of further sea level rise may force people to move inland as a result of floodings at high tides, coastal flood damage and increased erosion.

Next to sea level rise, more incidents of flooding are recognised. Striking recent examples are the 'nuisance floodings', defined as tidal floodings above the minor flooding threshold<sup>189</sup>, such as in Miami, in the United States of America. Also striking are the 'sunny day floodings', tidal floodings of low-lying areas that cause disruption to living deltas, like in Bangladesh, turning fresh drinking water into brackish water and necessitating mass inward population migrations<sup>189</sup>.

#### **Changes in freshwater sources and effects on the habitat and health of humans**

Wetlands, particularly those in coastal areas, are among the biologically most diverse places and, with 40% of the world's plants and animal species breeding and partially living in them, wetlands are considered global biodiversity hotspots. Peatlands and vegetated coastal wetlands have an immense carbon sequestering capacity, comparable to that of global forest ecosystems. Wetlands also neutralise the impacts of flooding by their buffering capacity and reducing the speed of floodwater flows<sup>190</sup>. Draining wetlands and converting them to land for agriculture, as has been done in many countries all over the world, enhances soil matter to oxidise and release CO<sub>2</sub> into the atmosphere<sup>191, 192</sup>. Moreover, coastal mangrove deforestation leads to substantial additional CO<sub>2</sub> releases. Therefore, Anthropogenic activities, like water extraction, agricultural nutrient eutrophication (a process by which excess nutrients lead to selective growth and the diminishing of biodiversity) and climate change effects threaten many wetlands globally<sup>193</sup>. Pro-

tection of wetlands has been suggested to be one of the most important actions in promoting the resilience and sustainability of biodiversity, as well as the wetlands playing the role of the 'earth's kidneys' in filtering the pollutants from water that flow through them on their way to receiving lakes, rivers and oceans<sup>190, 194</sup>.

A large body of evidence has shown that the natural flow of freshwater resources (rivers, lakes, wetlands and groundwater-dependent ecosystems) normally controls the environmental conditions of estuaries and coastal waters by influencing estuarine circulation patterns, water quality, the natural reduction of salinisation and balancing the growth of freshwater plant and animal life<sup>195</sup>. An altered flow regime leads to a vicious cycle of impoverishment, allowing an invasion of exotic species but also favouring vectors for disease transmission<sup>196</sup>.

Humans have changed the natural courses of many rivers and freshwater sources by diverting them and building around 50.000 large dams worldwide for energy generation and creating irrigation lands<sup>197</sup>.

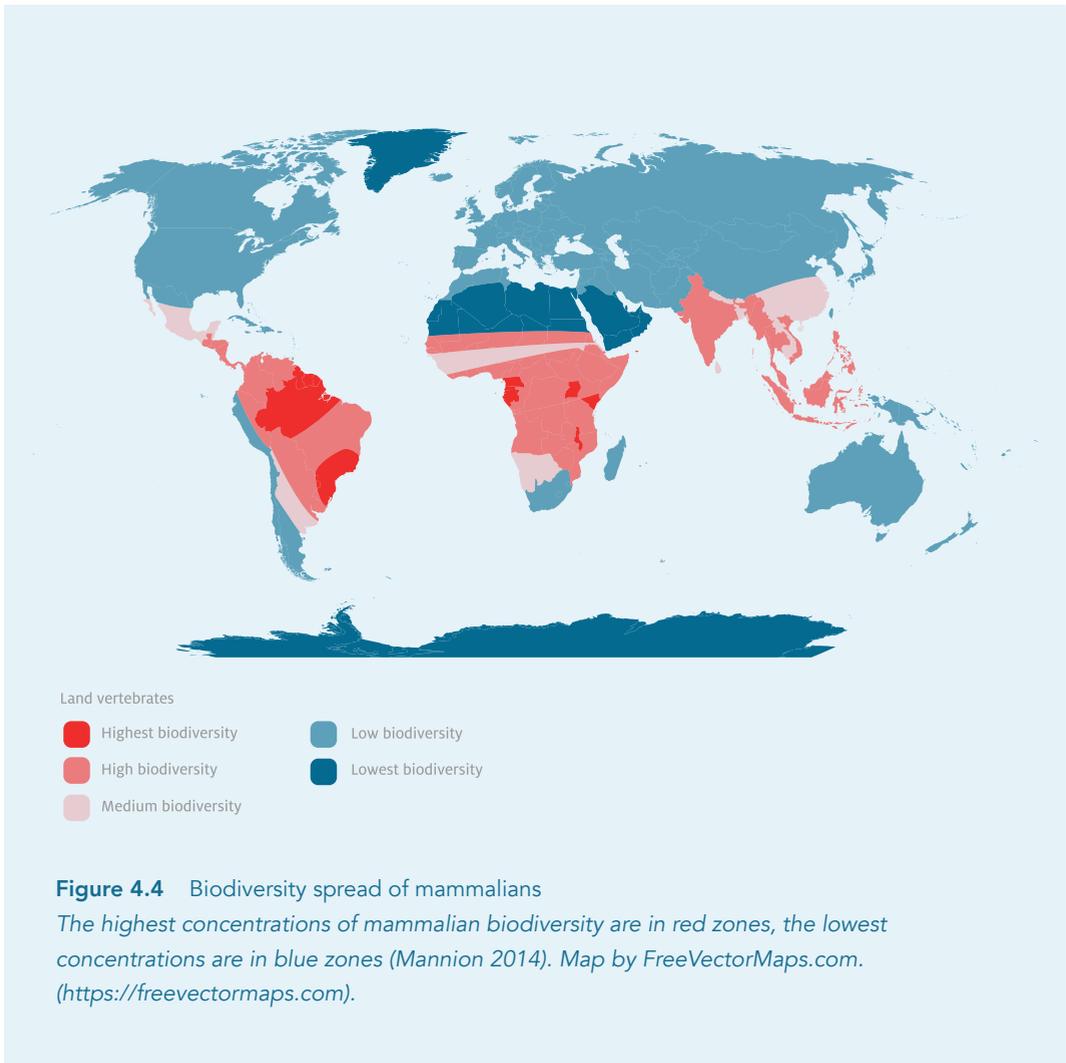
It is not only the building of large dams and the diversion of freshwater resources but climate change itself, with regions becoming warmer and dryer, that has led to decreased water availability and which forms an additional factor distressing freshwater availability for humans, animals and plants<sup>198, 199</sup>. Around one million animal and plant species are endangered, with freshwater species, especially, being most at risk of extinction (numbers have decreased by 84% since 1970)<sup>200</sup>. And this is in line with the global disappearing of 85% of wetlands as biodiversity hotspots, since 1700<sup>201</sup>.

### Groundwater contaminations

The chemical contamination of groundwater has many origins, for example, pesticides, herbicides and fertilisers. Pollutants from industrial, mining and agricultural activities, untreated urban and rural waste, oil spills and toxic dumping have caused strong negative effects on biodiversity and freshwater quality. Chemical manufacturing and chemical spillage, as the most important polluters of rivers globally, are responsible for the contamination of drinking water and form a serious health threat<sup>202</sup>.

### IV - Biodiversity loss

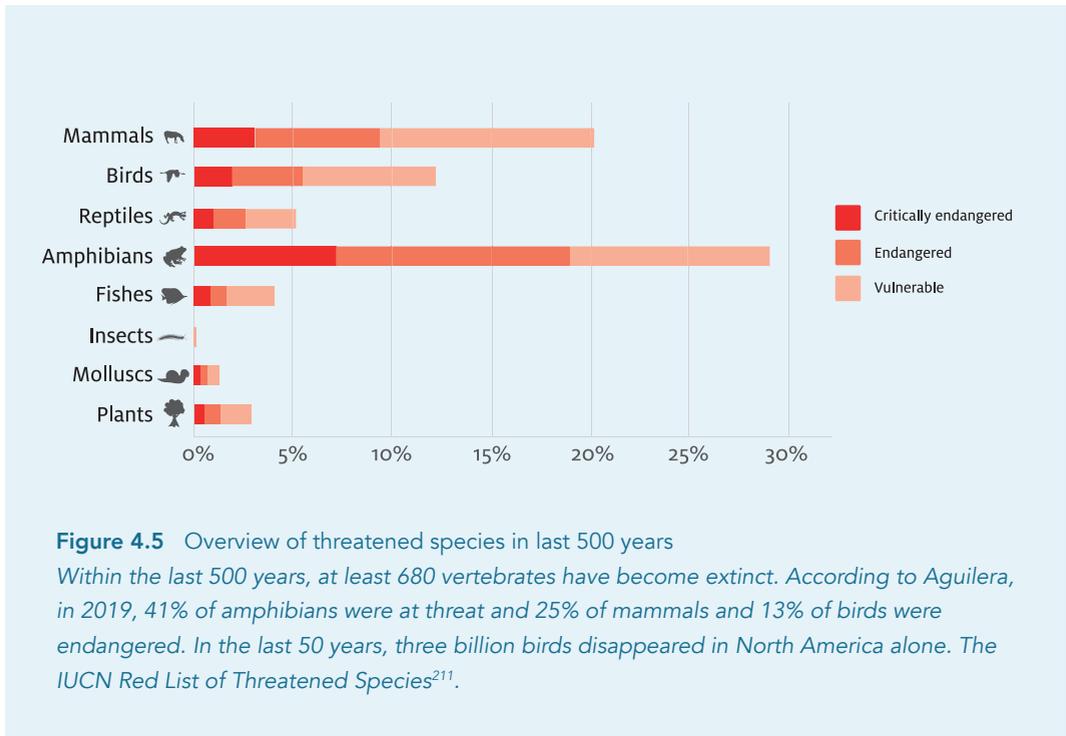
The fourth endangered planetary boundary is that of flora and fauna. Whereas previous mass extinctions among animals were the work of nature itself, the present, and ongoing, 20<sup>th</sup> and 21<sup>st</sup> century mass reductions of plant and animal species – sometimes referred to as ‘Holocene extinction’ – are at least accelerated by human interventions in the past three centuries<sup>203</sup>. The related loss of biodiversity has a negative impact on human health<sup>204-206</sup>. A stable biodiversity of flora and fauna reflects a balanced ecosystem.



Biodiversity is highest in dense forest regions (Figure 4.4). Non-living components like fossils are to be regarded as evolutionary end-products, as they are the remains of earlier living on earth. From such an evolutionary point of view, biodiversity needs time to resolve into new fossil resources and meanwhile, it also needs time to develop into new species<sup>207</sup>. However, today, with quickly changing circumstances in the biosphere, many species merely dissolve without evolution. The evolutionary latest and highest form of complexity, the precious living flora and fauna, is bound to be destructed at an earlier date than is usual. Within the last 500 years, at least 680 vertebrates have become extinct (Figure 4.5)<sup>208</sup> and 85% of wildlife mammals are

reported to be endangered<sup>209</sup>. Older planetary boundaries of our ecosphere are more robust and resistant to human-driven ecosphere disturbances<sup>208, 210</sup>.

The International Union for the Conservation of Nature (IUCN) has held the Red List of Threatened Species since 1964 (IUCN Red List)<sup>211</sup>. It is the most comprehensive inventory of all biological species globally. It is considered the most scientific and authoritative guide to the status of biodiversity. The number of species that have been periodically evaluated outnumbers 105,000 species, of which 28,000 are considered at risk of extinction<sup>44, 212, 213</sup>.



### Key points

Humanity is facing a triple planetary crisis, consisting of climate change, biodiversity loss and pollution. In this chapter, we explored the major planetary issues of today related to this crisis:

- Human activity contributes to tipping the natural balance between the **production and destruction of ozone**. With the depletion of the ozone, the earth's surface is more exposed to UVB radiation, thereby increasing the number of heatwaves and affecting biodiversity.
- Deforestation drives global warming as it contributes to **the build-up of carbon dioxide** in the atmosphere. Never have carbon dioxide levels been so high in human history.
- The **warm-up of the ocean** leads to cascading effects, including ocean acidification, sea-level rise, ice melting and floodings.
- Biodiversity loss reduces **nature's resilience to climate change**. The current rate of loss of biodiversity is unprecedented and undermines nature's ability to sustain a healthy climate.
- **Pollution** is everywhere, with for instance microplastics in soil, seawater chemical pollutions, and groundwater contaminations with pesticide and antibiotics.

Chapter



# The impact of environmental changes on human health

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## **Environmental change is the boomerang for human health**

According to the WHO, at the beginning of the 21<sup>st</sup> century, each year seven million people worldwide died prematurely from air pollution and human enhanced greenhouse gases. More than 7% of the global disease burden is caused merely by air pollution<sup>4</sup>. If the current trend of climate change continues, this will have a major negative impact on the disease burden in the second half of this century. And not only climate change, also land use changes and deforestation, hydrosphere changes and biodiversity loss all have specific effects on human health.

The 2021 WHO report on health and climate change identifies key climate-sensitive disease groups<sup>4,15</sup>. A number of these diseases and risk factors are further explained below.

- Heat-related diseases: According to the Lancet Countdown, 157 million more people were exposed to heat waves in 2017 compared to 2000, resulting in an excess mortality from cardiovascular and respiratory diseases<sup>28</sup>. Furthermore, a higher exposure to UV radiation is epidemiologically correlated with the increasing incidence of the most common skin cancers including melanomas<sup>29, 30</sup>. Exposure to UV radiation also increases the risk of cataract formation, which is responsible for 35% of total global blindness<sup>33</sup>.
- Vector-borne diseases. All kinds of natural disasters, such as floods, tsunamis, earthquakes, hurricanes and tornadoes have been linked to subsequent outbreaks of infectious diseases, including diarrhoea and acute respiratory infections. And worldwide, diseases such as malaria and dengue are strongly influenced by the climate.
- Water and food-borne diseases. An increase in the disease prevalence of water-borne pathogens has occurred due to warming air and water conditions that have altered habitat and toxin transfer<sup>36</sup>. In 2020, about 10 million people migrated as a result of hydro-meteorological hazards and disasters.
- Direct injuries/deaths and mental health problems<sup>38</sup>. Natural disasters not only lead to physical injury or death but also to emotional damage with mental disorders, including post-traumatic stress disorder and depression<sup>39</sup>.

Previous disruptions of the Earth's ecosystem have always led to complete extinction of parts of flora and fauna, like the previously described dinosaur extinction, after which a new balance of the ecosystem was achieved. Although humanity seems to be the dominant winning party at the beginning of the 21<sup>st</sup> century, there is growing concern that we may become a victim in the following centuries.

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**NOW,** with a basic understanding of the concepts of environmental change, in this chapter, the interactions of environmental change on human health will be discussed. Different effects of the triple planetary crisis will be discussed, together with its varying effects on different groups of people. Specific groups of the population and global regions are more at risk than others. The degradation of the planetary ecosystem has a boomerang effect on humans, by undermining its health. It makes the urgency to understand climate change and to become fully aware of its importance clear.

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## Populations at risk

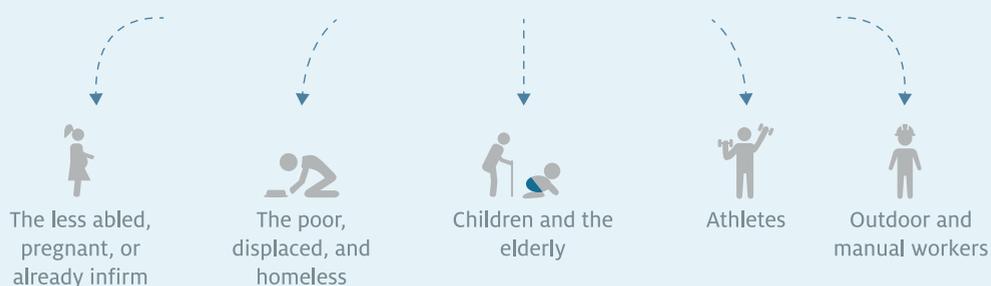
The IPCC climate change 2022 report estimated that 3.3-3.6 billion people live in areas that are highly vulnerable to climate change<sup>165</sup>. Vulnerability is highest for people living in coastal regions, megacities and (sub)equatorial zones, especially for indigenous peoples. Climate change impacts health, especially in LMICs<sup>214, 215</sup>. As King et al. indicated, it is the poorest regional populations that will be subjected to the greatest changes of global warming<sup>216</sup>. Therefore, climate change threatens to amplify the already persisting inequities and inequalities in the world, dividing those who have the resources to prepare, respond and adapt to climate change and those who have not. From this perspective, the prevention of global warming becomes an instrument

towards the prevention of poverty growth and widening of global inequalities. Children living in poor countries, elderly people, people with infirmities or pre-existing medical conditions are most endangered by prolonged expositions to health impacts (Figure 5.1).

## Mass migration

Endangered regional populations lead to mass migrations. Many mass population migrations have occurred throughout the age. Important examples include the Italian diaspora (1880-1915) or the partition of India (1947) into the independent states of India and Pakistan, when, according to the UNHCR, 20 million Hindus, Sikhs and Muslims were displaced<sup>217-220</sup>.

### Multiple vulnerabilities increase the risk of health impacts



**Figure 5.1** Vulnerable populations at risk

Various population groups, especially in poor countries, are most endangered by prolonged expositions to health impacts (WHO 2018 report)<sup>4</sup>. Examples of prolonged expositions are prolonged periods of drought, excessive seasonal flooding, prolonged periods of extreme temperatures and massive wildfires with air pollution.

In present times, however, more people are moving around the world than ever before due to war, human rights violations, persecution, freshwater scarcity and food shortages<sup>221</sup>. Many countries nowadays are confronted with intensive migration effects from three different perspectives: as countries where masses of migrants depart from (however, these countries accommodate by far the most internally displaced persons), as transit countries and as destination countries confronted with high numbers (but within the global perspective, relatively low numbers) of incoming migrants. Nowadays, UNHCR estimates that global forced displacement surpassed 89 million in 2021, with hotspots like the Syrian Arab Republic (with 6.8 million people) and recently, Ukraine, with four million people registered as being refugees by the UN Refugee Agency<sup>222</sup>.

## **I - Effects of climate change on human health**

Climate change, as the first driver of environmental change, will globally affect all people through the specific effects of stratospheric ozone changes and extreme weather conditions<sup>4, 174</sup>. It directly interacts with the basic needs of humans, like clean air, safe drinking water, sufficient food and secure shelter. Indirectly, it affects social well-being and health. According to the WHO<sup>2</sup>, between 2030 and 2050, each year, climate change will cause increasing numbers of additional deaths from heat stress, malnutrition, malaria and diarrhoea <sup>2, 223-225</sup>.

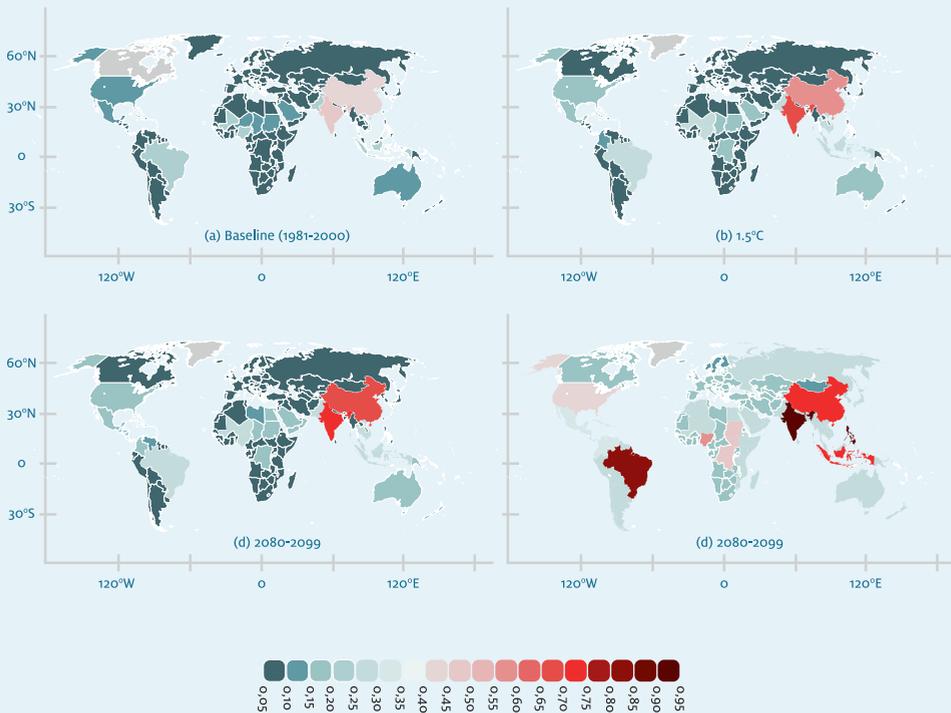
Specific attention is also paid to changes in stratospheric ozone over the last 60 years that have altered solar ultraviolet (UV) radiation conditions. Higher solar UV exposure is epidemiologically linked to increased incidences of the most common skin cancers: basal cell carcinoma

and squamous cell carcinoma. According to data from the Skin Cancer Foundation, about 5.4 million people in the United States get carcinoma-type skin cancer every year<sup>226</sup>. Furthermore, exposing the eyes to UV radiation increases the risk of cataracts, which accounts for 35% of total blindness<sup>33</sup>. Melanoma, although making up less than 5% of skin cancers, but with a higher mortality rate, is responsible for approximately 60,000 deaths worldwide each year. Exposure to UV radiation accounts for 60-96% of the risk of developing cutaneous malignant melanoma in light-skinned populations. There were almost 300,000 new melanoma patients worldwide in 2018 and around 90% of all new melanomas are believed to be caused by UV radiation, mainly from sunlight<sup>227, 228</sup>. The largest effects of increased UV exposure on the incidence rises of skin cancer are seen in the population cohort that was born between 1960-1980, since these have experienced the full period of stratospheric ozone depletion<sup>33</sup>.

According to the 2018 WHO report on health and climate change, the following five main climate-sensitive disease groups have been identified as being directly related to climate change<sup>4</sup>: heat-related diseases, vector-borne diseases, water and food-borne diseases, direct injuries/deaths and mental health issues<sup>10, 38</sup>. These will be dealt with below.

### **Heat-related diseases**

Extreme high temperatures are one of the greatest global natural risks to human health. The risk of human illness and mortality increases on extremely high-temperature days, especially when combined with increases in humidity, which limits people's ability to dissipate heat. The health heat index (HHI) is often used to identify episodes



**Figure 5.2** Exposure of heat stress during different global warming periods  
*Integrated exposure to dangerous heat stress during different global warming periods. Country-level average HHI-integrated exposure index values (dimensionless) for (a) the baseline period 1981–2000, (b) the 1.5 °C warming target, (c) the 2.0 °C warming target, and (d) the 2080–2099 (Representative Concentration Pathways) RCP 8.5 global warming scenario<sup>231, 232</sup>. Coming from a baseline HHI of around 0.05, a gradual global increase is seen towards an HHI of 0.30 and above.*

of extreme heat. According to the US National Weather Service, days with HHI > 40.6 °C are seriously dangerous for at-risk groups<sup>229, 230</sup>. In the baseline period 1981–2000, India, China, Brazil and several countries located in Central Africa experienced the greatest heat threats and, by the end of the 21<sup>st</sup> century, more than 95% of all countries worldwide will face exposure to health-related heat stress (Figure 5.2).

According to the Lancet Countdown, 157 million more people were exposed to heatwave events in 2017, compared to 2000<sup>233</sup>. Extreme heatwaves have been shown to be directly responsible for deaths from cardiovascular and respiratory disease, particularly among elderly people, as shown during the heatwave of the summer of 2003 in Europe, with more than 70,000 recorded excess deaths and the 2010 heatwave in Russia with 56,000 excess deaths.

High heat-related illnesses (e.g., heat exhaustion, heat syncope and heat strokes) caused by the inability of people, especially the elderly, to redistribute blood from the vital organs to the areas below the skin to thermoregulate the body results in increased stress on the cardio-pulmonary system, leading to severe illness and fatal health events<sup>3, 189, 234-237</sup>. In addition, increased morbidity and mortality rates among diabetic patients have been observed due to increasing complications or a diminished heat loss response by type 2 diabetes<sup>238</sup>. In addition, heat waves increase the vulnerability of pregnant women<sup>239</sup>.

Pollen and other aero-allergen levels are also higher in extreme heat. Higher temperatures and increased CO<sub>2</sub> levels promote plant growth, shifting timing and the production of aero-allergen and reducing air quality. Increased aero-allergens and prolonged pollen seasons are associated with increases in allergic rhinitis, and they trigger asthma, which affects around 300 million people<sup>240, 241</sup>.

### **Vector-borne diseases**

Natural disasters may lead to infectious disease outbreaks (of vectors like insects and parasites) by changing the environment and human conditions for disease transmission<sup>242, 243</sup>. A complex mixture of various environmental conditions (e.g., temperature and humidity) strongly affect the habitats of vectors and enhance diseases transmitted through insects, snails or other cold-blooded animals<sup>244</sup>. The availability of suitable vectors is a precondition for the emergence of vector-borne diseases. Climate changes and global warming, therefore, have catastrophic effects on human, animal and environmental ecosystems and more than 60% of human infectious diseases are zoonotic diseases of animal origin<sup>245, 246</sup>.

Small changes in temperature and precipitation can result in large changes in the transmission seasons of vector-borne and water-borne diseases and alter their geographic range, such as in Lyme disease and the West Nile virus<sup>189, 247</sup>. Extended spring and summer seasons increase life and reproduction cycles, as well as the geographic regions of ticks that transmit Lyme disease and lead to an increased risk of exposure to the disease<sup>235, 248, 249</sup>. In the case of the West Nile virus, an increased mosquito life cycle and a larger population, due to warmer temperatures, has led to faster virus replications and is thought to have been responsible for the 2012 West Nile virus outbreak in Texas<sup>250-252</sup>. Also, climate change has significantly widened the geographical habitat where the snail-borne disease schistosomiasis in China occurs<sup>49</sup>. And worldwide, large vector-spread diseases like malaria and dengue are strongly influenced by climate. Malaria kills over 400,000 people (especially children under five years of age) every year in Africa and, with locally expected temperature rises of 2-3 degrees, the population at risk for malaria could increase by another 3-5% of local populations.

All kinds of natural disasters, like floods, tsunamis, earthquakes, hurricanes and tornadoes have been connected with subsequent outbreaks of infectious diseases, including diarrheal diseases, acute respiratory infections, malaria, leptospirosis, measles, dengue fever, viral hepatitis, typhoid fever and meningitis, as well as tetanus and cutaneous mucormycosis<sup>174</sup>.

In LMICs, the above-mentioned events and circumstances have a detrimental effect on child mortality. One of the leading causes of the death of children is malaria. Every twelfth child's death is due to an infection with malaria, which adds up

to 350,000 dead children per year. Funding the availability and provision of bed nets for all children and the development of a vaccine against malaria, as recently tested in Burkina Faso, are the three factors that limit progress in fighting back against malaria<sup>253, 254</sup>.

### Water and food-borne diseases

The prevalence of water-borne diseases due to specific microorganisms like the Cyanobacteria, Cryptosporidium, Giardia and Vibrio bacteria has been on the rise in warmer air and water conditions as their habitat and transmission of toxins are changing<sup>36</sup>. Floods contaminate freshwater supplies, heighten the risk of water-borne diseases and create breeding grounds for disease-carrying insects such as mosquitoes. Higher temperatures and changing precipitation patterns may increase the reproduction and infectious dose of foodborne pathogens such as Salmonella and Escherichia coli, causing gastrointestinal illnesses<sup>255, 256</sup>.

In 2020, approximately 10 million people migrated due to hydro-meteorological hazards and disasters. Hydro-meteorological hazards depend heavily on regional circumstances like excessive temperature rises (e.g., in Middle and South America and Northern parts of Africa) or floods and droughts (e.g., in Southeast Asia). As droughts and floods enforce each other, the threats, therefore, are often multiplied. The unique complex combinations of climatic factors like heat, flooding, forest fires and sea level

rise endanger many regions and metropolises. Especially in coastal cities and, with over 50% of the global population living within 60 kilometres of the coast<sup>4</sup>, sea level rises, flooding and heat waves have resulted in mass spreads of disease, mass damage to infrastructure (like houses, roads and bridges) and mass population migrations<sup>257, 258</sup>.

### Direct injuries, deaths and mental health issues

Natural disasters like flooding, wildfires or landslides pose serious risks for direct injuries, including drowning, orthopaedic or burn trauma, hypothermia, electrocution and carbon monoxide poisoning. In addition, injuries such as physical harm or death, as well as the immense emotional harm due to various types of natural disasters, often lead to mental health disorders in both the victims and their relatives<sup>30, 39</sup>.

## II - Effects of deforestation and other land use changes on human health

Previously, we saw that forests are one of the top three main absorbing resources in the carbon cycle and biomass homeostasis and harbour roughly two-thirds of terrestrial plant biomass<sup>182</sup>. Humankind-driven deforestation, by disrupting the self-balancing function of CO<sub>2</sub>, adds significantly to the greenhouse effect and is considered the most important cause of biodiversity loss.

Deforestation is a growing threat to all life on Earth. Besides driving climate change and the

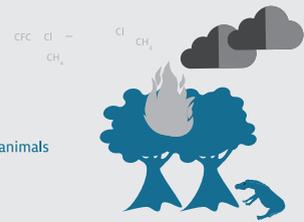
#### Effects of climate change on the habitat and health of humans

- Excessive temperature rises
- Flooding
- New combinations of climate changes like heat, flooding, forest fires, sea level rises
- Mass spreads of diseases
- Mass population migrations



### Effects of deforestation on the habitat and health of humans

- CO<sub>2</sub> sequestering capacity and greenhouse effect
- Biodiversity loss
- Large scale burning leading to record breaking air pollution
- Fragmentation and isolation of animal and plant populations, endangering indigenous tribes and large animals



loss of biodiversity, it causes many health-related problems for humankind. It may impact humans directly. For example, forests provide surrounding habitats with food and clean drinking water<sup>259</sup> but also increase the spread of pathogens as deforestation drives animal migration, leading to increased contact between wildlife and humans. As such, the emergence and re-emergence of pathogens is the most measurable impact of deforestation<sup>260</sup>. Moreover, the conversion of forests by industrial agriculture companies destroys the fertility and biodiversity of the land, thereby threatening food security<sup>261</sup>. In addition, trees protect people from flooding as they absorb rainwater and can hold soil firm during heavy rainfall.

These combinations of deforestation-related problems fire directly back at human health, as will be discussed later<sup>262</sup>.

### III - Effects of the ocean and other water-related changes on human health

#### Sea level rise and flooding

Next to sea level rises, more incidents of flooding are recognised. Striking recent examples are the 'nuisance floodings', defined as tidal floodings above the minor flooding threshold, such as in Miami, in the United States of America<sup>189</sup>. Also striking are the 'sunny day floodings' – tidal flooding of low-lying areas that cause disruption to living deltas – like in Bangladesh, turning fresh

drinking water into brackish water and necessitating mass inward population migrations<sup>189</sup>.

The health impacts of floods, like the 2009 Samoa earthquake and tsunami, include drownings and physical injuries, as well as the carbon monoxide and gasoline poisoning which came after those storms by damaging villages and disrupting their infrastructures<sup>39</sup>.

Globally, the number of reported weather-related natural disasters has more than tripled since the 1960s. Every year, over 60,000 deaths occur due to weather-related disasters, with poor people being the most vulnerable<sup>263</sup>.

Besides higher mortality rates from natural disasters, human health is also indirectly impacted by the loss and disruption of healthcare services due to weather shocks. For example, health facilities may be damaged for a long time due to flooding and storms (e.g., the Indian floods of 2019 and Cyclone Myanmar, 2008), thereby decreasing the supply side of health systems<sup>30</sup>.

#### Seawater plastic pollution

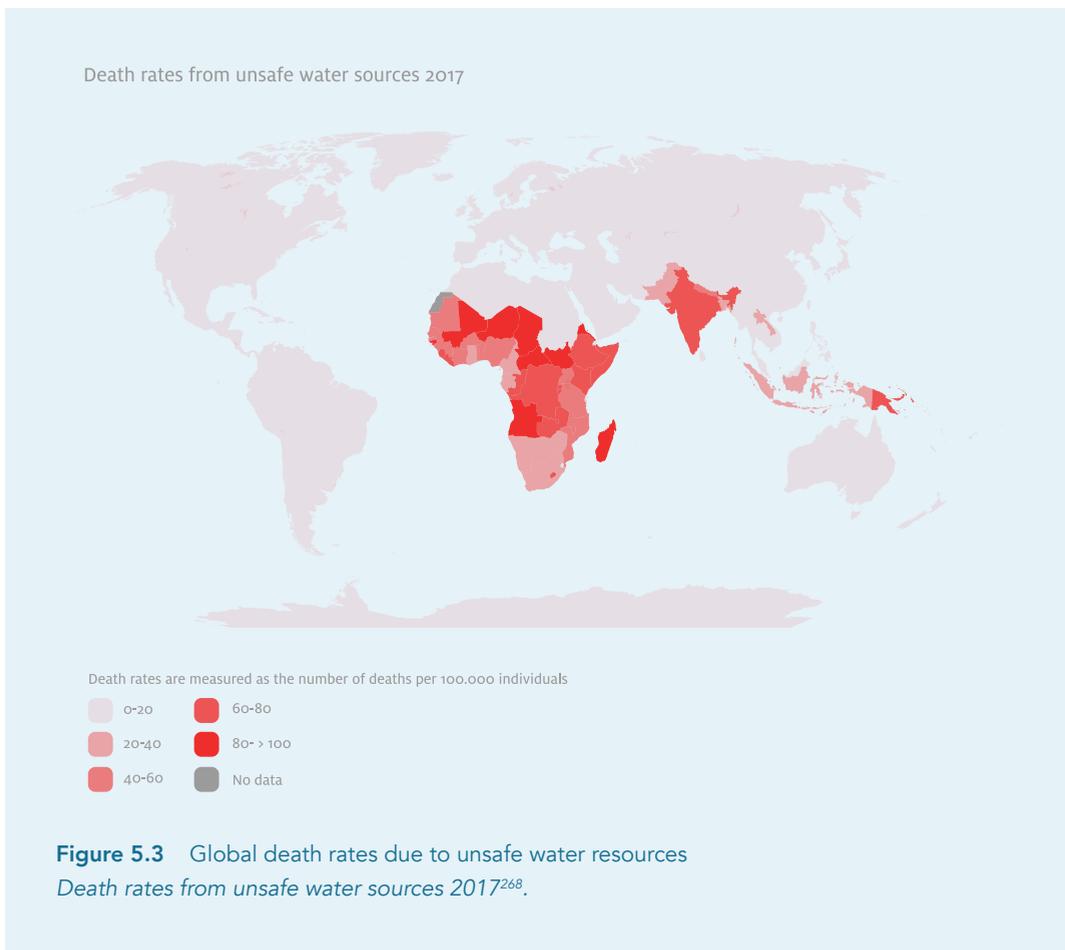
With the enormous amounts of plastic entering the oceans each year, plastics (macro, meso and microplastics) contain toxins and carcinogens that lead to an increase in human immune disorders, cancers and birth defects<sup>264</sup>. The exposure of infants in utero through the maternal consumption of contaminated seafood can damage

brain development. In adults, mercury ingestion has been associated with cardiovascular diseases and dementia.

### Changes in freshwater sources and effects on the habitat and health of humans

Despite these successes in controlling freshwater resources, we have been unable to supply safe drinking water to more than 800 million people (10% of the global population). And, at the end of the Millennium Development Goals period (2000-2015), 91% of the global population had access to improved drinking water<sup>265</sup>. However, according to 2020 data, at least two billion people worldwide use a drinking water

source contaminated with faeces; contaminated drinking water is estimated to cause 485,000 diarrhoeal deaths every year<sup>266</sup>. Other commonly occurring diseases transmitted through unsafe drinking water are infections like hepatitis, cholera, dysentery and typhoid. Moreover, the quality of 80% of the world's water supplies is at risk<sup>169, 267</sup> and the lack of safe drinking water, unsafe sanitation, hunger and undernourishment and diarrheal diseases are strongly correlated. The largest share of deaths from unsafe water sources is concentrated globally in the middle and south of Africa, India, Pakistan and South East Asia<sup>268</sup> (Figure 5.3).



## NARRATIVE

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### **New Orleans, Katrina and Ida**

In 2005, Hurricane Katrina destroyed much of the city New Orleans, Louisiana in the United States of America, a city with around 400,000 inhabitants. It killed 1833 people and cost at least 125 billion US dollars.

Katrina turned out to be a category five Atlantic hurricane. It was the third major hurricane of the Atlantic hurricane season that year and the fourth-most intense Atlantic hurricane on record and made landfall on 29 August 2005 in the contiguous states of Louisiana and Mississippi.

Katrina originated as a merger of three main protagonists: the Tropical Depression 10 from the Windward Islands, a tropical gulf coming from the African coast and a trough of low pressure from the western Atlantic Ocean and the Bahamas. After first crossing southern Florida, it strengthened into a category five hurricane over the waters of the Gulf of Mexico, and its subsequent landfall on 29 August over southeast Louisiana and Mississippi was at category three strength. The eye of the storm was 50 kilometres wide.

In Louisiana, which lies between 0.3 and six meters below sea level, most of the damage was caused by flooding. 80% of the city of New Orleans, as well as large areas surrounding it were inundated for weeks. The hurricane and subsequent flooding destroyed much of New Orleans's communication and transportation facilities. The economic impact was high due to the

destruction of oil platforms and refineries, with leakages from 44 oil facilities. Also, the forestry industry was severely affected with 5,300 km<sup>2</sup> of forest being destroyed. Katrina displaced over one million people from the central gulf coast to other areas in the US.

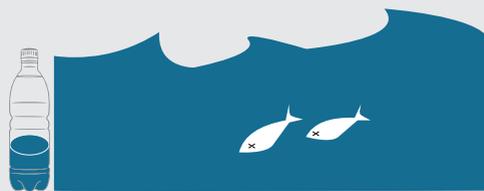
The main environmental effects were the results of damaging beach erosion, which devastated large coastal areas, Louisiana wetlands and important breeding grounds for marine mammals, pelicans, turtles and fish. Also, 16 National Wildlife Refuges were temporarily closed due to damages. The storm caused 53 breaches to various flood protection structures around New Orleans.

In order to prevent repeated disasters, a Hurricane and Storm Damage Risk Reduction System (HSDRRS) was developed (and finished in 2014), around New Orleans. This Delta plan of dykes, steel walls and large storm surge barriers keeps water out in times of extreme weather situations.

In 2021, Ida, a category four hurricane reached New Orleans. This time damage was limited and the HSDRRS protection system proved solid. New Orleans is just one example of hundreds of large cities worldwide to become endangered more frequently by climate change and is in need of future protective measures.

## Effects of hydrosphere changes on the habitat and health of humans

- Biodiversity loss of sea life, compromising its function as food larder
- 30% of fresh water species are endangered
- 10% of world human populations lacks safe drinking water
- 80% of total world's water supplies are at risk



### Freshwater Salination Syndrome

Indirectly, climate change also affects human health through the so-called freshwater salinisation syndrome. Freshwater salinisation is a globally emerging problem that impacts on the quality of drinking water, biodiversity, food production and other ecosystem functions and is caused by the widespread use of road salts, sewage systems, fertilisers, mine drainage and water softeners, but also saltwater intrusion due to sea level rises<sup>269, 270</sup>. Especially in coastal areas, often with dense populations, rising sea levels create salinisation through the saltwater intrusion of coastal regional freshwater sources<sup>271</sup>. Salinisation and other chemicals contribute to disorders of the cardiovascular system like hypertension, neurological systems and cancers<sup>272</sup>.

### Groundwater contaminations

Next to the chemical groundwater contamination with the earlier mentioned pesticides, herbicides and fertilisers, research from Huang et al. proved that the widespread use of antibiotics in human and veterinary medicine has clearly negative effects on human health. Increased levels of antibiotic resistance genes, both in surface waters and urban water systems have led to a widespread risk of the spread of resistant bacteria and horizontal transfer to human populations<sup>273, 274</sup>.

Already in 2006, Moe et al. summarised the major hydrosphere challenges on human health for the future. Based on the growing overall perception of water scarcity and water contami-

nation: (1) implementing low-cost sanitation systems in LMICs, (2) providing sustainable water supplies and sanitation for megacities, and (3) reducing global and regional disparities in access to water and sanitation<sup>197</sup> were and are considered most relevant.

### IV - Changes in biodiversity and their impact on human health

According to the report: 'Connecting Global Priorities: Biodiversity and Human Health,' 2015, five key factors underpin the importance of biodiversity to human health<sup>275</sup>. Biodiversity is essential in sustaining the baseline health status of the human population. Safeguarding biodiversity secures living conditions and the resilience of communities<sup>276, 277</sup>. More and more, we realise that biodiversity is a foundation of ecosystem processes and that its decline impairs the magnitude and stability of the ecosystem. An ecosystem that, in turn, adversely affects human well-being. For a transition towards a more sustainable global development, the linking of biodiversity (e.g., genes, traits, species and other dimensions) and human well-being (e.g., health, wealth, security and other dimensions) is needed and is of research interest in biological sciences<sup>278</sup>.

Biodiversity is the inherited supplier of a great variety of essential needs for maintaining human health. It supplies food (fruits, vegetables, livestock and marine food), nutrients, genetic resources for crop development, freshwater, energy and natural medicines and also delivers

### **African Swine Fever and the world's largest pig factory industry in China**

Once only a rare luxury symbol, now pigs in China are farmed in mass factories with profound consequences for people's health, the environment and biodiversity.

Traditionally, household farmers in China kept two to three indigenous pigs (*sus scrofa*) for self-consumption. Since the 1980s, China has commercialised pig meat consumption and has adopted, developed and intensified the 'factory farm' model for industrial meat production. Agricultural industrialisation has led to a growth of 1.3 billion pigs worldwide, with half of them in China. The industrial pig farms grew out to the world's largest agribusiness sector, with factories that can raise hundreds of thousands of pigs per year. Officials estimate that 90-95% of China's pork is from imported breeds like the Yorkshire and Landrace breeds. Housing is narrow, making the animals immobile, with only some distraction when feeding, including vaccinations and antibiotics. These animals have become more productive with two annual nets of 10-15 piglets that reach maturity within one year.

The consequences are enormous. First, biodiversity is manipulated. Not only has the import and breeding of up to half a billion pigs led to the near extinction of dozens of indigenous China pig species. Next to this, it has proven to be a seedbed for livestock diseases like African swine fever, which has nearly halved the Chinese pig herd by

40%, or 180 million pigs, since the 1980's. By burying infected animals, the normal practice in China, groundwater dissemination of the viruses of infected animals may subsequently prevent China to ever get rid of the viral load.

Not only the viral spread is a leading concern of environmental pollution. The pig factories also lead to a build-up of high concentrations of groundwater antibiotics and antibiotic-resistant organisms in the environment. Manure oversupply from pig factories over pollutes the environment, crippling drinking water supplies. Also, the build-up of growth hormones and heavy metal in meat are considered to attribute to human health problems like cardiovascular disease and cancers. Finally, while humankind in 2020/21 was horrified and distracted by the COVID-19 pandemic it had to endure, meanwhile in China and South Korea hundreds of thousands of pigs were buried alive, a moral delict to animal species and an ethical insult first to animals, but also to humankind.

the basic ingredients for pharmaceuticals. Biodiversity also attributes to entertainment and sports/leisure industries and thus supports societal well-being and economic opportunities, as illustrated and emphasised by studies on the importance of natural environments and green spaces by Aerts et al.<sup>279</sup>.

Changes in biodiversity, and specific biodiversity loss, are probably the most striking and imminent threat to human health. Human population has experienced exponential growth, from two to eight billion humans globally, in just around 120 years, which has been accompanied by changing circumstances in the biosphere, with 85% of wildlife mammals being reported to be endangered<sup>209</sup>. Whereas precious living flora and fauna are grossly endangered, one species, humanity, is exponentially growing. This discrepancy in itself is alarming and questions the sustainability of this special juncture in time.

In this context, a specific example of how influencing local biodiversity directly impacts human health needs consideration: intensive livestock farming, combined with population density. One of the explanations why increased disease burdens on both humans and animals occur is the high density of their habitats. Examples that have shown epicentres for mass epidemics are the province of Guangdong in China and the Po

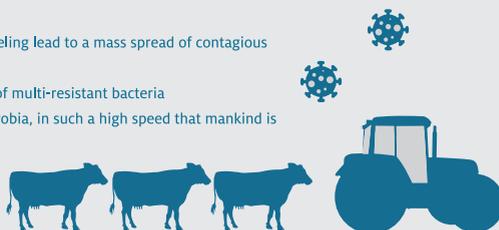
Valley (Padania) in Italy, but also the province of North Brabant in the Netherlands, with 2.5 million inhabitants and an intensive swine (5.4 million pigs), goat and poultry industry. The results are not only infectious epidemic outbreaks like Q fever, African swine fever, the avian influenza flu and COVID-19. They also lead to new mutations and multi-resistance, making disease treatment more difficult<sup>280, 281</sup>.

### Biodiversity and pharmacy

Biodiversity also plays an essential role in health research and traditional medicine. Today, approximately 60% of the global population uses indigenous or folk medicine, within or outside of the disease care system. In addition, medical plants and natural products (either plant, animal or microbe-based) play a key role in drug discovery programmes in the pharmaceutical industry and scientific research organisations<sup>282</sup>. Among the world's 25 best-selling pharmaceutical agents, half of them are derived from natural products, and half of the plant-based medicines come from the tropics. The impact of deforestation becomes most apparent when we realise that 70% of all plants that have been identified as having anti-cancer characteristics (US National Cancer Institute) are found only in tropical rainforests<sup>283</sup>. Tropical rainforests, as resources of natural products for medicine therefore prove to be another essential resource for human health and well-being.

#### Effects of biodiversity change and biodiversity loss on the habitat and health of humans

- Flora and fauna species dissolve without evolution
- Exotic spread of animals around the world, and mass global human traveling lead to a mass spread of contagious viruses, bacteria and zoonoses
- Pharmaceutical antimicrobial groundwater pollution causing endemics of multi-resistant bacteria
- Mass dense farming lead to seedbeds for more pathogenic variants microbia, in such a high speed that mankind is unable to build up immune responses



Approximately two-thirds of all human infectious diseases are shared with animals, being Anthro-zoonoses (human to animal), Zoono-anthroposes (animal to human) or amphi-zoonoses (both directions). Biodiversity loss and a changing flora and fauna ecosystem impact on the patterns and prevalence of human infectious diseases by introducing more frequently new pathogens, as most recently evidenced by the SARS-COVID endemic and the COVID-19 pandemic<sup>284</sup>.

### **Microbiome and human health**

Ultimately, rapid declines in global biodiversity may also be contributing to a negative megatrend in human health and well-being<sup>285</sup>. Although still unproven and a topic of research, the biodiversity hypothesis posits that a healthy development of the microbiota of human skin and gut depends in part on inoculation with microbes from environmental sources. An ongoing and rapidly increasing global loss of macro-di-

versity (species richness of macro-organisms with microbial biodiversity in symbiosis) results in a decrease in human exposure to microbial diversity. Human microbiota deficits may result in a wide variety of inflammatory-based illnesses<sup>286</sup>. These disorders include allergies and asthma, inflammatory bowel disease, cardiovascular diseases, some cancers, potentially some neurodegenerative diseases, type 2 diabetes, inflammatory-associated depression and some forms of obesity<sup>287-289</sup>. Otherwise, exposure to microbial diversity can improve health. Whereas human exposure to nature has been found to have a strong positive effect on mental and emotional health, much research is being done on the effects of exposure to microbiota on physical health<sup>290</sup>. Biodiversity conservation, as a research and development concept, may be a potential win-win strategy for maintaining ecosystem health and protecting public health. However, research and more evidence are needed to support this strategy. →

### Key points

Climate change affects people disproportionately. It is the poorest (regional) populations that will be impacted most, thereby amplifying persisting inequities and inequalities in the world. In this chapter, we explored the interactions of environmental change and human health:

- **Climate change** lengthens the transmission season and increases the (geographical) spread of many infectious diseases. It will bring emerging health issues, including the five main **climate sensitive disease groups**: heat-related diseases, vector-borne diseases, water- and food-borne diseases, direct injuries/deaths and mental health issues.
- **Deforestation** worsens air pollution, as forests are essential to clean air. Besides, it increases the risk for pandemics, threatens the livelihoods of vulnerable people and threatens food security.
- **Ocean acidification** affects our health in many ways. It affects the availability and nutritional quality of seafood. Contaminants of the marine environment may consequently be taken up by organisms and end up in the food chain. Seawater levels are rising, creating water salinisation that contributes to disorders of for instance the cardiovascular system.
- **Biodiversity loss** is probably the most striking and imminent threat to human health. Global diversity loss causes deficits in human microbiota, causing inflammatory-based illnesses. In addition, biodiversity loss threatens the supply of food, fresh water, energy and natural medicines.

Chapter



# Challenges to economic growth

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## **Contemporary Western diets question the sustainability of the traditional food industry**

The contemporary western diet differs from traditional diets. The agricultural and husbandry (livestock) revolutions, followed by the Industrial Age and the 20<sup>th</sup> century fast food revolution have introduced foods humans evolutionary have not been adapted to. Refined cereal grains, nonhuman mammalian milk and refined carbohydrates in energy dense products have replaced vegetables and fruits as main ingredients. Compared to historically long-lasting societies, like the Hunter-Gatherer Civilisation (up to 3000 BC) and the Agricultural Society (up to 1750 AD), the Industrial Age (from 1750-present) has so far been relatively short but the impact and changes to food ingestion have been immense and much faster than in the eras before.

Western diets have long marginalised noncereal grains and non-leguminous plant foods (like beans, peas and lentils). Moreover, other basic concepts, like a moderate animal-source of protein and increase of sodium chloride intake, together with low potassium consumption are fundamental changes in modern diets.

Approximately 80% of supermarket food in western society is based on wheat. Wheat is an enriched grain with fast fermenting glucose and high glycaemic index, leading to rapid blood sugar changes, which causes vascular damage. Modern Western wheat-based diets are carbohydrate rich and lead to glucose addictions. The fast food and soda industries have changed our food habits immensely, leading to different and more food intake. They are responsible for an enormous change in eating habits and therewith, in our health, and to a great extent nullified the effects of the technical advances healthcare has made since the 1960's.

Despite our medical technology, it seems we have never been further from healthy ageing. Global food overconsumption and healthcare overconsumption are the results, making the healthcare industry – and in spite of the inaccessibility issue in LMICs – the biggest industrial sector worldwide. Together with a world population of eight billion people today and an increased global overall life expectancy of 74 years, the growth of the traditional food industry, the traditional health industry and other resource consuming industries question the sustainability of the system.

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**IN** this chapter, we explore the different eras of the Industrial Age. Economic developments have created new opportunities and prosperity in our society but have also induced unhealthy behaviours, especially since the 1950s. Economic developments are, therefore, strongly connected to today's challenges of human health, as well as to our planetary state of health. But the economy itself has important challenges as well, especially when boundaries of economic growth or resource depletion are considered. In this chapter, first, a basic overview of two economic models of the Industrial Age is given, as well as most of the innovations relevant to human and planetary health developments.

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## The Industrial Age

Various models describe the Industrial Age, and usually, they overlap. The most used and well-known is the model of the four periods, or revolutions, within the Industrial Age (Figure 6.1). These revolutions can be understood as a logical consequence of the pre-industrial period of culture, art and trade.

### Four industrial revolutions

First, the four industrial revolutions are briefly described, followed by a more detailed description of the economic cycles that fall within them (Figure 6.1). Within those economic cycles, specific effects on human and planetary health will be described. Describing both models is somehow confusing. However, the economic cycles resemble specific developments that truly revolutionised dominant industries at those times.

The first period of the Industrial Age (starting 1750 AD) is characterised by industrial mechanisation, with the invention of the steam engine and the massive extraction of coal. This first period of the Industrial Age became known for its new sources of energy and its initiation of mass transport options.

The second Industrial Revolution (1870 AD) was characterised by mass transport development and advancements in the fields of the electro-technical and chemical industries. The most important development was the creation of the internal combustion engine, which started to reach its full potential. Other important points for industrialised countries were the development of a mass steel demand and new methods of communication, such as the telegraph and telephone. As a result of the combustion engine, probably the most important landmarks of the

second Industrial Revolution were the invention of the automobile and the aeroplane, at the beginning of the 20<sup>th</sup> century.

A century later, the third Industrial Revolution (1970 AD), introduced by the global oil crisis, gave rise to seeking new solutions for human energy needs<sup>291</sup>. And again, with increased knowledge of nuclear energy, a so far untapped source emerged, which opened new doors to research and biotechnology. The third revolution also brought forth the rise of electronics and telecommunications and opened the era of the computer world.

The so-called 'Industry 4.0' is the new fourth Industrial Revolution happening right now. It is characterised by one dominating invention, the internet, which bends the classical laws of physics and opens new knowledge fields like genetics and artificial intelligence. These seemingly unlimited possibilities should also create solutions to dispose of the dependency on fossil energy resources. In healthcare, the digital revolution is considered one of the solutions to manage increasing disease care consumption and its concomitant labour shortages.

### Five economic cycles, according to Nikolai Kondratieff

The model of economic cycles, according to Nikolai Kondratieff, is particularly useful for describing specific developments with regard to human health<sup>292, 293</sup>. In this model, five cycles, each averaging about 40-60 years, are described (Figure 6.1) by Kondratieff. And today, a new, sixth economic cycle of global sustainability is developing. Each cycle is triggered by ground-breaking basic innovations. Each cycle is a reorganisation process of the economy and society, with the



**Figure 6.1** The Industrial Age with its industrial revolutions and economic cycles

A combined model of the Industrial Age, composed of four Industrial Revolutions (outer circle) and six shorter economic cycles (the inner circle, according to Kondratieff): The first cycle was that of the steam industry, in 1780, and the textile industry, in 1830; the second cycle was of railroad steel, in 1850, and mass transport, in 1870; the third cycle was of the electrotechnical industry, in 1890, and the chemical industry, in 1920; the fourth cycle was of petrochemical industry, in 1950, the automotive industry, in 1935, and the food, alcohol and tobacco industries; the fifth cycle was of information technology, in 1980; and the sixth is the developing new economic cycle, 2005-present<sup>292-297</sup>.

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### Steam Industry & Textile Industry

1780

1830

- Main demand: local production of mass consumption goods
- Basic innovation: steam engine
- Main industries: textile industries ('economies of scale')
- Value chain: prosperity and rights of new social factory workers class
- **Health and societal consequences: a new social class coming up for their social rights, trying to improve the new hardship work circumstances and new urban life circumstances of poverty and poor health conditions**



objective of opening up areas of great demand. These demands are being fed by human needs and basic innovations provide solutions. These cycles are not only economic cycles. They also create new social value chains, which determine the primary direction of economic growth over several decades and which change all levels of society.

Main demands, basic innovations, main new industries and the created value chain of each economic cycle are summarised after each cycle in order to be able to better comprehend the different cycles.

#### **First cycle: steam engine (1780 AD) and textile industry (1830 AD)**

With the invention of the steam engine in 1780 AD in Europe and the United States of America and with textile manufacturing (e.g., spinning machines) becoming possible, a fundamental shift occurred from the home-based production of clothing, giving rise to mass production factories. Changing from an agricultural to an industrial society, many people migrated to cities. As a result, a new social class, factory workers, developed, and their fight for political rights and social security significantly shaped the 19<sup>th</sup> and 20<sup>th</sup> centuries. Whereas initially, the factories were built to produce only for local demands, once

this demand was saturated, its' growth limit was reached. As the transport infrastructure at that time did not permit expansion to superregional markets, due to poor roads and horse-drawn vehicles, slowly, a new demand would arise<sup>298</sup>.

#### **Second cycle: railroad steel (1850 AD) and mass transport (1870 AD)**

While local demands were merely met, recession followed, due to the limited growth potential of the first cycle. A new main demand for effective transport rose and new inventions like the production of high-grade steels with the Bessemer converter and the invention of the railroad industry fed this demand. These 'economies of scale' further developed with mass production and mass transport, leading to other industries, including the steel industry, with steel machinery and weapon industries, bridge building and shipping.

Factory workers became the largest occupational group and their social democratic and communist ideas led to major social reforms, like health insurance coverage, accident insurance and old age and disability insurance.

2<sup>nd</sup>

### Rail road steel & Mass transport

1850

1870

- Main demand: efficient transport of mass goods
- Basic innovation: rail road system
- Main industries: steel industry (Bessemer converter)
- Value chain: major social reforms like health insurance and pension provisions
- **Health and societal consequences: first health and accident insurance laws and pension provisions**



### Third cycle: the electro-chemical industry (1890 AD) and the mass food (meat) industry (1920 AD)

Basic innovations in the third economic wave were electrotechnology and chemical process technology. The Siemens invention of the electro-dynamic principle enabled the conversion of mechanical energy into electrical energy. Also, the understanding of quantum mechanics imparted the knowledge of manipulating material, leading to modern chemistry.

This basic innovation of electro-chemical inventions made the third cycle the first long wave that was triggered by the practical application of scientific knowledge. The third economic cycle brought a vast extra expansion of mass production. And social changes in the third cycle

were immense: for instance, the effect of electric light introduced working in three shifts and allowed for more nightlife. Furthermore, industry changed through the use of electrical motors.

More people acquired higher education, climbed the societal ladder, and their role became more important as consumers and voters, known as the 'Revolt of the Masses'<sup>299</sup>.

During the first three economic cycles, Europe became the leading region in science, economics and technology. But this also led to political changes, like the rise of nationalism, militarism, imperialism and colonialism. Unfortunately, these changes also led to the First World War. The third economic cycle ended with the global economic crisis, starting in 1929 AD, the 'Great

3<sup>rd</sup>

### Electro-chemical industry & Mass food (meat) industry

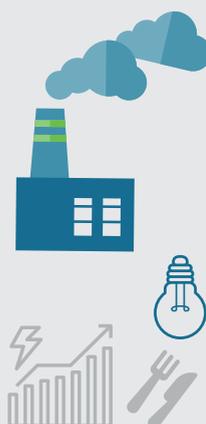
1890

1920

- Main demand: expanding from local to superregional mass production needs
- Basic innovation: principle of electro-dynamic energy conversion, and chemical process technology
- Main industries: electrical and chemistry industries
- Value chain: expanding and stretching societal work-life changes; 'revolt of the masses'
- **Health and societal consequences: health endangerment by economic differences in prosperity, suppression by colonialism, political unrest, a global economic crisis and warfare.**

**Global acceleration of societal changes leading to stress-induced behavioural diseases.**

**First onset of a wide-spreading of so-called diseases of civilization.**



Depression', which was caused by an unbridled, mass overproduction of food, industrial products and money<sup>300</sup>.

#### **Fourth cycle: the automotive industry (1935 AD), the petrochemical industry (1950 AD), the granary food industry (1960 AD) and alcohol and tobacco industries**

Resurrection from the Great Depression was driven by new industrial drivers: the automotive industry and petrochemistry emerged and initiated the next, fourth, economic cycle. The basic innovation of this fourth cycle was the automobile, which responded to a new basic need for both mass transport and individual mobility. The cycle started shortly after the global economic crisis as a bandwagon effect, with many new industrial sectors and professions developing like new legislation systems (e.g., traffic laws) and technical inspection agencies. Together with the upcoming technical universities, this formed the new value chain of the fourth economic cycle. Up to the end of this cycle, the production and consumption of energy were uniquely associated with economic growth and progress. The OPEC crisis during the 1970s, with massive crude oil price increases, caused the abrupt ending of this cycle.

Particularly since the 1960s, large multinational industries boomed and the food, alcohol and tobacco industries rapidly changed the population's food patterns with tremendous – negative – effects on health. For instance, the Chronic Disease Centre of the Ministry of Health calculated that the average sizes of meals and drinks in US-American restaurants had increased three to six-fold during the last 70 years<sup>301</sup>.

But food and related industries were not the only industries with detrimental effects on health. The upcoming television industry introduced the advertising of smoking and other unhealthy lifestyle choices and changed daily evening activities into more passive entertainment. Also, the drug industry and the environmental spread of industrial biochemical waste increased in this period<sup>302</sup>, with still underexposed mass negative effects.

#### **Fifth economic cycle of information technology (1970 AD) and mobile technology (2000 AD)**

The basic innovation at the beginning of the fifth economic cycle was the concept of information technology (IT), which shaped the technological, economic and social changes in Western countries. Importantly, this cycle was no longer de-

4<sup>th</sup>

#### **Petrochemical industry & Automotive industry & Food / Alcohol / Tobacco industry**

1950

1830

1960

- Main demand: mass transport and individual mobility
- Basic innovation: automobile
- Main industries: automotive industry, petrochemistry and oil industry
- Value chain: a bandwagon of industries like legislation systems, and knowledge institutes like universities
- **Health and societal consequences: mechanisation and motorized transport led to a gross reduction energy expenditure of 300Kcal/day per person.**

**Mass food industries have increased daily energy intake in Western societies with approximately 300 kcal.**



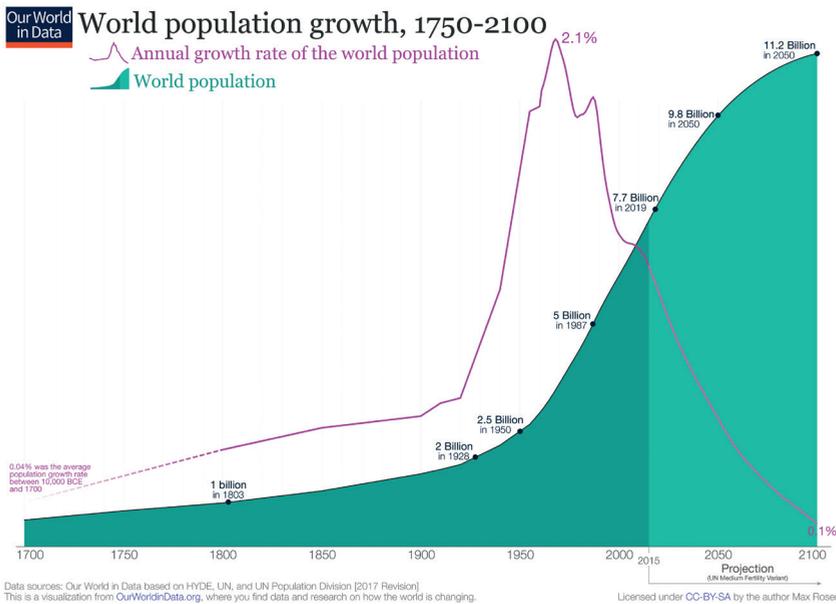
5<sup>th</sup>

## Information Technology industry & Mobile Technology

1980

2000

- Main demand: answers to limitations of industrial growth capacities and energy consumption
- Basic innovation: information technology
- Main industries: IT computer hard and software, social media industries
- Value chain: information and knowledge as new main industrial product
- **Health and societal consequences: sedentary life, stress to comply in fast changing 'Just Economy', neurotoxic agents (e.g. pesticides), substance use industry and electro-magnetic waves lead to mental illnesses and degenerative neurological diseases.**

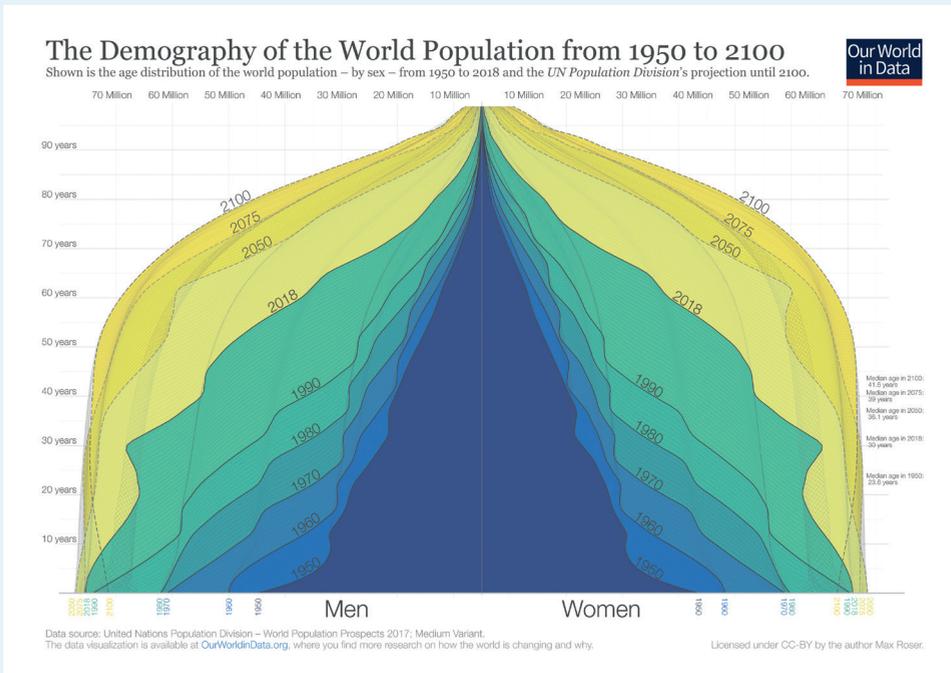


**Figure 6.2** World population growth and annual growth rate of the world population<sup>303</sup>  
The world population is prospectively to grow to approximately 10 billion people shortly after 2050. The world population growth rate, with a maximum annual growth rate of 2.1% in 1968, will reach a plateau phase in 2100. Global population growth projections indicate that the annual growth rate will decrease from 1.08% (2019) to 0.1% in 2100.

pendent on the utilisation of energy and chemical processes, but, rather, knowledge transfer became the main driver. This fifth cycle changed the industrial society into an information society, making the integration of IT and factory work (computerised production) the strategic winners. A completely new IT industry as a leading industry swiftly became one of the most important industrial sectors, with global revenues of 2400 billion US dollars by 2000.

### Effects of global population growth, ageing and poverty decline

Thinking about the Industrial Age in this way, with its models and the specific innovations that had an impact on human and planetary health, three general effects stand out most and need to be reflected on first. One of the first and most remarkable effects of the Industrial Age has been the exponential growth of the global population size in the last 100 years (Figure 6.2). Presently, the earth is host to eight billion humans. Whereas it took more than 300,000 years for the modern human being to grow to a population



**Figure 6.3** The demography of the world population from 1950 to 2100 (Max Roser 2019) *The global population pyramid: How global demography has changed and what we can expect for the 21<sup>st</sup> century<sup>305</sup>. Since 1990, and towards 2100, global population demographics have changed from a triangular distribution to a hyperbolic form, indicating the relative increase of the old aged, when compared to younger people. It well explains double, triple and quadruple ageing effects.*

of two million people, it took only 100 years to grow from two to eight billion people. The world population growth rate peaked at 2.1% per year between 1960-1970 and is projected to lower to less than 0.1% in the 21<sup>st</sup> century<sup>303</sup>. Next to the increasing number of inhabitants, life expectancy has increased to 72.4 years (2017) globally and is still increasing.

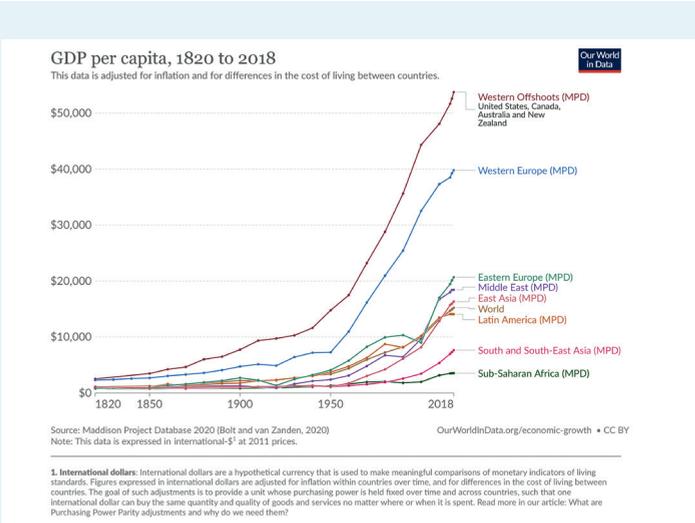
Another important general demographic to reflect on is the effect of ageing in the 21<sup>st</sup> century. Global population demographics are changing from a triangular distribution to a hyperbolic form, indicating the relative increase of old people when compared to younger people (Figure 6.3). Also, the majority of people, 55%, live in cities. In total, 1.5 billion people (22%) live in the top 600 cities, which are financially responsible for more than half (30 trillion USD) of GDP<sup>304</sup>.

Apart from the increasing global population and the increasing life expectancy of today's elderly (the 'double ageing'), we see a prolonged and increased prevalence of chronic diseases (the triple

ageing effect). Particularly in western countries, we see the combination of an increase in the number of elderly people (aged 75-90) and a relative decrease in the younger generation of family caretakers (aged 40-65), and so a quadruple ageing effect is foreseen.

Next to population growth and ageing, two other important effects are relevant. First, the Industrial Age introduced global economic growth in most regions worldwide. However, not all regions benefited from the Industrial Age and, with this, economic differences increased. Among many ways to describe economic growth, a well-used method is the measuring of economic growth by tracking Gross Domestic Product (GDP) per capita. Figure 6.4 clearly shows that in most regions worldwide, GDP per capita, corrected for price changes over time and price differences between countries, has increased.

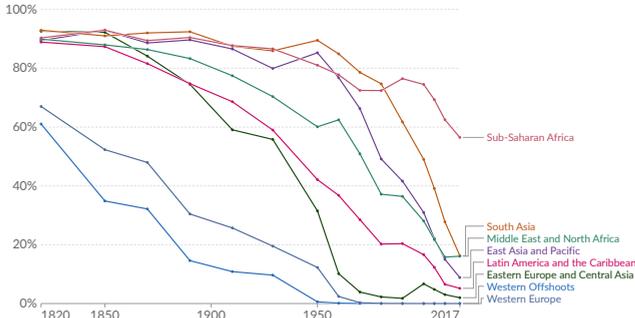
Next to economic growth, a general decrease in poverty is also seen globally, and again, specific regions like South Asia and Sub Sahara Africa show a delayed decrease. The decline of poverty



**Figure 6.4**  
Economic growth per capita  
Economic growth per capita is corrected for time and country differences.<sup>295</sup>

### Historical national accounts estimates of the share of people living below \$5 a day, 1820 to 2017

Average incomes measured in national accounts are often much higher than those observed in survey data. As such the poverty rates shown are lower than corresponding estimates based on survey data – this includes the official estimates produced by the World Bank used to monitor progress against SDG1. See Roser and Hasell (2021) for further discussion.



Source: OVID based on Maddison Project Database 2020, van Zanden et al. (2014), de la Escosura (2012) OurWorldInData.org/history-of-poverty-data-appendix • CC BY

**Figure 6.5**

General decline of poverty in global regions. The Maddison Historical Statistics Project captures information on historical and comparative economic growth in 169 countries. Data from this project indicate a decrease in poverty within global regions<sup>295</sup>.

is measured as the share of the population being unable to ‘obtain a bundle of very basic goods and services’ or as ‘share of people living below \$5 a day’ (Figure 6.5).

And exactly that economic growth, the reduction of global poverty, as well as better living circumstances, have improved individual life expectancies and given rise to an impressive global population growth since 1900. However, today, this combination imposes other problems on that exponentially grown global human population, namely, the exhaustion of resources and limits to economic growth.

### Limits to growth

The concept of limits to growth is not new. Already in the 1970s, the Club of Rome postulated ‘Limits to Growth’ as a beckoning perspective<sup>306</sup>. Now, in the 21<sup>st</sup> century, economic growth seems only to be feasible under the condition of low or even zero-carbon energy. Whereas fossil fuel-based energy has been a driver of economic development and growth over the past 200 years, economic growth with low-carbon energy is

believed as a new, realistic 21<sup>st</sup> century perspective<sup>307</sup>. Limited growth of 3% per year is now aimed for, according to the Sustainability Development Goal 8 (SDG8)<sup>296</sup>. Whereas economic growth has been the default for decades, nowadays, it needs reframing because of the effects on planetary health and the direct and indirect effects on human health.

Throughout the different ages, basic human needs such as access to food, clothing, shelter, and social inclusion have urged people to search for innovations. When new innovations to fulfilling these needs became scalable through inventions in the field of physics and chemistry – for instance, the steam engine (James Watt), mass steel production (Sir Henry Bessemer) and Boyle’s gas laws – they became within reach of a vast number of people. So, seen from this perspective, not the Industrial Age itself, but mankind’s intrinsic needs and its successes in creating new solutions can be held accountable for today’s human and planetary health issues. It could be argued that mankind has become a victim of its own success. Currently, many global regions

are challenged in dealing with both high-density populations, as well as the abundance of 'basic goods and services'<sup>308</sup>, while, in other regions, mass migrations take place due to a mismatch between population needs and services. This situation truly asks for different behaviours and a different mindset, as well as new scientific solutions to balance global ecology and gross demands on earth's resources.

### Key points

The following changes are recognised in human health, disease and mortality during the five economic cycles of Kondratieff of the 18<sup>th</sup>, 19<sup>th</sup> and 20<sup>th</sup> centuries.

- Economic developments in the **Industrial Age** have created new opportunities and **prosperity** in our society but also induced unhealthy behaviours.
- Economic developments are strongly connected to the **challenges to human health** we face today, as well as to our **planetary state of health**.
- The economy itself has important challenges as well, especially when **boundaries of economic growth** or resource depletion are considered.
- In this chapter, a basic overview of **two economic models** of the Industrial Age was given, as well as most of the **innovations relevant to human and planetary health** developments.
- A new developing sixth **economic cycle of global sustainability** is recognised.



Chapter



# The impact of economic developments on human health

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## **The economic developments of the Industrial Age have changed human behaviour fundamentally and have a dominant say in healthcare consumption**

Four general effects of the Industrial Age are recognised, with long-lasting effects in time.

First, as a result of urbanisation, already in the beginning of the Industrial Age, large-scale epidemics, such as the cholera outbreak in the 19th century, became common. Although an awareness of hygiene, infection prevention and medical knowledge is at an all-time high in the 21<sup>st</sup> century, new epidemics, related to dense populations of humans and animals, create large scale threats to human health.

Secondly, another determining factor is the structural change in human physical activity. Industrial mechanisation and the existence of motorised transport, since 1935, decreased the energy expenditure of physical labour by approximately 300 calories per day, per person by the end of the 20<sup>th</sup> century<sup>14, 15</sup>.

Thirdly, the food industry, starting with the granaries in Russia and the United States and the rice industry in Asia, made large scale food production possible but also led to a higher level of consumption of fast fermenting carbohydrates, thereby structurally increasing our intake of calories per day<sup>26</sup>. Globally, rates of obesity have nearly tripled since 1975, and continue to grow due to this combination of decreasing physical activity and increasing calory intake, leading to a so-called 'overweight pandemic'<sup>34</sup>.

Finally, and to make it even more complex, we have experienced the increasing pace and regulation of a fast-changing society. Stress has become a dominant factor in the lives of the 'multi-tasking' generations, X and Y<sup>35</sup>. People strive to satisfy their daily needs. Stress is no longer a driver for survival, as in earlier times of famine and danger, and people stress due to the 'fear of missing out'. Mental illnesses, such as anxiety, depression and burn out, along with substance abuse, are among some of the most important health problems today.

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**HUMAN** health changed significantly during the Industrial Age. Industrialisation has led to prosperity, changed people's behaviour fundamentally and introduced the rise and fall of diseases. Effects are visible in all economic cycles but have become more prominent since the 1950s. Now, 70 years later, we are faced with the consequences.

Let us explore the specific phases of the Industrial Age to understand what these most alerting effects have been. First, four overall effects of the Industrial Age will be described, followed by a description of specific economic cycles and their specific effects on human and planetary health.

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### **I - Human health, disease and mortality effects of the first three economic cycles**

Considering the first three economic cycles, from around 1780 to 1935, what have the main effects on health, disease and mortality been? It must be noted that as the economy and socio-cultural situations differ regionally, no overall effects are to be described from one global perspective. Historically, registration systems were often incomplete or non-existent yet and uniform disease criteria were not available. Therefore, mortality rates have historically been considered to be the most reliable indicator. Mortality decline first started in western countries in the 17<sup>th</sup> and 18<sup>th</sup> centuries, whereas mortality decline in LMICs did not occur until the 20<sup>th</sup> century<sup>309</sup>.

Several large health events related to socio-cultural and economic developments in the first half of the Industrial Age impacted large regions throughout the world. First, famine outbreaks have plagued many regions of the world throughout the ages. During the first three economic cycles of the Industrial Age, many important famine spikes occurred, especially in Europe (e.g., the Sweden famine outbreak in 1773, the Potato Blight in Ireland in the 1840s and outbreaks in Finland in 1868, in Russia and Ukraine, in 1933, and in Greece, in 1942).

Secondly, in relation to industrialisation and urbanisation, large-scale epidemics like the cholera outbreak in the 19<sup>th</sup> century, smallpox, in 1870, and the 1918 influenza pandemic effected large regions worldwide.

Thirdly, as a consequence of differences in economic prosperity and geo-political unrest, high mortality rates were caused by wars in Europe,

facilitated by the rise of industrialisation. For example, the Franco-Prussian war (1870-1871), World War I (1914-1918) and World War II (1939-1945).

Nevertheless, despite the devastating losses of these supra-regional and sometimes global events, they never impacted the global population as a whole. And, at the same time, the growth of economic prosperity, due to the rise of industrialisation – with an increased understanding of hygiene, sanitation and antibiotics, as well as food availability – led to both a diminished amplitude of famine and epidemic mortality spikes, as well as to a decline of the average levels of mortality. These mortality declines impacted population growth as well. Mackenbach explained that, for Europe, “Around 1870, the annual death rates for European countries averaged between 20 and 35 per 1000. This rapidly declined to between 10 and 20 in 1930, and even further to between 7 and 13 in 1960.” This decline in the mortality rate has been one of the most important factors for the rapidly increasing European population numbers<sup>49, 309</sup>. Whereas the early economic cycles of the Industrial Age impacted human health and survival, their impact on ecological changes and global health was limited. Moreover, concerns about the possible consequences of industrial resource demands and factors like greenhouse emissions was not yet a reality, and the global population number was still limited.

### **II - Human health and global health effects of the 4<sup>th</sup> economic cycle**

The fourth economic cycle, in the 20<sup>th</sup> century, distinguished itself from the first three cycles as important effects impacted on issues beyond

human health and survival. In this time frame, the consequences of this cycle on ecology and global health became more and more apparent.

### **Human health**

First, for three reasons, the fourth economic cycle has been the most important one for contemporary health issues. This cycle has had impacts on human physical activities, the spread of epidemics, as well as on the distribution of mass food production. First, with industrial mechanisation and motorised transport, human physical exercise changed, leading to the previously mentioned reduction of energy expenditure of 300 calories per day per person at the end of the 20<sup>th</sup> century<sup>120, 121</sup>. Secondly, with global mass transport, the dissemination of contagious diseases has accelerated. Whereas, historically, epidemics spread gradually through continents with years to decades of lag, as a result of mass sea and air transport, supra-regional and global spreads within short periods of time have become more common.

Thirdly, as a result of industrialisation and increased transport possibilities, a mass food processing and distributing industry developed. This mass food industry was a technical development of the agricultural revolution (1700-1850). In this period, seed press farming techniques became more productive and the large-scale growth of crops like potato, maize and rice developed. Together with the increased availability of farmland, not only crop yield improved but the numbers of livestock also increased. Worryingly, the growth of expanding market offsets and mass food production practices led to jam-packed livestock situations<sup>310</sup>. International companies that manage livestock in such unsustainable environments were urged to make use of preventive antibiotic

therapy to manage the threat of the rapid dissemination of infections<sup>67</sup>. As discussed in chapters two and five, these ‘production-purpose antibiotics’ have been increasingly used since the 1970s to realise faster rates of growth and thereby reduce costs and stimulate trade. However, they have also contributed to the global spread of antimicrobial resistance<sup>311</sup>. Industrial mechanisation overtook horses and manpower, and US-American and Russian granaries, together with the mass Asian rice industry, became the dominant industries. New technical knowledge of genetically modifying wheat enabled mass grain production. Wheat, with fast fermenting sugars, became the dominant energy supplier of modern western food and diets.

Nowadays, 80% of all supermarket food is wheat-based. As explained in chapter two, the combination of diminished average energy expenditure and increased daily energy intake has been the main explanation for the rise of obesity and metabolic syndrome at the end of the 20<sup>th</sup> and the beginning of the 21<sup>st</sup> century. Both the modern food industry, with ‘sugar high’ addictions, and the alcohol and tobacco addiction industries further negatively afflicted human health through the increasing prevalence of lifestyle-related diseases. The global spread of these diseases is striking.

### **Neoliberalism and austerity**

Next to the three forementioned reasons, another important factor in the fourth economic cycle has also had a major impact on healthcare: neoliberalism. Especially since the 1970s, neoliberal reforms led to deep changes in healthcare systems around the world. By putting the emphasis on free markets instead of the right to health, neoliberalism impacted access to healthcare for

the general population. Case studies of many countries on structural adjustment programmes have shown a strong negative impact on access to healthcare. Especially people with lower socio-economic status, or disabled people, were most affected. Back in the 1980s and 1990s, in countries under crisis, like in Latin America, Africa and the former Soviet Union, neoliberalism combined with austerity reforms led to higher unmet needs by health services, higher rates of poverty and the increased prevalence of mental illnesses.

With the recent 2008 economic crisis, neoliberal policies have again been criticised, as many countries – especially in Europe – have adopted austerity measures in order to decrease healthcare budgets, while global healthcare consumption and population sizes are increasing<sup>312</sup>.

### Global Impact

Compared to changes in the longer-lasting societies of mankind's history, the impact and changes to society during the relatively short Industrial Age have been immense and occurred much faster than in eras before. Human employment in the Industrial Age became more and more based on mass production, using energy resources like coal, electricity and, later, crude oil, natural gas and nuclear fission. As a result, its impact on human behaviour, society and the environment rapidly grew in the fourth economic cycle.

Looking back at this time in the fourth economic cycle, and perhaps fortunately, the economic oil crisis of the 1970s was a historic turning point as a new awareness emerged as to the limitations to global population and economic growth<sup>313</sup>, as well as the new concept of an emerging competition between earth and mankind.

With, in retrospect, these early 21<sup>st</sup> century insights, limitations of industrial growth capacities based on energy consumption necessitated the invention of new economic drivers. The basis for the next, and fifth, economic cycle as a new demand for economic development was established.

Since health inequalities are usually aggravated by neoliberal policies, political commitment, together with public understanding and support of measures reducing health inequalities are necessary in order to address both the increased healthcare needs of disabled people but also to tackle underlying health determinants.

### III - Human health, disease and mortality effects of the fifth economic cycle

Two globally shared dominant factors hallmark the fifth economic cycle: an abundance of information and the speed of change. In this dynamic economic cycle, disruptive changes have become fashion and human behaviour sometimes grasps for breath to comply. Stress from fear of missing compliance to societal regulations and innovations has a yet undefinable impact on our mental health status.

Next to these effects, substance use addictions arose as an escape from pressing realities and seeking refuge from unhealthy food temptations. Whereas it may activate the individual human brain, it also leads to an abundance of changes in society. The increased prevalence of substance use disorders (alcohol, drugs and smoking), but also of mental illnesses and degenerative neurological diseases (e.g., dementia, Parkinson's disease), as seen presently in the early 21<sup>st</sup> century, is believed to have found its breeding ground in the second half of the 20<sup>th</sup> century, in the fifth economic cycle.

Additionally, and from a different order, a new 'kid on the block' arose: the radiation effects of magnetic, electric and 3, 4 and 5G waves on human physical and mental health. The true effects are still unclear and largely undiscussed, however, overall, the fifth economic cycle added, in particular, mental effects on health. Together with the continued feeding of lifestyle (eating) disorders, this fifth economic cycle will distinguish itself as another unique health-changing era.

### Key points

The following changes are recognised in human health, disease and mortality during the five economic cycles of Kondratieff of the 18<sup>th</sup>, 19<sup>th</sup> and 20<sup>th</sup> centuries.

- **Large epidemics** and supra-regional wars caused the main disease and mortality peaks within the first half of the Industrial Age, containing the first three economic cycles. They never reached such dimensions that the survival of humanity was at stake.
- With industrialisation, Western countries preceded LMICs in a **general mortality decline**.
- Unlike the previous mortality spikes of the first three economic cycles, in the fourth cycle, a more **global synchronicity of the spread of lifestyle-related diseases**, like obesity, diabetes, (non-alcoholic) fatty liver disease and cardiovascular problems was striking and their penetrations – with, for instance, a global rise from 15% to 30% in rates of obesity – are unprecedentedly higher than ever before.
- On top of this, diseases like **mental illness** (like anxiety and depression), together with **degenerative neurological diseases** (like dementia and Parkinson's disease) and **substance use disorders** (alcohol, drugs and smoking) are becoming some of the main problems facing health in the 21<sup>st</sup> century. Through lifestyle related diseases, together with mental disorders, this fifth economic cycle has distinguished itself as another unique health changing era.

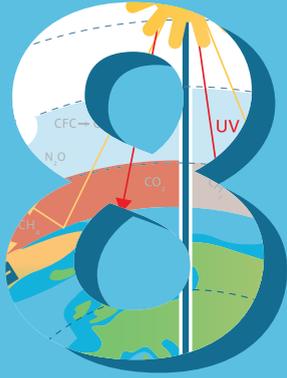


Part



**Future perspectives**

Chapter



# The 21<sup>st</sup> century economic cycle of global sustainability

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## Refinding purpose in the sixth economic cycle of global sustainability

Healthcare professionals have become aware that merely gradually changing and optimising the current disease care system will not suffice, nor will it help the meaning and purpose of professionals in the long run. As discussed in previous chapters, our present young generations, Y and Z, already face a different future, and adjust their ambitions accordingly, as compared to the Baby Boomers and Generation X. The needs and beliefs of the 21<sup>st</sup> century generations, Z (2000-2015) and Alpha (from 2015), will develop differently to those of the generations of the 20<sup>th</sup> century. Generation Alpha will, in adulthood, probably be severely challenged to become the most transformative generation ever. As an inheritance, this generation will need to develop sustainability in a broad sense, in order to solve current problems.

In this first half of the 21<sup>st</sup> century, a new economic cycle is emerging, best characterised as the cycle of Global Sustainability (2005-present) (Figure 6.1), in which the current disease care system will shift into an integrative health system. A new sustainable system will develop by the integration of new industries at economic and environmental levels. Human health becomes an integrated part of the 'One Health' concept, a concept that strives for the optimal health for people, animals and planet<sup>6,7</sup>. Three important challenges are foreseen: feeding a growing and increasingly affluent population, reducing environmental impact and adapting to changing climate.

The four main industrial sectors in the next economic cycle are: information technology, environmental protection, biotechnology and integrative health (Figures 6.3 and 6.4). Looking at information technology, environmental protection and biotechnology, all three of these industries go through tremendously fast developments and already dominate over many old industries, like the petrochemical and traditional automotive industries.

In line with previous economic cycles, these global sustainability industries will accelerate via an s-curve that will last for 40-60 years. Only new industries that create enough value and are big enough for real economic prosperity and full employment for several decades, will survive. The development of this cycle will be more a socio-cultural reorganisation process than merely an economic development, depending on the young generations' beliefs and needs.

Traditional healthcare (disease care) will be transformed into an integrative healthcare system that is part of a 'One Health' economy. Such a transformative change needs different thinking. To quote Socrates, "The secret of change is to focus all our energy, not on fighting the old, but on building the new."

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# THE

contemporary economic cycle can be characterised as the cycle of Global Sustainability (2005-present) (Figure 6.1). New industries successfully emerge as they focus on sustainability solutions, which appeal to planetary health and human health perspectives.

The human disease care crisis is not an isolated problem but a combined so-called 'One Health' problem and is interdependent on global economic and socio-cultural developments<sup>314</sup>. Considering the main demands of the new economic cycle raises the question of which other main industrial sectors should be involved in innovating the health system. Which other industries are required to contribute to the long-lasting value chain of the decrease of the population disease rate and global ecological prosperity?

In this chapter, the most relevant industrial sectors in this field are described: information technology, environmental protection and biotechnology (Figure 8.1). Together with the 21<sup>st</sup> century integrative health industry (to be described in chapter nine), they will form a broad base of the sixth economic cycle of global sustainability.

Realising, though, that other crucial industries like the energy and transport sectors and pharma industries are also to be included to create multi-systemic solutions<sup>315</sup>.

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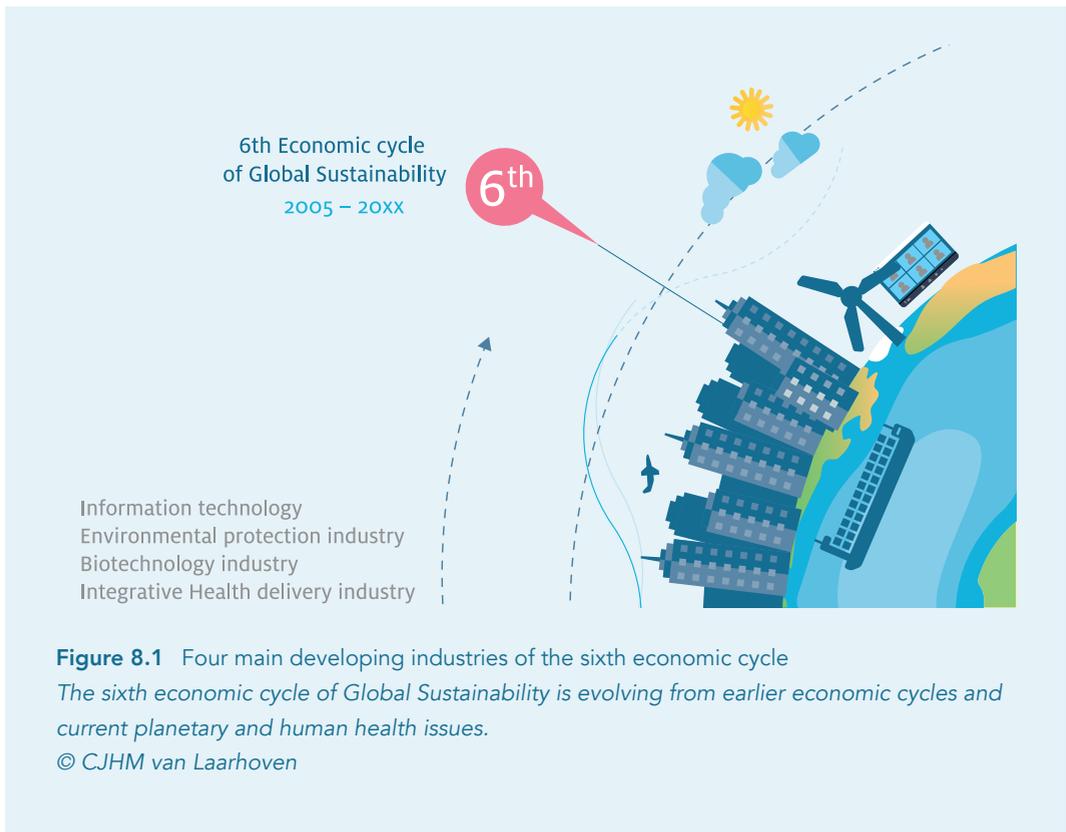
## Integration of the health system into the sixth economic cycle

The traditional disease care system is becoming unsustainable (chapters one and two), environmental changes have a profound impact on human health (chapter five), and the system is driven by the economy. Moreover, human behaviour, in terms of increasing disease care consumption, as well as global human population growth, asks for a true fundamental mind shift. For the transformation of disease care towards an integrative health delivery industry, integration of disease care and health promotion is needed first, and many signs of global awareness of this necessity are already visible. Ideally, a shift from the current 95% of our focus on disease care to at least half being paid to prevention and health promotion is needed.

Considering the interconnectedness, a pure medical transformation from disease care towards an integrative health system alone is not possible and the disease care system needs other partners.

Therefore, economic integration, as the second level of an integrative health delivery industry, with industries that have sustainability in their propositions, like the bio food and biotechnology industries and information technology (economic integration), is mandatory; joint ventures between the integrative health delivery industry and industries that can create healthy living environments in the 21<sup>st</sup> century.

On a third level, integration with environmental protection is needed, based on the widespread





**Figure 8.2** Integrative health delivery industry at three levels to align with the sixth economic cycle of Global Sustainability

*Level one, medical integration: from disease care to an integrative health delivery system, involving lifestyle promotion and preventive measures (e.g., cessation of smoking programs and dietary advice for hypertension). Both primary prevention (disease prevention), secondary prevention (the early detection of diseases) and tertiary prevention (the prevention of disease recurrence) are important preventive measures to integrate.*

*Level two, economic integration: from disease care towards an integrative health industry, through partnering with bio food and biotechnology industries and information technology.*

*Level three, environmental integration: from disease care to an integrative system for planetary and human health, combining sustainability concepts on energy use, mobility, food and water, living environments and environmental protection, according to the principle of 'One Health'.*

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emerging call to improve the ecological system. Environmental decline serves as an urgent driver to combine both planetary and human health into a 'One Health' approach<sup>316-318</sup>. Such a multi-sectoral approach of an integrative health system at three levels – medical, economic and environmental – will lead to improved individual health and a healthier living environment (Figure 8.2).

The 'One Health' initiative, already described by Gibbs in 2014, has combined human health and planetary health into one concept and strives for optimal health for people, animals and the planet<sup>41</sup>. Three important challenges are foreseen: feeding a growing and increasingly affluent population, reducing the environmental impact of human activities and adapting to the changing climate. Realising that the disease care crisis is not an isolated problem raises the question of which other main industrial sectors, like those that came up in the 21<sup>st</sup> century, should be involved in innovating the new health system (Figure 8.1).

The demands of the 21<sup>st</sup> century create new possibilities for industries to develop. Investments in sustainability propositions are considered the new value chain, with new science to fuel these demands. Numerous new innovative industries have emerged and traditional ones are shrinking. For instance, the energy sector and automotive industries urgently need to reorientate their strategies. Alignment is crucial, and any existing – leading – industry is likely to become disrupted unless it understands how to innovate and invest in new societal demands and make impactful propositions. These new industrial sectors, quick to adapt, will become the most

successful industries, devaluing the traditional 'A' industries, as we have seen in the past, and with classic examples, like the Kodak company, between 1975 and 2015. Agile industries with global sustainability propositions have become the leading number one.

An interesting example is the B Lab Company, which introduced a Benefit Corporation certification system ('B-Corp') for other companies that truly committed themselves to serve the good of the global community. A network of over 4,000 companies in more than 70 countries developed. Based on their decision to contribute structurally to the well-being of their employees, to society and to climate, there were certified as Benefit Corporations<sup>319</sup>.

Also, the concept of ESG, Environment, Social and Governance is becoming mainstream in investment strategies for multinationals<sup>320</sup>.

Now, let us explore why information technology, environmental protection and biotechnology are important industrial sectors in this new era of sustainability and how these industries can contribute to a new integrative health system (see infographic below). Which impactful propositions do they envision?

## I - Information Technology Industry

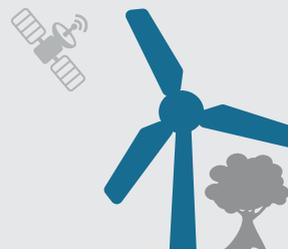
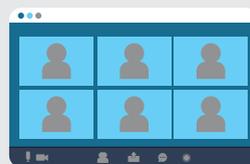
Already in the fifth economic cycle, the information technology industry became the basic leading innovation and changed society from an industrial labour-oriented society to an information-oriented society. Healthcare, which went through a transformation towards digital archiving and electronic health records not so long ago, is now entering an explosive era of new

6<sup>th</sup>

## Global Sustainability Industry

2005 - 20XX

- Main demand: decrease of population disease rate, purpose economy, ecologic sustainability, personal mental development, meaningful live.
- Basic innovation: renewable Energy Supplies; Robotics and Artificial Intelligence
- Main industries:
  - Information Technology: digital communication industry, Robotics and Artificial intelligence
  - Environmental protection: renewable energy industries, electrical mobility industry, 'building with nature', seacoast protection industries and reforestation
  - Biotechnology: (bio-)food industry, bio-fishing, bio-chemistry, bio-energy and bio-ecology industries, agrobusiness and agroforestry
  - Integrative Health delivery industry: disease treatment and health promotion
- Value chain: ecological sustainability and connectivity, circular economic prosperity and global population health



technologies using big data and artificial intelligence (AI). Today, in the sixth economic cycle, information technology is developing towards app-based informatics and remote monitoring and controlling. Robotics, virtual reality and app-based e-health technologies now form the basic innovations and increasingly influence our social behaviour and businesses. With the advent of sophisticated sensors in the consumer sphere, it is now possible to collect Patient Generated Health Data (PGHD) and gain valuable insights into an individual's real-time health status, as well as its future development, by analysing these data using AI analysis technologies. In economic terms, this sector is growing immensely<sup>321, 322</sup>.

More recently, in November 2022, ChatGPT (Generative Pre-trained Transformers) was launched as an artificial intelligence chatbot, able to communicate (chat) with humans and generate novel, human-like text<sup>323</sup>. Although the core function of a chatbot is to mimic a human conversa-

tion, ChatGPT has many functions and some of its products are of a superior quality to those made by humans. High tech firms like Microsoft, Google, Apple and others all compete in a race to launch the best applications.

The World Health Assembly Resolution on Digital Health, in May 2018, acknowledged the value of digital technologies in advancing Universal Health Coverage (UHC) and other health aims of the Sustainable Development Goals<sup>324</sup>.

Many reports arise in which the role that ChatGPT can play in healthcare is both explored and questioned<sup>325-327</sup> and obviously, we are at the beginning of a whole new era of possibilities<sup>328</sup>. Futurists believe that within the next 5-10 years, most Americans will have an AI companion in their pocket, in terms of a smartphone or other device, which will double as a personal coach or tutor, or any other form of companionship<sup>329</sup>.

In line with mobile phone connectivity globally, digital innovations will continue to extend connectivity to the most remote areas<sup>330</sup>. Many digital initiatives are trying to improve both access to disease care and the quality of services, particularly in LMICs. IT and e-health are therefore considered as some of the most powerful aids in reducing health and wealth inequality worldwide.

During COVID-19, information technology caused an immense change in the mindset of healthcare workers. Digital teleconsulting, home-based monitoring, virtual care network and digital interprofessional consultations have become more frequently adopted to optimise outpatient care, especially in remote areas. Telemedicine appears on the right track to replace traditional care delivery, where appropriate.

The immense possibilities of digital services in healthcare are still difficult to estimate. The main directions can probably best be summarised as follows:

- Artificial intelligence and big data in medicine broaden to advanced diagnostics, like genomics, radiomics, proteomics and prediction analytics<sup>331</sup>.
- Telemedicine and e-health (ICThealth) have great potential to enhance an integrative health delivery system, both by improving transactions in disease care and facilitating disease prevention and lifestyle promotion. ICThealth meets retail and will expand globally by easy access to even most remote areas, thus enhancing the reduction of wealth inequality.
- It seems as if an AI revolution in medicine is imminent<sup>332</sup>. ChatGPT already turns the tables in society. With the launch of

MedPalm2 (Google), medical practice may be rewritten in the near future.

AI acquired knowledge transfer to patients will challenge professionals, our (former) knowledge authorities.

Decision making and responsibilities thereof will be questioned. Jurisdiction questions will arise about healthcare professional responsibility, as well as on the responsibility of AI machines themselves.

Advanced sensors, GPT technologies and smartphones have the potential to revolutionise healthcare and democratise access to care. The integration of these technologies can contribute to the concept of integrated health by providing patients with more personalised, proactive and efficient care. It can also facilitate the shift from disease care to healthcare by giving citizens insights into the value of prevention.

Advanced sensors can collect data on vital signs, movement, sleeping patterns and other health-related metrics. This data can be utilised to monitor health status, track progress and provide early warnings of potential health problems by predicting future developments. With the growing availability of low-cost sensors in the consumer sphere, as well as sensors integrated into smartphones, patients can now engage in the self-monitoring of their health, without the need for costly medical equipment or frequent doctor visits.

One example of the use of advance sensors in the iPhone is the 'walking steadiness' feature. This feature uses the accelerometer and gyroscope sensors in the iPhone to measure a user's walking steadiness and provide feedback on their risk of falling.

Another example is a built-in electrocardiogram (ECG) sensor in a smart watch that can detect atrial fibrillation (AF). AF is an irregular heartbeat that can lead to strokes and other heart-related complications. The ECG app records the electrical signals from the user's heart and can identify the presence of AF.

GPT technologies, as well as other data analytic technologies, can be utilised to analyse the vast amounts of data generated by sensors, along with other health-related sources, such as patient records. These technologies can identify patterns, detect anomalies and provide personalised recommendations for prevention or health improvement. User-friendly GPT-powered chatbots can offer patients information on symptoms and suggest appropriate treatments, including recommendations for lifestyle habits, vaccination and screenings to prevent future health issues.

Smartphones will be the platform for integrating sensors, GPT technologies and the storage of patients' data, like medical history from the EHR. With over three billion smartphone users worldwide, smartphones provide a ubiquitous and accessible tool for healthcare delivery. Smartphone apps can be used to store and visualise health status data, track progress and communicate with healthcare providers.

The combination of advanced sensors, GPT technologies and smartphones has the potential to democratise healthcare by providing patients with more control over their health and greater access to care. Patients can now take a proactive role in managing their health, and healthcare providers can use these technologies and insights to deliver more personalised and

efficient care. These technologies enable the breaking down of silos between disease care and health promotion and promote the concept of integrated health.

## **II - Environmental Protection Industry**

The current debate about economic development is less dominated by economic growth. Furthermore, ecological stability and environmental protection are increasingly considered important. Environmental preservation has made us realise that growth has a limit and needs to be counterbalanced. But the new environmental (protection) industry is difficult to define or summarise, as activities vary enormously, from biosphere protection (like climate, water, land use and wildlife) to the global energy transition.

One obvious example is the industry to make the global energy transition to renewable energy supplies. As societal awareness rises, evidenced by the fact that governments at the 26<sup>th</sup> UN Climate Change Conference of the Parties have committed themselves to phase out fossil fuels, and which creates an essential, long-lasting value chain. However, the industries that work towards the building of such an energy transition require huge amounts of raw materials and commodities. In addition, a 16,000 billion USD circular industry for recycling raw materials is foreseen, towards 2030. Although recycling products are still more expensive than 'virgin' products, a recycling industry of this size will become one of the top industrial sectors of the next economic cycle of sustainability. And many innovating parties eagerly search for new techniques to become market leaders. For instance, with shortages of lithium and other heavy metals for liquid batteries, new techniques like solid-state

batteries are being developed. Experts prospect that these batteries will definitely replace fossil automotives.

The impact of a broad environmental protection industry on the integrative health delivery system is not direct but will lead to creating healthier living and working environments. Global action plans (like the WHO Global Action Plan for the Prevention and Control of NCDs, 2013–2020) and the United Nations Framework Convention on Climate Change (Global Sustainable Development Goals) afford solutions that, via environmental protection, lead to the reduction and control of both communicable and non-communicable diseases.

In line with the global actions plans, for an environmental protection industry to flourish and meet its environmental goals, including the targets set in the Paris Agreement and in the Glasgow COP26<sup>318</sup>, both HICs, as well as LMICs, will need to invest, as was made clear during the Egypt 2022 meeting<sup>333</sup>. Whereas six of the top ten emitters of greenhouse gas emissions are now LMICs, HICs are also responsible and need to develop environmentally sustainable industries<sup>297</sup>.

Especially the third level of environmental integration will address the overarching 'One Health' concept (Figure 8.3). It will involve developments that add to a changing mindset from nature-consuming and disease care to eco-balance and health. Healthy behaviours and sustainability are likewise key concepts of the next economic cycle and which are not part of but form an answer to the Industrial Age. This level sees the living environment in a way in which respect and compassion for all living things on earth and its

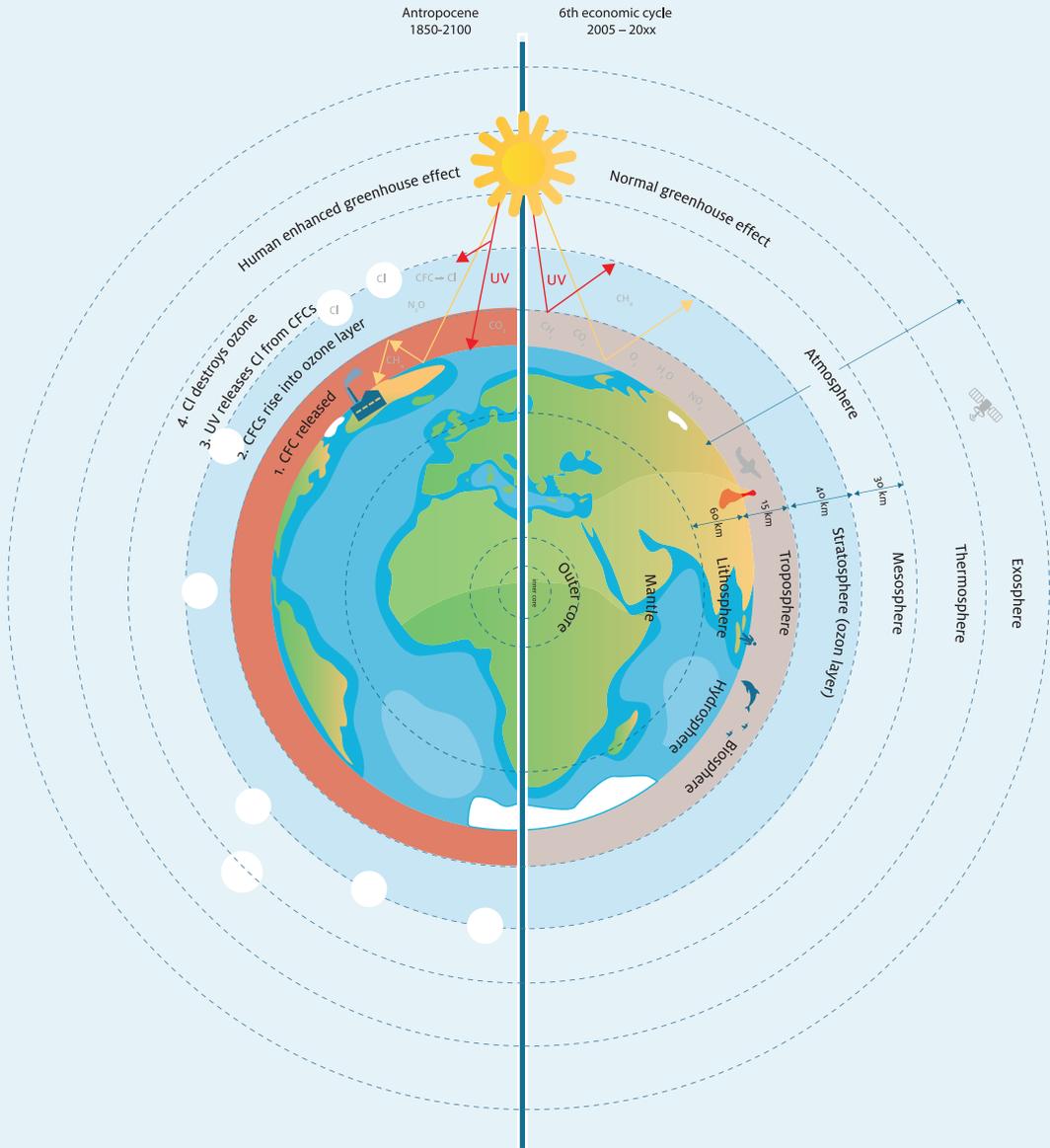
resources are the guiding principles. In creating such a healthy living environment, the reshaping of the health delivery system will go hand in hand with this.

### III – Biotechnology Industry

The European Union emphasised the potential of biotechnology as a broad basic innovation and economic driver to create an overwhelming value chain spread over many new emerging industries<sup>334</sup> and connected into an overall industrial sector called 'bio-economy'. Bio-economy includes the (bio-)food industry, agriculture and agroforestry, the bio-fishing industry, bio-energy and the biochemistry and bio-ecology industries.

We see prominent food corporations changing their protein food production to plant-based meat, laboratory-grown meat and aquatic protein. The food industry has designed plant-based food with essential amino acids and meat-related supplements, like iron and vitamin B12. These biotechnological food changes facilitate a consumption shift, making societies more conscious of the need for sustainable bio-food. A completely different 'healthy' food industry is developing, adopting plant-based and protein-rich food, revolutionising agribusiness (by using insects as natural pollinators, for instance) and involving the different use of raw materials like water, minerals and solar energy. With new technology, it will be possible to sustainably produce food for 10 billion people<sup>335</sup>.

Also, with the concept of 'One Health', the WHO enhances the bio-food industry<sup>6, 314</sup> by designing and implementing programs on food safety, controlling zoonoses and combatting antibiotic resistance.



**Figure 8.3** Restoration of ecosystem and climate change during the next economic cycle  
*Integration of the human health delivery industry with the environmental protection industries will decrease human-enhanced greenhouse effects, creating a healthier living environment and improved human health.*

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In line with the success of the previous five economic cycles, the future success of the three leading industries and the integrative health industry of the sixth cycle will depend on scalability, in terms of employment and monetary impact, so that a long-lasting value chain is formed for at least half a century.

### Key points

- A **new, sixth global economic cycle (2005-present)** is defined as the economic cycle of Global Sustainability.
- In this cycle, the current health system will transform into an **integrative health industry**.
- Different levels of integration are needed:
  - **Medical integration** of disease care to an integrative health delivery system by combining it with health promotion.
  - **Economic integration** by connecting an integrative health industry with other industries.
  - **Environmental integration** from disease care to planetary health, involving sustainable thinking around energy use, mobility, food and water, living environments and environmental protection, according to the principle of 'One Health'.
- Three other **main industries** (among others) attribute to the integrative health industry: biotechnology, information technology and environmental protection.

Chapter



**A 21<sup>st</sup> century  
sustainable  
integrative  
health system**

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### **Integrative health systems: from gradual change to a fundamental transformation**

Today's disease care system is a consequence of the demands and possibilities of the second half of the 20<sup>th</sup> century. The necessity and the merits of this system are clear, but there are a number of issues with it that are not sustainable, such as those related to its accessibility or affordability.

Why, in spite of the fact that medical knowledge and technological solutions have never been more advanced, do we face more diseased populations than ever? The answer is that the fundamental aim of current disease care systems, namely 'to ensure that every patient always gets the best, most affordable care' is no longer reachable. The key lies not in producing more disease care but in reducing disease care demands. With such a changing focus, reactive disease care will evolve into a sustainable integrated health system. Only in the long term will it render better health and therefore lead to less disease care consumption.

Healthcare professionals, especially young ones, driven by a different purpose and work-life balance will redesign the health system. For this, healthcare professionals (nursing, medical and other) need to become aware and self-confident enough to stand up and take their medical and societal responsibility. Next to this first responsibility, other responsibilities count with regards to guiding patients towards 'human dignity in every stage of life'. With this second responsibility, we get to a higher level of medical societal responsibility; a continuous role in designing and orchestrating our health system.

Whereas the medical integration of health promotion, prevention and disease care is attractive and will become the cornerstone of the future health system, when introduced as an isolated change, it will be doomed to fail. We have seen that although lifestyle coaching, and programmes like pre and rehabilitation for surgical interventions, are effective in the short term, sustainable changes (on an individual level) are difficult to maintain.

New insights show that the personal interaction between care professionals and patients or clients will not, on its own, lead to success, but a multi-sectoral approach that creates healthy living environments will enable patients to become healthier persons and will create healthier communities. Creating a healthier living environment globally will not only lead to less disease care consumption and a higher level of human health, it will also contribute to improved planetary health.

Therefore, a multi-sectoral approach involving all new industrial sustainability sectors is needed to develop a new health delivery system and introduce new concepts within it.

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**IN** this chapter, we lay out the design for an integrative approach to health and disease that creates a new sustainable health system for the future. We move away from 20<sup>th</sup> century gradual and transactional improvements towards a true fundamental and transformational change that addresses the different levels of technical, process and social innovations. This leads to an integrated health network design, with care close to the patient's home, personalised and based on the patient's self-management and with seamless connections between all layers of the health system. It is integrated in a way that personal behaviour, health promotion and prevention and disease care are all combined in one system. It also leads to a design that contributes to a healthy living environment; a new health system in which healthcare professionals have adopted the self-responsibility of creating a value chain of population health growth, rather than sticking to disease care growth.

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Various terms, like Integrative Medicine, Integrative Care, Integrative Health, and also adjectives integrated, and integral are being used in relation to new approaches of designing healthcare. Basically, the integration of disease care, health and lifestyle promotion and prevention into one system creates Integrative Care. Integrative Health Systems aim to impact human health by using such an integrative care approach. It leads to new insights and knowledge, with Integrative Medicine as a new medical discipline. According to Duke University<sup>46</sup>, “Integrative Medicine includes the full spectrum of physical, emotional, mental, social, spiritual and environmental factors that influence your health.” It also deepens our understanding of human health as not independent but strongly related to and dependent on economic and social factors like global income differences and wealth inequality. According to this way of thinking Integrative Health is becoming the changing mindset that we must begin to adopt. It seeks to combine personalised health promotion, enduring chronic disease, and enhancing the ability of humans to cope with life.

Next to Integrative Medicine and Integrative Care, the term ‘Integrative Health’ comes up. Integrative Health considers living environments as a dominant factor in diminishing or improving human health. Whereas we worry about the human impact on, for instance, climate change, biodiversity loss and deforestation, in the same way, environmental change strikes back at human health like a boomerang. Human and planetary health are therefore considered as two interconnected factors in Integrative Health.

The need for integrated actions to strengthen health systems is continuously underpinned by the WHO. Public health functions and compe-

tences are essential in reaching the key health goals specified in the agendas of Universal Health Coverage (UHC) and Sustainable Development Goals (SDGs)<sup>47, 48</sup>. Resolution WHA 69.1 provides the WHO with a strong mandate to support Member States in strengthening public health capacities and clarifying the essential functions of public health. As healthcare systems differ, no one-size-fits-all definitions are feasible.

Disease care will develop through technical innovations in numerous sciences like biotechnology, pharmacy, chemics, nanomedicine and genetics. Especially on the micro and meso level, process innovations will redevelop the landscape for healthcare providers, as well as the digitisation process and virtual care provisions. Medical doctors, nurses and other professionals will deliver hybrid care in hospitals and virtual care networks and use Artificial Intelligence for advanced personalised treatment. Patients’ independence, as well as their roles and responsibilities, will alter.

### **Merits and failures of the 20<sup>th</sup> century disease care system**

The traditional disease care system has been the logical consequence of the demands and possibilities that became apparent in the second half of the 20<sup>th</sup> century. Increased knowledge and emerging technological possibilities challenged healthcare professionals and they took up the responsibility to supply all kinds of solutions to patients under their care to the best of their abilities. Meanwhile, although overall progress has been hampered, we must realise that we have been able to make tremendous progress on a number of big health and social well-being problems.

Much progress has been made in various areas, such as in mother and child health, poverty re-

duction and basic education. However, in many other fields of disease care, progress hasn't really been made and considerable challenges continue to persist.

- Today's disease care service is far from inclusive and has failed in hoping to achieve 'an overall level of health' or 'Universal Health Coverage'<sup>47</sup> and health inequalities still persist, both within and between countries. This is clearly the case for lower-income countries but unacceptable inequalities in access to care also exist today in middle and high-income countries. Furthermore, pandemic events, like COVID-19, have served to exemplify these capacity borders.
- Secondly, today's disease care service, which is very much institutionalised, is becoming overburdened as a result of increasing demands and a lack of staff.
- Thirdly, the cost and human resources (personnel) of today's disease care service vary widely and spending is often being cut. These three factors forecast that an unsustainable disease care industry is on the horizon<sup>336</sup>.
- Moreover, from a broader, rather than a merely medical perspective, when considering food as one of the main sources of health, with 840 million people worldwide projected to be undernourished by 2030, and with nearly 10 billion people to feed in 2050, global food systems are insufficient and need to improve the availability of food to all. At the same time, increases in our food production capacity need to be achieved in a manner that is sustainable both for our environment and our health; the world has seen drastic increases in the use of pesticides since

World War II, which was considered necessary at the time in order to feed a fast-growing global population, but the use of pesticides and other toxic chemicals also comes at a costly price as prolonged exposure leads to debilitating medical conditions such as cancer, Parkinson's disease and cardiopulmonary conditions.

Considering these and many other examples, the complexity of the disease care system, along with the global food system and other interconnected systems, requires a combined, multi-sectoral approach, and all socio-cultural, political and industrial sectors are needed to develop a sustainable health delivery system for this century<sup>253, 337, 338</sup>.

And this insight is not new. The gradual and cyclic development of public health, both in high income countries (the North) and low and middle income countries (the South) throughout the 20<sup>th</sup> century has played a significant role in developing the science for preventing disease and health promotion<sup>339</sup>.

### **A historical perspective on public health and primary healthcare**

To understand the role and importance of public health and primary healthcare in developing a new integrative health system for the 21<sup>st</sup> century, we need to look back at some historical landmarks. As early as 1920, Winslow defined public health as "the science and art of preventing disease, prolonging life and promoting physical and mental health through organising societal efforts in various domains, like hygiene and sanitation, fighting infections and others"<sup>340</sup>.

In 1978, at the WHO conference on primary healthcare in Alma Ata, a broad conceptual foundation for public health and primary care in low and middle income countries ('the global south') and high income countries ('the global north') was laid out. The WHO expressed the "need for urgent national and international action to protect and promote the health of all, believing that it is a fundamental human right and that the attainment of the highest possible level of health is an important worldwide societal goal whose realisation requires the action of many social and economic sectors, in addition to the health sector." This same goal was repeated and updated at the Geneva (2008) and Astana (2018) WHO conferences<sup>341, 342</sup>.

Two mainstream developments have been important: in high income countries, family medicine evolved from being individual and patient-oriented, towards a professional practice where a community focus is also the primary goal. The general practitioner or family doctor becomes responsible for the health of the community. In low and middle income countries, healthcare tended to be focused on prevention and fighting epidemics. Much later, over the past 50 years, a basic healthcare service for the local population, with good accessibility, was developed. Both perspectives – both bottom-up and top-down – gradually merged. Primary healthcare and public health have evolved into a combination of care for the population and the individual – an 'and-and' story – in situations where contexts may strongly differ but where basic objectives remain similar.

In general, public health aims at health promotion, both at the individual level, as a primary care service, by affording accessible, high quality inte-

grated and personalised care that is embedded in local communities, as well as on the societal level, by organising an evidence-informed health policy (prevention, health promotion, curative care)<sup>343</sup>. Through this focus, primary healthcare plays a pivotal role worldwide in strengthening the overall aim in achieving universal health coverage<sup>344</sup>.

Health district systems and the integration of healthcare with social domains sectors, as well as the intersectoral collaboration with (local) governments, policy makers and industries are all recognised as essential building blocks. Primary healthcare and public health have become the knowledge authorities that direct contemporary integrative health delivery systems.

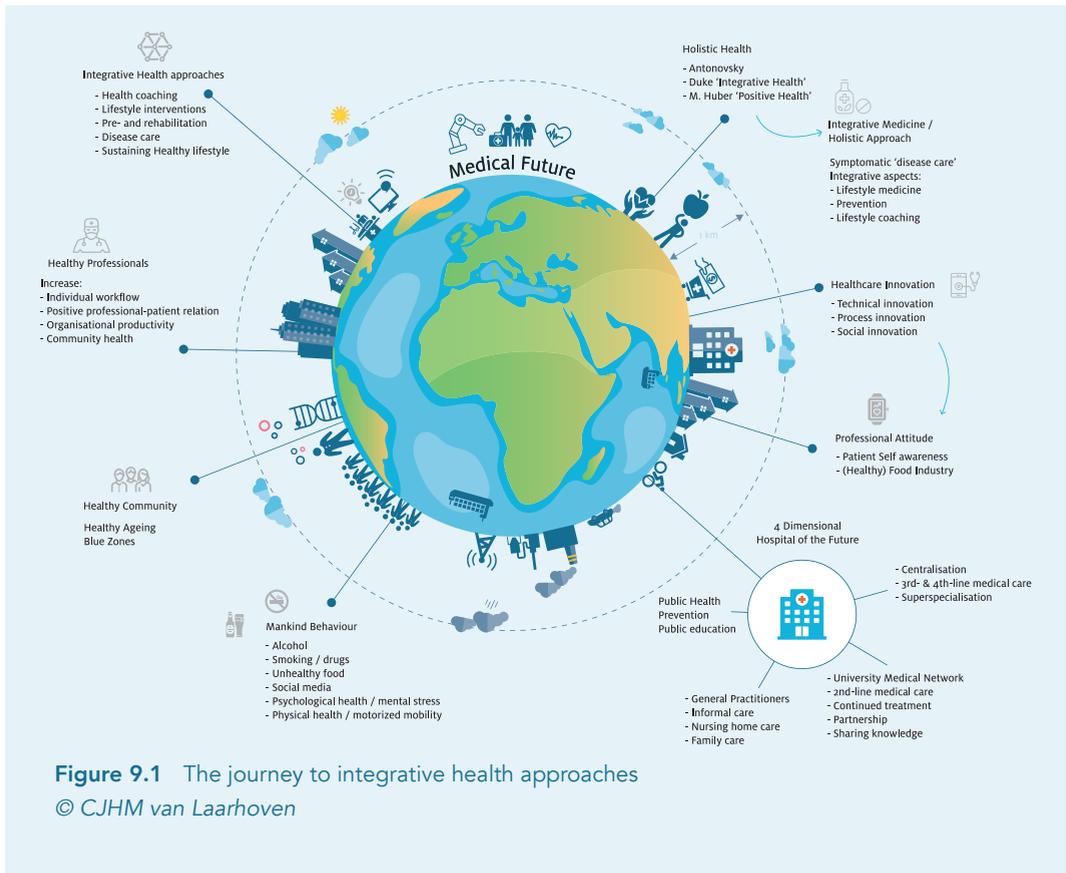
### **The next steps in the transformation of the health system**

Taking into account the changes in health and disease, the question arises of which main demands, from an individual or societal perspective, will guide the development of healthcare in the near future. Which basic concepts will inform healthcare transformation in a way that creates a new, large value chain for the next decades? One that is in line with that proposed by Kondratieff, and in a way that new concepts of health respond better to the changing health needs of populations. This question raises a number of other questions, such as: Why do the traditional disease care systems fail? Why are populations more diseased than ever, despite unprecedented medical technology? What is the role of health and disease in human life? And, how will these fundamental questions influence the design of healthcare systems?

These questions (and their answers) point to the need for a new perspective or paradigm in order to increase the level of health and decrease the disease rate worldwide; a true fundamental evolution from a traditional disease care approach towards a sustainable health delivery system. Whereas the traditional system embraces the definition of health as the absence of any disease, according to the original WHO definition, more modern definitions appeal more to a contemporary approach to care. Examples include integrative health, holistic health and 'positive health', defined as the ability to adapt and self-manage. These new definitions, which will be explored further down, are a much better reflection of the changing contemporary mindset. As stated before, in Chapter 1, integrative health

is becoming the changing mindset that we must begin to adopt and involves personalised health promotion, enduring chronic disease and enhancing the ability of humans to cope with life (Figure 9.1). It is no longer the mere absence of any type of physical, mental and social discomfort that defines health but also how we deal with such challenges, both as individual patients and as a society.

With this new mindset also, new complementary thinking is developing and, as such, diagnosing and treating patients' diseases is not the single focus. Instead, strengthening the human's ability to face and cope with their individual reality of life, including their limitations, becomes the central focus of medical care as well. This



includes domains like well-being, lifestyle and living environment, social binding and purpose and meaning in life, work and informal care.

### I - Person-centred approaches to integrative health

The integrative health approach empowers clients to safeguard their personal health process and places the person's life at the centre, enhanced by a shift from mere reactive disease management to a more proactive, integrated approach to achieving sustainable personal health. With this, the integrative health approach impacts the behaviour of patients, healthcare professionals and their organisations.

The emergence of this new paradigm or value proposition requires a shift from mainly reactive disease management to a more proactive integrated approach to sustained human health. Integrative health can be seen as a process innovation but it has the characteristics of social innovation as well. And, as it can be strongly supported by new techniques like telehealth and artificial intelligence, it is also related to technological innovation.

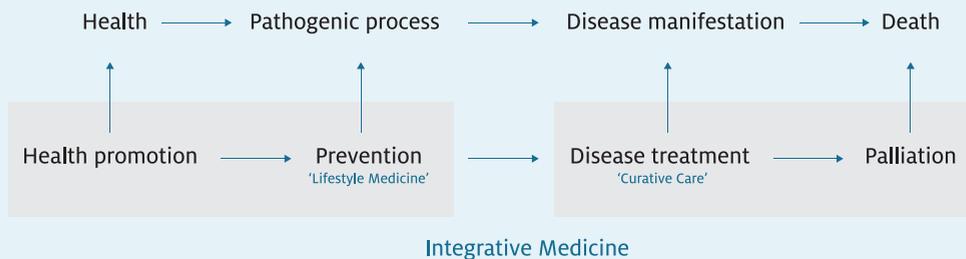
Such a change in mindset from disease-centred to well-being-centred brings us to the concept of 'salutogenesis', the origin of health. The medical sociologist Aaron Antonovsky introduced his salutogenesis theory as a way to view the world, claiming that the way people view their life has a positive influence on their health<sup>345, 346</sup>. Likewise, the 'sense of coherence' explains why people in stressful situations stay well and are even able to improve their health. He explains this by addressing the 'salutogenesis' question of what creates health and searches for 'the origin of health', rather than looking for 'the causes of disease'<sup>347</sup>.

Other concepts of 'integrative health' in public health address similar aspects of the combined approach to disease and health (Figure 6.2). For instance, the World Health Organisation posed a health system-based definition of integrated care as 'an approach to strengthen people-centred health systems through the promotion of the comprehensive delivery of quality services across the course of life, designed according to the multi-dimensional needs of the population and the individual and delivered by a coordinated multidisciplinary team of providers working across settings and levels of care'<sup>348</sup>.

Early on, starting in the 1990s, the concept of integrative health was developed at Duke University, North Carolina, United States of America (Figure 9.2). In two decades, the concept had infiltrated the disease care system and an Academic Consortium for Integrative Medicine and Health was founded in 1999. Over 75 academic medical centres were united, and Integrative Health was incorporated into the mission and vision of academic centres<sup>349</sup>.

It is not only in the United States of America that medical schools and universities focus on combining and integrating disease care and health promotion interventions, it happens in many countries on all continents where academic learning takes place.

For instance, in the Netherlands, in 2011, Machteld Huber, from the Dutch Institute of Positive Health, introduced and promoted the concept of positive health: 'Health as the ability to adapt and take control over one's own life, in light of physical, emotional and social challenges'<sup>350-352</sup>.



**Figure 9.2** The spectrum of integrative health<sup>22</sup>

*Conceptualising life as a changing state of (relative) health at birth, towards disease and death. Traditional Western medicine typically intervenes at the later stages through disease treatment and palliation. In the integrative medicine concept, prevention to intervene with the pathogenic processes and early health promotion are equally important ingredients of the system.*

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Basically, an integrative health system aims to re-humanise the health system, going beyond the purely bio-medical approach and honours the complexity of human health and healing<sup>353</sup>. Ultimately, it leads to a cultural transformation of organisations. First, an integrative health system puts the client at the centre, while addressing the full range of physical, emotional, mental, social, spiritual and environmental influences on a person's health<sup>354</sup>. It offers evidence-based interventions, both to treat illness and to prevent disease, via a personalised strategy in which the patient's unique conditions, needs, preferences and circumstances are considered. Moreover, an integrative health system helps clients to regain and maintain their optimum health through open relationships between client and provider. In this way, patients become empowered and fully engaged in their own care. It implies a transition from being passive consumers of care into active participants who can engage in activities that support sustained health in the process of co-creation, together with healthcare providers.

The ParkinsonNet initiative is a rare example of an integrative health delivery approach. By using a patient-centred approach to care, it aims to transform the traditional disease care of Parkinson's disease patients by integrating lifestyle and health promotion around the client at a personalised level and preferentially, outside the hospital<sup>355, 356</sup>. ParkinsonNet is a multidisciplinary network that aims to improve the quality of care for persons with Parkinson's disease<sup>357, 358</sup>; the specifically trained healthcare professionals in the network continuously improve their Parkinson-specific expertise. This approach has been supported by two developments: first, the development of a community-based network of allied healthcare professionals and scientific researchers to evaluate the cost-effectiveness of this integrative approach. Results have shown that ParkinsonNet improves the quality of care delivery, reduces disease complications among patients and has resulted in considerable cost savings. Importantly, patients feel more secure within such an integrative healthcare network,

while healthcare professionals take pride in participating in such an innovation.

The ParkinsonNet approach thus stands as a model for innovative and integrative health delivery. In 2010 it was fully rolled out in the Netherlands and has meanwhile been expanded to other areas internationally. If adopted, key components of ParkinsonNet can be applied to similar care networks for other chronic conditions<sup>359</sup>.

With such examples, the health system landscape changes and clients, formerly 'patients', become the leaders of their health journey using a personalised health environment<sup>360</sup> and virtual care centres connect clients with a regional landscape of high tech intervention centres, regional care and cure facilities and local first line facilities. E-health and retail health facilities also play important roles.

## **II - The role of healthcare professionals: medical, societal responsibility**

In this chapter, we have explored our current century's changing demands in the disease care industry: personalised disease care and health promotion. Healthcare professionals themselves, as experts, need to conceptualise and implement a new integrative health delivery system. Traditional solutions that just fix the disease care system, for instance by investing in more new technical solutions and improving its efficiency, will not fix the job. As such, the disease care industry at the turn of the century has become unaffordable and unsustainable. Healthcare professionals are explicitly challenged to come to fundamentally different solutions. (Inter)national policymakers and national politics will have to direct and facilitate such fundamental changes;

a new proposition that aims to decrease the total disease burden in the long run will make a sustainable health system industry in the next economic cycle of the 21<sup>st</sup> century.

Healthcare professionals are therefore urged to think about sustaining population health by creating a high-quality, affordable and accessible system. As in every industrial sector, technical experts from the field define which innovations respond best to contemporary demands. For health, healthcare professionals are the experts in designing our future healthcare in a process of co-creation with the individuals affected by diseases themselves – patients.

Four other aspects need addressing when considering the future role of healthcare professionals. First, there is the risk of professional delusion. During their careers, professionals become more and more aware of disease progression patterns and many patients return with recurrent manifestations of their – lifestyle-related – diseases, many of which are often preventable. Generally, professional motivation and enthusiasm become tempered as disease curation falls back into remedial disease control.

Another issue is in medical education, which historically has paid little attention to health promotion. As a consequence, professionals continue to feel uncomfortable and incapable of the societal role they should play as experts in the field. In new educational programs, lifestyle medicine and health promotion content is becoming more and more standard. The CanMEDS model (Canadian Medical Education Directions for Specialists) has proven to be a very useful educational framework for this and has been adapted around

### **Dilemmas in today's healthcare system**

#### Thinking differently in end-of-life care

In 2017, a very powerful and inspirational person presented her narrative about being 90 years old and extremely healthy on Dutch television (see YouTube: 'being 90 years and extremely healthy'). She showed great wisdom in her comments on the dilemmas of ageing in our current society. Using her heart and brain, she explains how crucial it is to grow old with dignity and to maintain pleasure in staying active, curious and without feelings of loneliness. Moreover, she had a mission to empower others in their ageing trajectory and pleaded for people to use their own power to shape their lives and to take care in ending the story of your life with dignity.

Some years ago, she got more and more fatigued in her daily walks, which turned out to be related to an aortic valve stenosis. Luckily, health innovation in the last decade have made transcatheter aortic valve (TAVI) repair available for this indication, making it unnecessary to have open heart surgery and she has been selected for this so-called 'TAVI' procedure. Her life and health-span was estimated to be long enough to benefit from the TAVI procedure. This turned out to be the right decision as she quickly recovered and benefited from four happy, good years of life.

In the following years, this lady still was an excellent role model of successful ageing and underlined how older persons and

other vulnerable groups may benefit from technological advances in medicine, but also how appropriate selection is pivotal. Her story shows that we should not just focus on mortality or survival as relevant outcomes but also take the preferences of older people into account and prioritise adding good years of life, well-being and the capability to communicate and share life with others.

This lady was very clear in her pro-active attitude towards dying. She carefully prepared her will, together with her children and general practitioner: when she would no longer be able to have meaningful exchange with her children, she preferred to end her life in a peaceful, self-directed manner, abstaining from medical intervention. How courageous she was, and how well she illustrated the courage we should have as physicians to arrange integrated care for our patients. This bottom up, practical strategy is probably the best way to solve the big health care dilemma; let's aim to being good physicians aiming to improve the 'years of good life'.

Despite these insights and role models, ageing continues to be considered as a major threat to the sustainability of health care. Often, the rising expenditures of the health care system are attributed to older persons and their last years of life. However, a recent international study concluded that the widespread idea that there are high levels of wasteful spending just before death is not supported by firm evidence.

Instead, the research shows that ageing leads to the postponement of some, but not all, costs to later time, rather than to an increase in per capita expenditure. The increasing cost and volume of procedures, as well as the never-ending spread of technology, and not population ageing, are the most important factors that drive the steep increase in health care costs<sup>24, 25</sup>.

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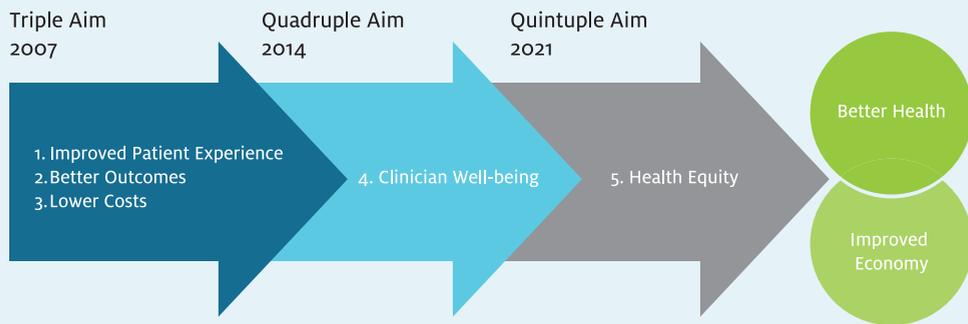
the world. The CanMEDS model describes the abilities – competencies – of physicians, which are required to meet patients' healthcare needs efficiently<sup>361</sup>.

These competencies are grouped thematically under seven roles: medical expert (the integrating role), communicator, collaborator, leader, health advocate, scholar and professional. Especially the role of health advocate enables professionals to integrate lifestyle medicine and health promotion in the medical treatment of patients.

Thirdly, doctors, by virtue of their authority, play a confidence-inspiring role in society. They are particularly suited to communicating disturbing messages to patients and also, in public. They are trained for it, it is their daily work. They are skilled in compassionately interacting with patients' fears and adapting these into positive actions. This skill is rewarding and adds extra purpose to a lifelong career in care.

Finally, healthcare professionals can also 'lead by example'. Taking the example role, they can bridge their own health attitude towards patients' awareness. With this, they have impact on individuals, organisations and the community.

Addressing these aspects of the old, as well as the potential new roles and responsibilities of healthcare professionals in an integrative health system may help retrieve purpose and meaning. Furthermore, converting the present disease care system into an integrative health system may be beneficial by also addressing the fourth organisational aim (Figure 9.3). No longer will (i) good quality of care, (ii) patient satisfaction and (iii) cost-efficient care suffice for



**Figure 9.3** Triple, Quadruple and Quintuple aims in healthcare  
*Evolution in time of aims in healthcare. Traditionally, good quality of care, cost efficiency and patient satisfaction were the three main aims of healthcare organisations. Then, along came professional purpose and well-being as important assets for organisations. Nowadays, health equity is considered the fifth aim of healthcare<sup>363</sup>.*

prosperous healthcare organisations. This new mindset enhances professionals to retrieve their purpose and meaning (iv, quadruple aim)<sup>362, 363</sup>. Disease care organisations need to adapt their value propositions to align to the sustainability aspects of their patients, their professionals and societal demands. Today, health equity is added to the concept of the quadruple aim, in order to achieve improved patient care, healthcare costs and health outcomes for all (Figure 9.3)<sup>363</sup>. With the emergence of this concept, the importance of the social determinants of health is underpinned and recognised<sup>364</sup>.

In summary, the knowledge authority of healthcare professionals, their experience in interacting compassionately with patients' personal needs and their professional purpose in guiding patients towards 'human dignity in every stage of life' all mandate professionals to take up more medical and societal responsibility.

Transformation to integrative care comes with resistance on all levels, both on the individual-professional level, as well as at the hospital and macro-economic levels. To address this resistance, more general implementation strategies are also important to address. Both for professionals and the general population, the educational strategy, with an upskilling of knowledge and awareness, is a first line strategy. Next, local implementations of best practices and spreading of good examples will visualise the potential of integrative care and decrease resistance. On hospital and macro-economic levels, a change of payment systems is needed, with population-based financing as an attractive alternative that eliminates the disease-product to cost connection and reimburses health promotion activities. Foremost, enforcing the role of healthcare professionals as early adopters is a fourth important implementation strategy. Professionals have the ability to act as 'tipping points' by influencing the bystanders who are slow to react or respond.

### III - Solutions at different levels

In line with this changing paradigm, disease care services are changing along the lines of process innovation, technical innovation and social innovation. Transactional changes (more easily done, necessary but incremental changes) and changes at a more transformational level (visionary, more looking at long-term prosperity, more fundamental changes) occur side by side. Not one change will lead to 'the solution', nor will it be possible to comprehend the process completely. Let's try to outline the landscape of such an integrative health delivery system.

#### Incremental process innovation

In the transactional process of reorganisation, many ongoing initiatives, like patient pathway descriptions, clinical guideline developments, multidisciplinary team approaches and value-based care change today's disease care system. The institutionalised disease care system will further change through the development of regional integrated care networks, which include primary, secondary and tertiary care levels and are supported by information technology to enable more community-based services.

This all has an impact on the hospital sector that will be reduced, on the one hand, but will also take up its new role in newly developed and highly specialised intervention centres. Such centres will be supported by a large spectrum of advanced technologies in diagnostics (e.g., AI in imaging, genetic coding and pathology), therapeutic interventions (e.g., image-guided techniques and robotics) and new medical therapeutics (like immune therapies, nanomedicine and genetic engineering).

A burning issue in the short (and somewhat long) run is the need to expand the chronic care capacity for the currently ageing populations. The transition described above is expected to have an effect on the younger generations but, in the meantime, healthcare systems will need to respond to the high chronic care needs of today's older generations. This may require difficult (political) decisions. Current attempts to curb healthcare expenditure may be hampered or fail<sup>365</sup>.

Until the middle of this century, our healthcare system will need to follow this double track and provide high volumes of chronic care in low-complexity clinical, rehabilitation and nursing facilities; this 'old' system will operate in parallel to new network infrastructures with remote support facilities centred around patients<sup>366</sup>.

The concept for the high volume, general hospitals of the last half a century is changing in HICs. Day care facilities, with 'fast lane' trajectories, omitting unnecessary hospital stays, are becoming more standard. Parallel to this, and stimulated by entrepreneurship and lean process innovation, specialised clinics, with either day or short-stay care have emerged in the HIC markets and nowadays take care of substantial parts of national healthcare programmes<sup>367</sup>.

The 'retailing' of the health system is an emerging concept in western countries. For example, the commercial availability of screening tests – such as full body CT/MRI imaging tests and genome and biomarker testing – online consultations and online pharmacies has led to a whole new emerging industry. But also, at the other end of the spectrum, established industries like Wall Mart and Amazon offer healthcare services.

As such, a health delivery system that is centred around the patient and is outside of the hospital is possible. Effective marketing and attractive commercials predict even an 'augmented health for sale'<sup>61</sup>. At the same time, care must be taken to ascertain equal access to care for all, including traditionally underserved populations that live in poverty or that have lower education levels. Another concern is that commercially driven healthcare institutions may only focus on economically interesting healthcare challenges while leaving the more challenging cases to the traditional healthcare system.

### **Social innovation**

Socio-cultural changes also impact the disease care system. New technical innovations, like telehealth, virtual care with digital remote monitoring and artificial intelligence will change our socio-cultural interaction. Virtual care, combined with medical and social home care, will supply most of the needs of elderly people, in particular, who seek to live independently for longer. For younger generations, the so-called 'digital natives', these virtual facilities will become natural and easily accessible. Family care, formerly an informal service, is now becoming recognised and formalised as an important cornerstone of the emerging health service. In western societies, many adults between 40-65 years of age already fulfil the role of being family caregivers. In this era of ageing populations, and due to the high personal demands on family care members, this system is fragile, and the concept of family care needs a safety net in terms of temporary residences for acute situations in case the family care system is overloaded.

## **IV - Integrative health systems: from transaction to transformation**

The enormous medical knowledge and technical treatment possibilities give reason to worry about the ongoing growth of healthcare consumption. However, whereas the Hippocratic oath suggests 'to afford the best possible care for my patient', this one-dimensional approach is more and more being questioned.

Meanwhile, a true transformation to an integrative health system industry, as a new and different value proposition, is needed. An integrative health system needs embedding in a broader planetary health – and, ultimately, a 'One Health' – concept to ignite and support that transformation. Realising the interconnectedness of human and planetary health makes us realise that 'fixing' the disease care system cannot be realised in isolation.

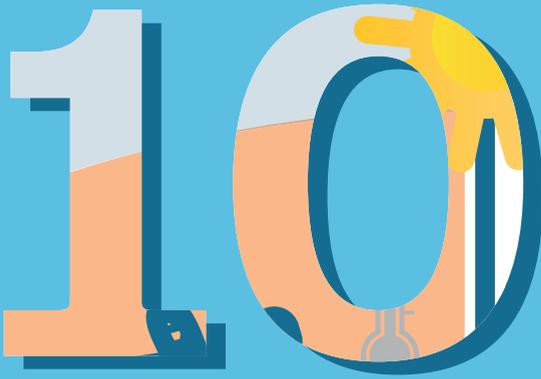
But only with a well-conceived value proposition – from both a human as well as a planetary perspective – will the system transform successfully. 'Successful' means it will be economically feasible and capable of redirecting human behaviour towards health and well-being. Characteristics of the new system involve the following: a balance between global health, well-being and the utilisation of curative care; patient-centredness, including personal responsibility for lifestyle and health; and the changed roles of health professionals beyond purely curative care and palliation.

### Key points

In the 21<sup>st</sup> century, reactive disease care will transform into a **sustainable integrated health system**.

- Considering the **global increase in disease care consumption**, the old mindset of the present traditional health system 'to ensure that the patients always get the best affordable care' will no longer be maintainable.
- Next to the first responsibility of healthcare professionals, **to afford the best achievable care**, a second responsibility, with regards to **guiding patients towards 'human dignity in every stage of life'**, becomes more important. With this second responsibility, we get to a higher level of medical societal responsibility, namely, the role we have in designing and orchestrating our health system.
- Long-term investment is needed to transform to an integrative health system that will render a **true sustainable population health**, two to three decades from now.
- **Healthcare professionals** (nursing and medical) need to stand up and take their medical societal responsibility.
- **Clients** (patients) are empowered to safeguard their own personalised health delivery process, within a surrounding regional care landscape.
- New insights show that the personal interaction between care professionals and patients or clients will not necessarily lead to success but that a **multi-sectoral approach** that creates healthy living environments will help patients to become healthier persons and will create healthier communities
- Creating a healthier living environment globally will not only lead to less disease care consumption and a sustained population health, it will also contribute to **planetary health**.

# Chapter 10

The number '10' is rendered in a large, bold, sans-serif font. The '1' is white with a blue outline and a blue shadow. The '0' is white with a blue outline and a blue shadow. A yellow hand is shown holding a blue pen, writing the '0'. The background of the '10' is a light blue gradient.

## The Humansphere Towards a sustainable future living environment

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### **Humansphere, a 21<sup>st</sup> century beckoning perspective**

Imagine the year 2100, by which point an overall conversion to global sustainability has taken place due to a new economic cycle of emerging industries. Humankind had understood what it had to do early on, at the beginning of the 21<sup>st</sup> century. It made the right choice. Younger generations, Y, Z and Alpha, created a new 'Humansphere', with a global 'clean-up' as a dominant mindset<sup>5</sup>.

By 2070, cities became the dominant seat for most of the earth's inhabitants. Many villages were absorbed by cities and people left rural living behind as traditional agriculture was replaced by the new agribusiness. Cities became able to support themselves in areas like food and water management, mobility and infrastructure and ecology and circular waste processing.

By switching to a vegetarian and protein-based food system, utilising agribusiness, agro-forestation and local food productions, this new food biotechnology sector enabled the restoration of much of global land use, as well as decelerating biodiversity loss. Sea level rise forced some cities to be relocated and also involved coastal line changes, such as those facilitated by 'building with nature' programs, making water resource management another major industry in the environmental protection sector.

The great energy transition in the first half of the 21<sup>st</sup> century moved us from a fossil energy supply system towards the availability of cheap, abundant and near-universal access to electricity<sup>23</sup> based on nuclear fusion energy, combined with non-fossil renewable sources.

Furthermore, a completely transformed integrative health system became one of the new leading industries of the new economic cycle of sustainability.

Restoration of the global ecosystem and climate change took place in the economic cycle of sustainability, making a more spacious world for 10 billion people.

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**IN** the tenth chapter of this book, a future perspective is imagined. It is a clear and optimistic view, integrating solutions on economic health, ecological health and human health; a perspective on how the planet may evolve in terms of sustainability, prosperity and health. So far, we have understood how human behaviour within the Anthropocene has impacted human health and environmental change<sup>368-371</sup>. But looking forward, the Anthropocene can be transformed into a new state of balance of the earth system within the next two centuries<sup>372</sup>. In this perspective, 'the earth system behaves as a self-regulating system comprised of human components as well as atmosphere and biosphere components, with complex interactions and feedbacks between these components,' a new Humansphere to be created<sup>373</sup>.

The term 'Humansphere', as a new entity within the biosphere, is introduced to frame these future visions. And although, in the beginning, it may sound unfamiliar, it may help in giving substance to the imagination by combining the human and unique biosphere factors. It identifies the lost connection between human health and planetary health and visualises sustainable human behaviour as a beckoning perspective.

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Humansphere is defined as a living environment, different to the living environment of today, led by upcoming younger generations with a different purpose, values and beliefs. It is an optimistic view of how and where mankind might live in the near future<sup>171, 374-377</sup>.

### **An inheritance of 250 years of the Industrial Age**

As explained in chapter six, we live in an era of growing global economic prosperity, in which we acquired increased life expectancies. Prosperity, however, is not evenly distributed<sup>378</sup>. Globally increasing life expectancies come at the cost of more disease and, as a consequence, are accompanied by increasing disease care consumption.

In chapter three, we saw that, parallel to human ageing and disease, our planetary health is at stake, with most planetary boundaries having already been crossed. As described previously, living in the thin 50 kilometre wide 'apple peel' in and around the earth, the following global challenges stand out most at the beginning of the 21<sup>st</sup> century: creating a sustainable living environment for 10 billion people, developing a sustainable food and water supply, energy resources and mobility issues and improving human health and well-being. Solving these four challenging global issues will depend very much on how resilient our ecosystem will be able to adapt but, more importantly, how mankind will be able to adapt and change to these new demands.

Fortunately, humankind, historically, has proven to be most adaptive and Mackenbach, in 2020, classified changes in human health as either 'spontaneous', such as changes in living conditions without human interference, or as more or less intentional man-made changes<sup>49</sup>. He also

stated that long-term health improvements have been mostly human-made. Significant historical examples include improved hygiene and sanitation, improved agricultural harvest yields, reduced exposure to hazardous industrial working conditions, anti-smoking campaigns and new medical treatment breakthroughs<sup>49</sup>. He concludes, 'the multifaceted nature of all these 'man-made' changes also explains why 'population health is so closely related to economic, political and socio-cultural conditions'. So far, we have seen that the Anthropocene has given us the insight to take action from a human responsibility approach and we have the intelligence and technical knowledge to create solutions<sup>375, 379</sup>.

In order to visualise a future 'One Health' solution, possible developments related to some of our contemporary issues, although incomplete, will be described below.

### **I - Living environments**

By 2070, cities will have become the dominant habitat for most people. Many villages will have been absorbed by cities and traditional agriculture has been replaced by new agribusiness. Megacities of over 10 million people will become more and more important. This political transition will be elicited by a complete outlier: sea level rise. As predicted by the Verisk Maplecroft Climate Change Vulnerability Index (2018), numerous coastal cities will have become uninhabitable and coastal exodus will have led to mass land inward migration to new cities, while other cities will have adapted to climate change through mega projects involving 'building with nature' to fortify their coastlines (Figure 10.1). Sea level rise has been predicted to displace tens of millions of people in the first half of the 21<sup>st</sup> century and might become the costliest con-

sequence of climate change<sup>380, 381</sup>. The move of cities most at risk, like the Indonesian capital Jakarta, was exemplary. Next to the general sea rise effects, more specifically, damage due to cyclones and heightened storm surges was anticipated, with coastal cities of low-income countries being the most susceptible.

After 2025, the world population came to the insight that present international politics, being embedded in the national forces of the West (the United States of America and the European countries) and North and East Asia (Russia and China), was no longer going to sustain a solid balance for peace and economic collaboration. Geopolitically, a new balance of power grew in which megacities became more independent

of countries. Cities developed self-sufficiency in areas like infrastructure, ecology, water management, circular waste processing, food and mobility. Also, renewable energy supply systems, smart multi-functional buildings and socio-cultural aspects changed cities into new habitats. Traffic congestion has become history and IT possibilities for virtual connectivity have made long-distance travelling unpopular. Megacities developed as a number of city hubs were connected by interregional, high-capacity and high-velocity trains. Those cities with strong industries directed at sustainable production and self-supportiveness became the dominant economic players. 'Building with nature' became the impactful value proposition of growing cities.

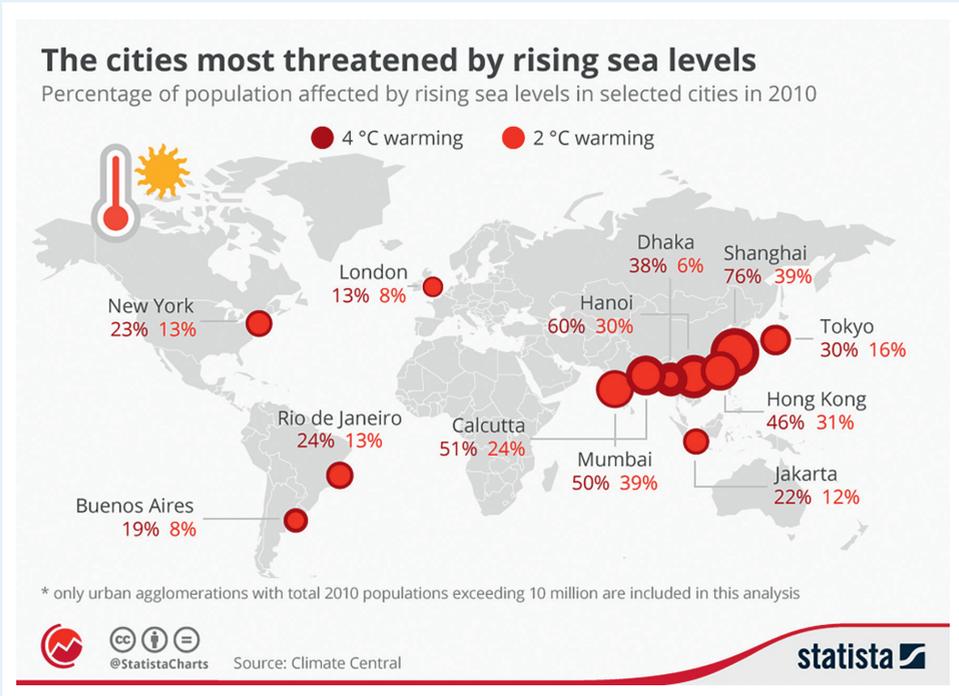


Figure 10.1 Most endangered cities

<https://www.statista.com/chart/4045/the-cities-most-threatened-by-rising-sea-levels/>

The mobility of citizens was redirected by replacing and even abandoning the automobile, creating car-free streets with public transport with both local and interhub, high-velocity trains, bicycle and pedestrian areas, as well as drones to carry people. Home delivery services for most products became standard, either by electric bicycles or drones.

Megacities became embedded in regions with protected nature areas, both inland and offshore, offering coastal protection and wildlife habitats. Hundreds of megacities worldwide needed to adapt to climate change, either through infrastructure against sea level rise in coastal cities, or by moving inwards. Forced city replacements and coastal changes by 'building with nature' programs, like mangrove forests, sandbanks and swab areas, made water resource management another major industry in the environmental protection sector.

Ecology, (re-)building with nature and respecting local natural circumstances direct these new cities' developments. Renewable energy supply systems, geothermal energy for warmth, green roofs, rainwater management and automated irrigation systems build green cities that approach zero emission rates. Restructuring city water management, drainage and the reuse of rainwater and sponge areas create habitats for wildlife that lead to the recovery of formerly dried wetlands surrounding cities. City gardens and green parks neutralise city temperature rises and improve habitats for both humans and small (bird) wildlife.

Smart, multi-functional buildings arise, with different heights and an effective use of light and solar energy. Light and air are preserved at

street level. Socio-cultural aspects have changed cities into new habitats where new generations work from home with flexible working hours and remain fit through daily physical activities by convening at sports accommodations or by virtual reality-aided sports activities.

Worries remain about the ageing processes in cities with a shortage of younger generations (double and triple ageing effects) as a result of halving the population birth rate since 2020. Global population increase has stopped at around 10 billion people, based on a global 'two child female birth rate'<sup>382</sup>.

## II - Food and water

In 2020, agriculture absorbed 70% of all freshwater supplies, 80% of deforestation in (sub) tropical regions was done in order to make way for agricultural farmland and the global footprint due to livestock and ocean fishing was immense. Meanwhile, with an increase in the global population towards 10 billion, food production worldwide was prospected to grow by an additional 70-100%. An enormous deficit in food was impending.

A fundamental transition was needed to overcome the problem of food waste and shortage. This awareness gradually changed the human mindset, evolving mixed fish and meat-based, high carb fast food diets into dominantly vegetarian/vegan diets, with plant or insect-based 'lab-grown meat'. Many engineers, farmers and designers worldwide created new products and innovated food processing into a new agribusiness. Livestock was phased out as most protein food sources now come from insects and fish farms and synthetically grown meat from cell-culture farms. Fish and meat became exclusive,

luxury foods. Agribusiness, as part of biotechnology, became one of the top new sustainability industries and looked nothing like agriculture in the 20th century.

Looking back from 2100, we were late in converting biodiversity loss. But, whereas in 2020, when many species of flora and fauna were endangered, the damage was limited by 2100. The lungs of the earth have been reshaped by reforming millions of acres of former agricultural lands in subequatorial areas of China, Australia, India, Africa and North and South America into agroforestry. A reforestation industry developed on every continent with a new habitable climate for forest species. Impending and uncertain techniques, like stratospheric cooling technologies and cloud seeding (artificial generating rainwater) to reverse the shrinkage of large tropical rainforests were avoided.

By switching to a plant protein based food system – with agribusiness, agroforestry and local food production – this new food biotechnology sector enabled the restoration of much of global land use, as well as decelerating biodiversity loss.

High technological innovations, like greenhouse facilities that rely locally on nature's abundance of sunlight and seawater now produce high-value crops. Agribusiness farms harvest without the use of pesticides or pollutants while using bees and other insects as natural defence systems and for the natural pollination of plants. They produce their own salts and minerals as by-products of the desalination of seawater and use them as nutrients for the fertilisation processes. By 2100, multi-story greenhouse farms will produce more than half of crops worldwide, located in

the inhospitable deserts of Australia and Africa. Even underground hydroculture farming, with efficient LED lighting and clean rooms, without the need for pesticides, adds attractive forms of agribusiness.

Although this highly intensive new agribusiness, due to automated and robotised processes, negatively impacted employment opportunities, people throughout the 21<sup>st</sup> century understood and accepted this way of food development as its footprint decreased and agricultural lands were restored to wildland.

More locally, in megacities, 'vertical farming' – growing vegetables on roof gardens and on allotments – as well as hydroponic platforms – growing plants on a nutrient-rich solution with a water base, without the use of soil – for growing food indoors became the standard of local farming.

Combining multiple facets of these newly developing industries, a much more sustainable real estate developed in 21<sup>st</sup> century megacities, with close connections between food production and the living environment and with a minimum of transport needs.

All came together in a new horticulture industry, a research-based scientific discipline focusing on the cultivation and optimisation of edible and non-edible crops to the benefit of people and the planet. Scientific research is not only focused on growing plants but also on environmental protection and uses plants in landscaping and the beautification of urban areas and cities, as well as for other social causes and educational purposes. Horticulture will have become a true science and global business by 2100, within one full generation.

In the first half of the 21<sup>st</sup> century, freshwater resources became a major problem, not just for low-income but also for middle and high-income countries. With a growing global population and increasing industrial and urban water demands, as well as the high demand put on agriculture on freshwater resources, the scarcity of water became a global issue. Not surprisingly, the demands launched new freshwater and desalination industries and a new science of water management developed. The availability of safe and fresh water significantly changed, with issues being specific to the different global regions.

### III - Energy and mobility

With the mass use of fossil energy resources since 1850, after 150 years, humankind realised that using that much of a global resource made an energy transition inevitable. After the initial introduction of renewable energy sources between 2000 and 2020, a second phase, up to 2050, started. In this second phase, a strong urge was felt to abandon fossil fuels in order to reduce CO<sub>2</sub> production and attempt to become a zero-emission economy by 2050. Oil and natural gas were replaced, partly, by wind and solar energy and hydroelectric power stations. But, with an immense increase in energy demands, fossil energy, as well as nuclear energy, was still needed.

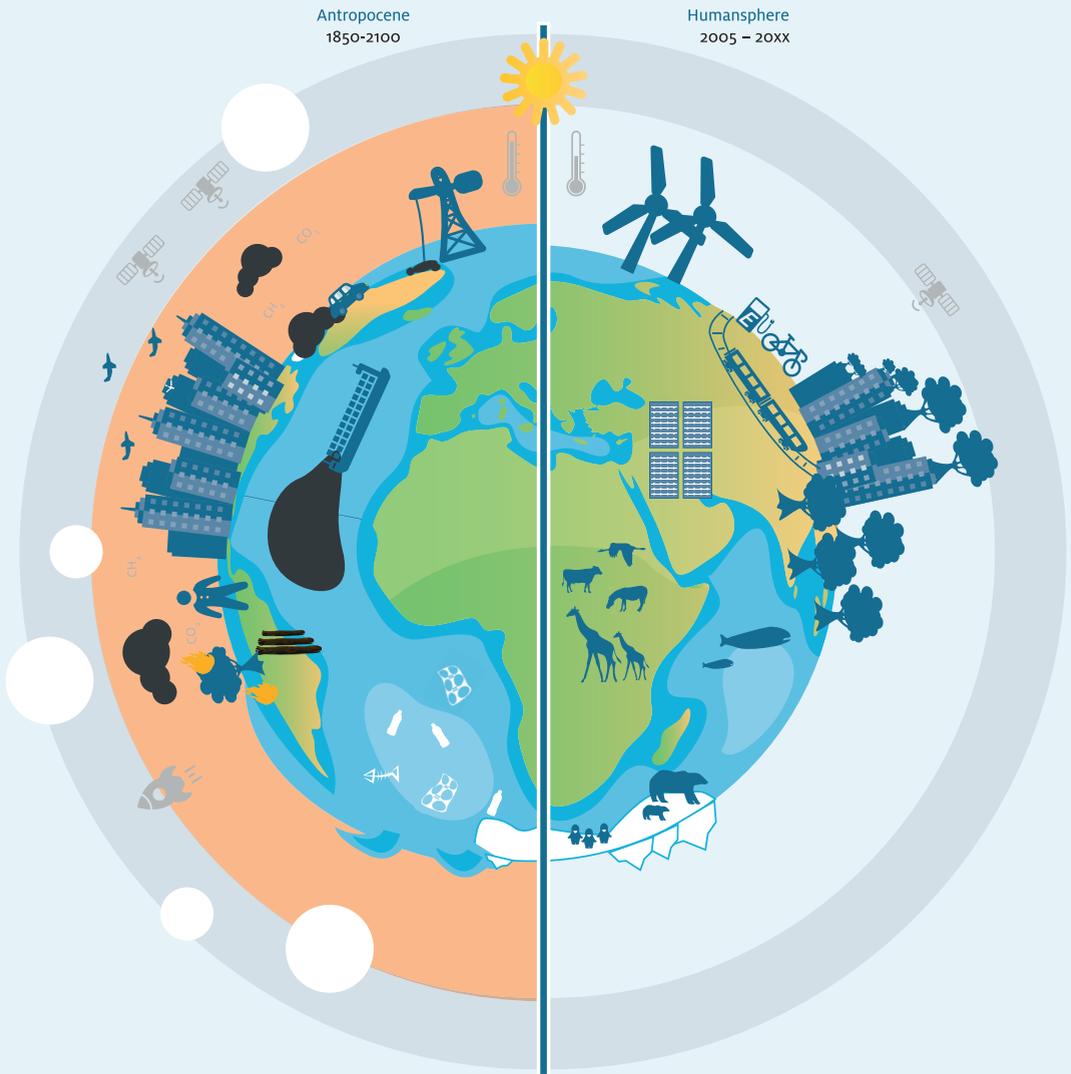
However, the impact on infrastructure building for wind, solar and hydroelectric energy was huge and debates about their pros and cons fed the surge for alternative energy sources.

In the third phase, after 2050, a long-lasting societal discussion about the pros and cons of nuclear fission energy took place. Nuclear fusion entered midway through 2050 as a safe energy

source and at an unprecedented level, with heat production as the primary energy output, which is converted into warmth and electricity. New technologies became available and addressed the containment of heat with adequate heatsink materials, as well as magnetic techniques to protect storage heatsinks against melting. Finally, hydrogen energy became another new main energy source, very useful in heat networks, the transport industry and the new recycling industries.

A conversion occurred from an Industrial Age-derived fossil energy supply system towards an abundance of nuclear fusion energy, combined with non-fossil fuel renewable sources. The great energy transition that happened in the second half of the 21<sup>st</sup> century led to the availability of cheap and near-universal access to electricity<sup>23</sup>. Oil companies were reformed into sustainable low-carbon energy companies, disposing of most of their oil activities and becoming green, zero CO<sub>2</sub> emissions companies after 2050.

The mobility industry was redirected in different ways. Due to the global population growth demands on automotive industry became unsustainable. The automotive industry invested in electric cars as mobility solutions. However, as discussed in the living environment above, with 10 billion people, individualised car mobility became untenable. Automobiles were generally banned from cities and alternative public transport became dominant<sup>303</sup>. Congested traffic became globally questioned, due to the possibilities afforded for working from home and having distant digital meetings.



**Figure 10.2** The global clean-up in the 21<sup>st</sup> century

*Visioning the global transition from an endangered 20<sup>th</sup> century biosphere to a 21<sup>st</sup> century 'enlightened' Humansphere: from ozone depletion and CO<sub>2</sub> climate change towards ozone restoration and CO<sub>2</sub> neutralisation; from drilling rigs and oil disasters at sea to coastal windmill parks and Saharan solar parks; from smog cities due to fossil car combustion to public fossil-free electrical and hydrogen energy-aided transport; from forest fires and biodiversity loss to agribusiness and reforestation; from ice melting and ocean plastics to Antarctic ice regrowth and the rebuilding of biodiversity with polar bear and penguin populations; a spacious world for 10 billion people; a global clean-up leading to human and planetary health: One Health.*

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#### IV - Health and well-being

At the turn of the 20-21<sup>st</sup> century, the disease care industry worldwide had become one of the biggest industries. However, people also realised that the main contemporary health issues, as well as the long-term care sector, were responsible for an unaffordable system, and that continuing the traditional system would impossibly supply the increasing demands. COVID-19 created even more awareness of the unsustainability of the system. In the decades after 2020, a gradual transformation, as a new mindset, towards an integrative health system, combining disease care, long-term care and prevention occurred, a transformation that started with listening to the health needs of civilians and providing a professional response. Listening to the effects of 250 years of the Industrial Age made the effects on human health obvious<sup>171, 374-377</sup>. It was there that the needs and behaviours of older and younger generations impacted, in different ways, health and well-being.

First, the older generations (the Silent Generation and the Baby Boomers) grew enormously, as did their needs. According to the World Population Ageing 2019 report, this group would grow from 700 million (9%) in 2019 to 1.5 billion people (15%) in 2050<sup>383</sup>. Due to the 'double ageing' of this group (because of the increased life expectancy of the older generations), their basic needs increased, especially in terms of facilities for prolonged independent living, as well as for family care and/or increased dependency on long-term care<sup>384</sup>.

Different generations showed different purposes and attitudes towards life. And again, generations' needs differed globally per region. In HICs, the present younger generations (Y and Z)

grew up in times of relative economic prosperity, whereas in other regions like Africa, poverty and lack of prospects for work resulted in mass migration.

But also, having been confronted with several crises in the early part of the 21<sup>st</sup> century, like the economic crisis (2008), the climate crisis, global resource depletion, mass migration, the COVID-19 pandemic and the Russia-Ukraine war, this generation has been challenged to move away from the materialistic mindset of the 20<sup>th</sup> century. Instead, a renewed wisdom of purpose and meaning, sharing and community spirit became common ground and new connectivity was aided by the digital revolution and social media. They developed a new approach to today's planetary health problems but need their seniors right now to prevent further harm<sup>385</sup>.

In conclusion, different generations each had their specific needs and (intrinsic) habits that impacted mankind's behaviour in the 21<sup>st</sup> century.

#### How will the 21<sup>st</sup> century Humansphere unfurl?

If we were able to look back from 2100, hopefully we would see an overall conversion to global sustainability due to a new economic cycle of emerging industries. We could say therefore that humankind understood which scenario it had to choose early on at the beginning of the 21<sup>st</sup> century and made the right choice.

In the 21<sup>st</sup> century, global sustainability and prosperity went 'hand in hand'. But also, for decades, the world struggled with the aftermath of conflicts. Younger generations realised the need to convert to a new mindset, away from war, power, humanitarian crises and mass migration.

The world's megacities created new societies, focused on diversity and equality, and created living environments based on sharing, rather than possession – cities without the ambition to rule large regions of the world. Fights between countries or religions subsided due to a common discernment about global sustainability. Global

politics democratised, critically turning its back on the non-democratic and autocratic governments of the late 20<sup>th</sup> and early 21<sup>st</sup> century.

Generations created a new 'Humansphere' with global clean-up as the dominant mindset (Figure 10.2)<sup>5</sup>.

### Key points

Looking forward to a sustainable living environment, a connection between human health and planetary health is made by visualising a new **Humansphere**.

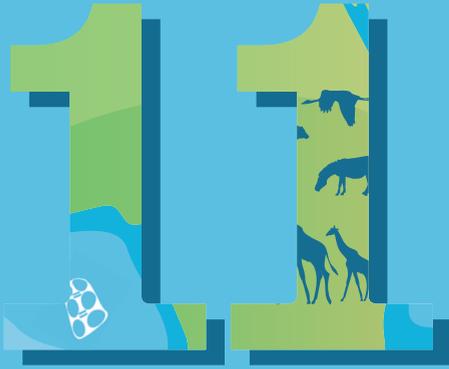
Within this Humansphere:

- **Cities** develop self-supportiveness in areas like infrastructure, ecology, water management, circular waste processing, food and mobility.
- A new **horticulture industry** is built: a research-based scientific discipline focusing on the cultivation and optimisation of edible and non-edible crops.

- Oil companies reform into sustainable **low carbon energy companies**, becoming green zero CO<sub>2</sub> emission companies after 2050.
- The younger generations of the 21<sup>st</sup> century create a new healthy living environment, with a **global clean-up** as the dominant mindset.



Chapter



# The Humansphere and the four main health issues tackled by multi-sectoral health plans

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### **From disease-specific recommendations and WHO 'best buys' to multi-sectoral health plans**

By now, we acknowledge that disease care systems need conversion to integrative health delivery systems in a way that they become the facilitator of health rather than primary responders to the rise and fall of diseases. Health promotion and disease prevention should be leading instead of merely taking care of the expensive consequences of the onset of disease. Based on a literature survey of international policy reports, a set of recommendations is presented that can form the guiding principles of multi-sectoral plans, leading to sustainable healthy living environments.

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**THIS** chapter reflects the results of our survey on possible recommendations and guidelines from a wide range of policymakers, such as the WHO, the UN and other international governmental organisations, like the World Trade Organization (WTO) and regional or national bilateral investment treaties (BITs)<sup>386-388</sup>. Subsequently, we have extracted an overview of possible interventions related to human health and health promotion.

First, we present specific recommendations on the four main health issues as presented in this book. Next, most of the disease-specific recommendations can be compiled into a set of general recommendations in line with the WHO's four 'best buys'<sup>389, 390</sup>. Such a comprehensive disease prevention programme needs embedding in multi-sectoral (national) integrative health plans that will create sustainable healthy living environments. Ten WHO keystones are considered essential directives for this<sup>391</sup>.

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## Specific recommendations on the four main health issues

### I - Neurological and mental diseases

Prevention programs for youth, including the WHO Health Promoting School framework, show significant positive effects on the mental development of children and young adults<sup>392</sup>. Such programmes, which focus on the promotion of mental health at schools, raise awareness around mental health issues at an early age. Health promotion and prevention interventions for neurological and mental disorders should be designed for each developmental stage and age-specific risk factor. Also, they should include multidisciplinary approaches (psychological, social, familial and legal) and especially focus on school-based interventions, focusing on children, parents and teachers. For example, this could include the prenatal environment (e.g. maternal infections or stress, poor nutrition), preterm delivery, social risks (e.g., immigration, social isolation, living in poverty), trauma (bullying, little attention from parents), stressful events and sexual abuse<sup>392</sup>. Such factors are interrelated and could enhance synergistic effects.

Especially for late-onset neurodegenerative diseases and late-onset diseases like strokes, the concept of primordial prevention is valuable. This includes strategies that start from infancy and continue into childhood and adolescence<sup>393</sup> and is valuable in terms of increasing both life-span and health-span by decreasing morbidity.

Recommendations for the promotion of mental health and the prevention of mental and behavioural disorders were laid out in the Melbourne Charter in 2008<sup>394</sup>. Also, the WHO re-

cently produced a guideline on the prevention and management of physical health in relation to severe mental disorders<sup>395</sup>. In this report, to arrive at effective national systems for mental health promotion, cross-sectoral collaboration with non-health sectors, like education, housing, industry, transport, urban planning, as well as arts and sports, was considered essential.

Key recommendations for preventing and combatting neurological and mental diseases include counselling and monitoring healthy eating patterns, encouraging physical activity for children as part of school activities, promoting sleep hygiene early in childhood, the early start of smoking prevention counselling and safety measures to reduce accidents and prevent severe head traumas<sup>396, 397</sup>.

Examples of specific recommendations within universal primordial prevention programmes include prenatal vitamin D and phosphatidylcholine supplementation during pregnancies. And more recently, much attention has been drawn to the underexposed effects of pesticides in farming populations on developing neurodegenerative diseases like Parkinson's disease.

Substance use disorder is a chronic medical condition affecting mental health via intoxications and chronic dependences. The misuse of and addiction to prescription analgesics, heroin and synthetic drugs requires community-targeted and individual prevention strategies. An important intervention to decrease prescription-based opioid misuse is reducing inappropriate prescribing<sup>398</sup>. For example, in 2017, in the United States, 178 billion milligrams of morphine equivalents were prescribed (The US population at the time was 250 million people). The UN

General Assembly, in 2016, adopted a resolution to commit to effectively addressing and countering the world drug problem<sup>78, 399</sup>.

## II - Oncological diseases

Based on the knowledge that about 30-40% of all cancer diagnoses can be prevented, national cancer control plans (NCCPs) are essential components of WHO programmes to prevent cancer expansion<sup>400-402</sup>. National cancer control programmes are the sum of the prevention and control activities undertaken by a country to address the national cancer burden and are increasingly recognised as crucial programmes<sup>403</sup>. Cancer control, therefore, is regarded as an integral component of the path towards Universal Health Coverage (UHC) and will become a basic keystone of the 21<sup>st</sup> century integrative health delivery system<sup>401</sup>. Three pillars are essential for cancer control: service delivery, health financing and governance.

In regard to the first element, the appropriate capacity of palliative care should be promoted at all levels, including at home, in community centres, in hospitals and in specialised cancer centres. We also need to think of innovative ways to reach rural populations with screening programmes. Secondly, the financing of cancer control should be extended in steps, in line with the realisation of UHC. As the burden of cancer is quickly growing in LMICs, financing should be scaled up in accordance with that and to assure that patients are not impoverished after paying out of pocket.

Concerning the latter, the WHO suggests activating political will in regards to multiple elements of good governance, concerning transparency, participation, accountability, integrity and capac-

ity. In addition, by focusing on a set of priority interventions, more than seven million lives could be saved, by 2030. For instance, 'best buys' like tobacco control programmes and broad implementation programmes for vaccines against human papillomavirus and hepatitis B virus are effective and feasible methods to prevent cancer. In addition, early diagnosis needs to be prioritised to treat cancer in its early stages, before the disease progresses. Concerning cancer treatment, we have seen tremendous progress in the past half-century. While some recent innovative therapies improve survival rates or quality of life significantly, many of the newest treatments have only marginal population benefits.

Besides, palliative and survivorship care should be included in all national cancer control plans. Today, more than 50 million cancer patients have become long-term survivors. While recovering from treatment, these (ex-)patients need reintegration into society and workplaces. But also, the needs of the majority of cancer patients facing palliative care at some stage need to be paid attention to.

Moreover, a key recommendation to decrease oncological disease is to build capacity through cancer centres and networks linked to strong primary care. Especially cancer services are currently less well funded than other disease programmes in many LMICs, ensuring a continual, appropriate increase in the share of the health budget.

When looking at the individual, much of the specific (lifestyle-related) recommendations are in line with other NCDs. However, the mechanisms per specific disease differ. For example, maintaining a healthy body weight (BMI range 18.5-24.9) is specifically related to the prevention of

multiple types of cancer, such as most digestive tract cancers, as well as breast, gynaecological, prostate and kidney cancer. There is growing evidence suggesting that intentional weight loss reduces circulating levels of factors associated with cancer<sup>404</sup>.

In addition, lowering the consumption of alcohol is suggested to reduce the risk of developing cancers of the proximal digestive tract: cancers of the mouth, throat, oesophagus and stomach, but also to the liver, pancreas, colorectum and breast cancer. It's the same for tobacco use: while smoking is related to the development of multiple NCDs, it is specifically correlated to pulmonary and proximal digestive tract cancers, as well as to those of the urinary bladder.

In addition, other specific recommendations include:

- Prevention of exposure to chemicals that cause cancer. All countries should have programmes to control and eliminate the most widespread carcinogens in living environments and workplaces (e.g., asbestosis), using measures like introducing sources of information, such as the International Chemical Safety Card, control mechanisms for threshold limit values and using personal protective equipment.
- National programmes on the prevention of sunburn radiation, as well as national information and prevention programmes to limit exposure to the sun and to discourage indoor tanning.

### III – Pandemics and infectious diseases

Next to this, a combined approach of multi-systemic collaborations and interventions from veterinary, medical, ecological and industrial sectors, as well as governmental and public health authorities ('One Health' approach), is advocated for as an efficient and cost-effective way of preventing and managing pandemics<sup>405, 406</sup>. Earlier on, the 'One Health' initiative was born out of global anxiety during the HPA1 H5N1 pandemic fear (avian influenza)<sup>407</sup>.

The WHO One Health Network for the Global Governance of Infectious Diseases and Antimicrobial Resistance collaborates interdisciplinary to implement programmes and policies to achieve better public health outcomes<sup>111</sup>.

In managing epidemics<sup>408</sup>, the Emergency Response Framework (ERF) of the WHO is an international tool that outlines a set of procedures to strengthen the preparedness and capacities of countries to better respond to emergencies. This provides tools for a coordinated pandemic management plan in member states. Similar to the three pillars of cancer control plans, pandemic management is based on service delivery, financing and governance and expands its focus to information services, medical products, vaccines and technology.

Each epidemic requires a different set of interventions in order to manage the transmission rate, reduce morbidity and mortality and reduce the impact on the system, as well as the economic consequences.

The International Health Regulations (IHR) has analysed and made recommendations on all non-pharmaceutical pandemic countermea-

tures<sup>409</sup>. Being dependant on vaccine developments at the time of a new epidemic, non-pharmaceutical interventions, ideally, should be readily available in all countries as implementation programmes can be set up as general preparedness programmes. Non-pharmaceutical measures, as secondary preventive interventions, are aimed at delaying the introduction and spread of a new epidemic virus in a country and to delay the height and peak of such an epidemic, as well as reducing the total number of infections.

Some general recommendations, according to the IHR, are part of preparedness programmes. Key recommendations are specifically positioned for the influenza virus but, in general, can also be assigned to other vector-borne and air-borne viruses. In general, recommendations are geared towards the enforcement of personal protective measures, such as hand hygiene, (social) distancing to prevent contamination and wearing face masks during severe epidemics. In addition, environmental measures should be taken, such as cleaning surfaces and objects and increasing ventilation. On a broader scale, travel-related measures ought to be taken to limit localised outbreaks and prevent them from spreading.

Some other lessons of the COVID-19 pandemic need consideration. Whereas in HICs, the COVID-19 pandemic had a huge impact on life, in LMICs, who were not always able to fully comply with WHO recommendations, two effects were seen:

- First, being noncompliant with the new COVID-19 control strategies led to panic and anxiety in countries with high infection rates, like India and Brazil, where the majority of people live below the poverty line.

- Secondly, inadequate resources to manage and mitigate the pandemic locally have led to a worsening of health inequities, with disproportionate disease burdens, especially to the most vulnerable and marginalised persons within populations.

Finally, the enormous effect of COVID-19 emphasised several new aspects to address in future pandemics: stay-at-home and quarantine orders mandate nationwide jurisdictions; public health leadership, informed by the best epidemiologic information, must act in close coordination with governmental leadership; and the rapid scale-up of viral testing capacity is necessary to inform governments trustworthy for well-motivated decisions.

#### **IV - Metabolic Syndrome**

Two major actions form the basis of both the primary and secondary prevention of metabolic syndrome: adequate physical exercise and proper diet<sup>410</sup>. In addition to maintaining a healthy weight and being physically active, a balanced plant-based diet with limited amounts of fast foods, sugar-sweetened drinks, red meat and alcohol is recommended to enhance health.

Next to lifestyle improvement, social context needs consideration. Whole-family lifestyle intervention programmes have shown their effect on obese children, their parents and other family members. Not only individual and family lifestyle interventions but also living environments play a crucial role in preventing or developing an obesogenic population and a multi-sectoral approach with the food industry, alcohol and tobacco industries will be needed to enable patients to learn to resist the temptations of the obesogenic consumption world. For this, a mental shift is

needed, in which civil society and the tobacco/food industry lobby groups should initiate change, supported by public policies. The urgency of the NCDs problem has led to the adoption of the Sustainable Development Goals Target 3.4: “By 2030, reduce by one-third premature mortality from NCDs through prevention and treatment and promote mental health and well-being.”

Looking at general recommendations, secondary prevention and the management of the metabolic syndrome can be accomplished with lifestyle modifications, behavioural interventions, pharmacological and surgical interventions<sup>411</sup>. For example, exercise therapy is a cost-effective intervention to both prevent and mitigate the impact of the metabolic syndrome by reducing weight and blood pressure and by improving lipid disorders, including raising of high density lipoprotein and lowering triglycerides. Regular exercise also leads to improved insulin sensitivity, with the secretion of the metabolically beneficial hormone Irisin (reversing muscle insulin resistance) and the reduction of postprandial hepatic lipogenesis<sup>118</sup>. Based on the international panel recommendations, 30-60 minutes of daily physical activity is recommended, including aerobic and muscle-strengthening activities<sup>412</sup>.

Evidence indicates that total sugars and sugar-sweetened beverages are associated with a greater risk of metabolic syndrome and type 2 diabetes.

Considering alcohol, conflicting information still exists. Whereas liquor and spirit drinks generally are correlated to increased risks of developing metabolic syndrome, epidemiological data suggests that moderate wine consumption may protect against developing metabolic syndrome<sup>413</sup>.

Although intuitively contradictory, smoking cessation has a short-term detrimental effect on developing metabolic syndrome. Therefore, quitting smoking, while recommended for the long-term (secondary) prevention of metabolic syndrome and especially cardiovascular risks, should be supervised by professional coaching.

After reviewing the literature, there are more specific considerations to be made: (night)shift workers face potential health problems and are more prone to developing metabolic syndrome, especially insulin resistance and cardiovascular diseases.

Secondly, gut microbiota might play a pivotal role in reducing metabolic syndrome and also in carcinogenesis<sup>414-418</sup>. Precision nutrition forms a new upcoming science with the potential to improve dietary behaviours, both individually and on population-based levels<sup>419</sup>.

Next, when lifestyle interventions fail, a number of pharmacological treatment options are available, like statins and PCSK9 inhibitors (proprotein convertase subtilisin/kexin type 9 inhibitors) for dyslipidaemia correction, metformin and SGLT-2 inhibitors (sodium-glucose-cotransporter 2 inhibitor) or GLP-1 agonists (glucagon-like peptide 1 agonists) for glucose intolerance correction and weight reduction.

### General recommendations

In 2017, the WHO presented four general recommendations as ‘best buys’ for the prevention and control of NCDs<sup>389, 390</sup>. As we have consistently shown, a few risk factors repeat themselves per health issue, mainly tobacco use, alcohol use, unhealthy diets and the lack of physical exercise. ‘Best buys’ relate to these specific risk factors

and are evaluated as the most cost-effective interventions (cost-effectiveness analysis (CEA) < \$100 per Disease Adjusted Life Years (DALY)) to be applied in LMICs, as opposed to less effective interventions with CEA > \$100 and interventions for which no cost-effective analysis is available<sup>389</sup>.

The importance of tobacco use is probably best underlined with the data that indicates that tobacco is a leading global cause of premature death and accounts for 7% of all female and 12% of all male deaths globally. The WHO Framework Convention on Tobacco Control defines numerous 'best buys' for reducing tobacco use, including (i) an increase in excise taxes; (ii) the implementation of standardised or plain packaging with health warnings and comprehensive bans on tobacco advertising; (iii) the elimination of exposure to second-hand tobacco smoke; (iv) and mass media campaigns that educate the public about the harms of tobacco use.

The second recommendation considers the harmful use of alcohol. The WHO report on 'Tackling NCDs' considers recommendations as 'best buys'<sup>389</sup>, including (i) the increase of excise taxes; (ii) the enforcement of bans or comprehen-

sive restrictions on exposure to alcohol advertising; and (iii) enforcement of restrictions on the physical availability of retail alcohol.

As to the third recommendation, the implementation of a global strategy on diet, the WHO makes interventions on salt intake one of the 'best buys'.

As to the fourth recommendation, reducing physical inactivity, 'best buys' includes the implementation of community-wide public education and awareness campaigns for physical activity.

So far, recent history has shown that these recommendations by themselves do not lead to a gross effect on disease prevention and health promotion. Whereas sustaining individual lifestyle changes is difficult, a regional or national multi-sectoral approach is needed to embed and support such a set of recommendations. Ten keystones (see Appendix) are considered essential building blocks in creating a living environment in which people will be supported to make a change towards healthy living. In fact, the envisioned Humansphere, as the new sustainable living environment of the 21<sup>st</sup> century, than becomes more tangible. →

### Key points

Within the Humansphere, four major human health issues need attention. Existing preventive and promotive frameworks lay out disease-specific recommendations, including:

- Neurological and mental diseases
  - o The WHO's Health Promoting School framework
  - o The Melbourne Charter
  - o The WHO's Mental Health Action Plan
- Oncological diseases
  - o National Cancer Control Plans
  - o The Union for International Cancer Control
  - o The Global Initiative for Cancer Registry Development
- Pandemics and infectious diseases
  - o Emergency Response Framework
  - o International Health Regulations
  - o One Health Network for the Global Governance of Infectious Diseases and Antimicrobial Resistance
- Metabolic syndrome
  - o WHO Global Strategy on Diet, Physical Activity and Health
  - o National Obesity Strategies
  - o The International Diabetes Federation

Chapter

# 12

The number '12' is rendered in a large, white, sans-serif font. The '1' is solid white. The '2' is white with a blue outline and contains a stylized globe with green landmasses and blue oceans. The background of the entire page is a solid light blue.

**Multi-sectoral  
health plans to  
design sustainable  
living environments  
in the Humansphere**

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### **Young generations that create new blue zones as healthy living environments**

Given the chances and prosperity the Industrial Age has afforded, how could we as humans have resisted these economic temptations in our living environment? As humans, we are evolutionarily conditioned to deal with scarcity, but the speed of Anthropogenic advances has not given us the time to learn to handle luxury well.

Realising that our healthcare consumption is increasing, that sickness is not just 'bad luck' but also preventable to a certain extent and that the economy influences our health by changing our living environment, all of this forces us to think differently.

Focusing on a time horizon of 20 to 40 years (the career time-span of the present young adult generation) multi-sectoral health plans may help them to create a healthier society that includes the normalisation of the burden of disease per individual; multi-sectoral plans in which all economic sectors, such as the food industry, the energy and transport industries, the environmental protection industries and, of course, the healthcare sector itself, will lead to healthy living environments, as the new blue zones, with a more sustainable integrative health system.

It's clear that a multi-sectoral approach will only be considered successful if it results in better health, and ultimately, a decrease in disease. It will be successful only if good life expectancies are accompanied by a limited number of years of chronic illness, rather than the 30-40 years of disease humankind has to face on average today.

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**AN** integrative health delivery system is needed to increase human health: both for preventing and reducing healthcare consumption, as well as for the promotion of healthy lifestyles. But we have also learned that today's obesogenic living environment, along with all the other temptations, makes durable lifestyle change difficult. Creating a sustainable and healthy living environment, rather than individual lifestyle interventions, will, in the middle and long-term, create more health and a decrease in healthcare consumption (living environments according to the examples of natural blue zones, but then created by multi-sectoral health plans)<sup>315</sup>. Health plans are directed from an international global perspective but translated to national or regional plans for further implementation.

In this chapter, we will explore the general design and the various components involved in multi-sectoral health plans. Next, we will zoom into national or regional multi-sectoral plans: which main health issues are relevant for a country or region, and which sectors/actors are specifically relevant? Multi-sectoral plans vary tremendously and depend on national/regional scale differences, as well as on the health issues addressed, and various examples will be given, showing the variation in methodology and scope.

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As previously mentioned, already in 1978, at the Alma-Ata conference, the WHO promoted a multi-sectoral approach to increase global health<sup>420</sup>. And throughout the years, other important international statements, like the Adelaide Statement on Health in All Policies<sup>421</sup>, the United Nations Political Declaration on the Prevention and Control of Non-Communicable Diseases<sup>422</sup>, the Rio Political Declaration on Social Determinants of Health<sup>423</sup> and the Helsinki Statement on Health in All Policies<sup>424</sup>, have conceptualised earlier versions of multi-sectoral planning. In the 2018 report, 'Multi-sectoral and inter-sectoral action for improved health and well-being for all,' the WHO set out clear directives for countries to work on<sup>40</sup>. Multi-sectoral plans that start with fierce governmental decisions and legislations require the building of strong partnerships with a whole-of-society approach and lead to the initialisation of projects on national and regional bases<sup>40, 425</sup>.

Parallel to the development of multi-sectoral health plans by the WHO, the United Nations Development Programme (UNDP) 2030 Agenda, with its 17 SDGs is relevant, as actions related to the SDGs are, by nature, multi-sectoral oriented. SDGs number one, two, three and six are important as they specifically aim at improving human health and well-being<sup>426</sup>. But also, other SDGs, like SDGs seven, 11, 12 and 17, relate to recommendations and interventions that improve human health and well-being as well.

### **Design of a general model for multi-sectoral health plans**

With the existing reports in mind, and starting from the best medical knowledge, we developed a comprehensive overview that tries to involve

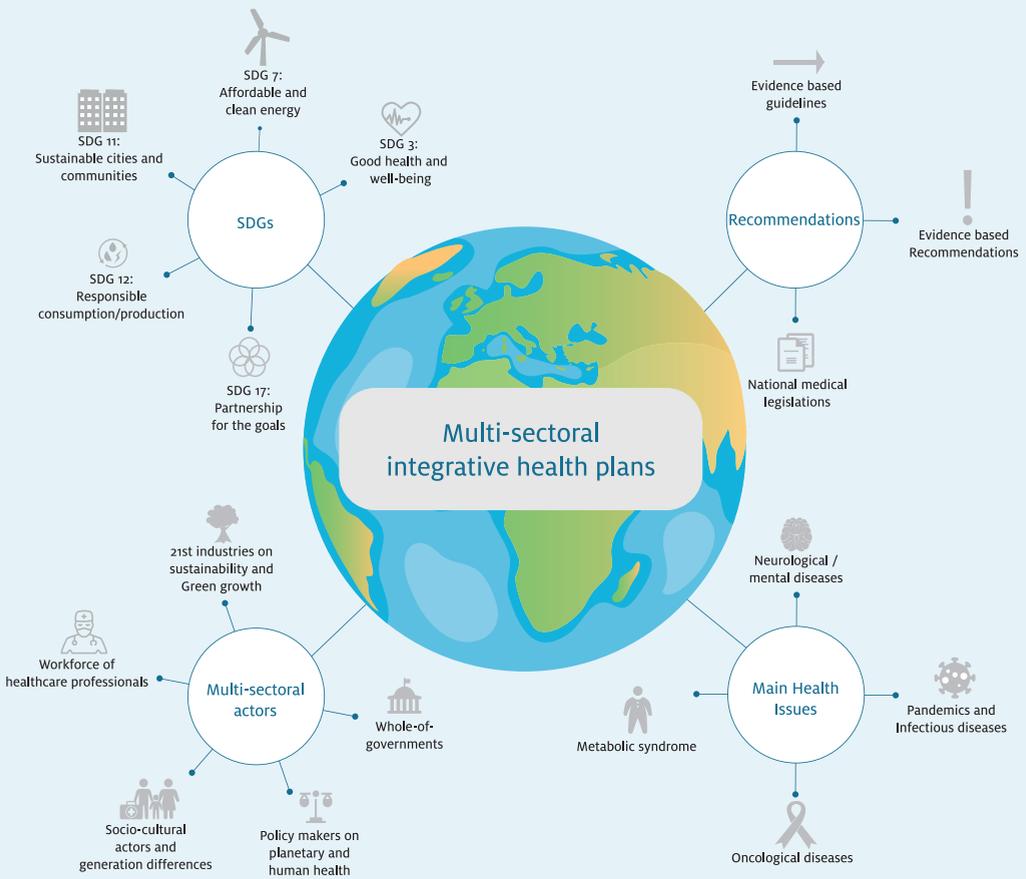
most of the conceivable components. Realising that every overview will have its limitations, we developed a basic and practical model based on four components (Figure 12.1).

The first component of the multi-sectoral health plan concentrates on our main contemporary health issues, namely, neurological and mental health issues, pandemics and infectious diseases, oncological diseases and the metabolic syndrome (Figure 12.1).

The second component consists of evidence-based recommendations, guidelines and medical legislations on health promotion, disease prevention and wellbeing, specifically those relevant to the inclusion of prevention and health promotion measures into disease care (Figure 12.1)<sup>40, 427</sup>. In the appendix, a summation is given of the most important and evidence-based recommendations, as well as guidelines on health promotion and disease prevention.

The third component concentrates on the health-related SDGs (one, two, three and six), but also all other SDGs. As we will see in the 3D diagram (Figure 12.2), many SDGs are strongly correlated to improving the four main health issues. This level of interconnectedness underpins the dependency of human health on environmental change and planetary health and they uncover the need for a multi-sectoral approach.

The fourth component summarises the stakeholders that are relevant for a multi-sectoral approach: governments, policy sectors, industrial sectors, scientific and policy-making institutions, as well as the healthcare sector itself. Each stakeholder has different interests and responsibilities.



**Figure 12.1** Overview of four components that play a role in modelling multi-sectoral health plans

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**NARRATIVE****The Blue Maas Valley: creating a blue-green zone for healthy people and a climate-resilient environment****The development of a multi-sectoral health plan, according to Dutch design**

According to the WHO, multi-sectoral health plans are to be developed to address human and planetary health issues simultaneously<sup>419, 422</sup>. Environmental changes like climate change, drought, deforestation and biodiversity loss all impact human societies. Although the 'One Health' issue is a global problem, in combining regional interventions of initiatives, both local population health and local ecosystems may be improved.

In the Netherlands, the Northern Maas Valley is a large rural area in North Limburg in which such combined interventions are emerging. Organisations active in health and the environment have initiated a novel collaboration to address the challenges imposed by climate change and other societal transitions (e.g., healthcare challenges, sustainable farming and biodiversity loss). Citizens are actively involved in this approach.

The initiatives make this area a perfect living lab for studying the relationship between climate adaptation and the health of humans and ecosystems. This health plan aims to identify promising ecosystem-based adaptations that will reduce the adverse effects of climate change. These measures will benefit the physical, mental and social health of its population, as captured by

the concept of Positive Health (Machteld Huber). Also, climate adaptation benefits to other relevant sectors, such as agriculture, will also be evaluated. In addition to the benefits for humans, biodiversity and ecosystem health effects are assessed, including the spread of new infectious diseases, in order to establish potential trade-offs.

Next, all effects are aggregated into an Integrated Health Index, providing overall insight into the combined effects of the adaptations. This insight feeds the governance and financial processes in the region, and invoke increased participation of the local population.

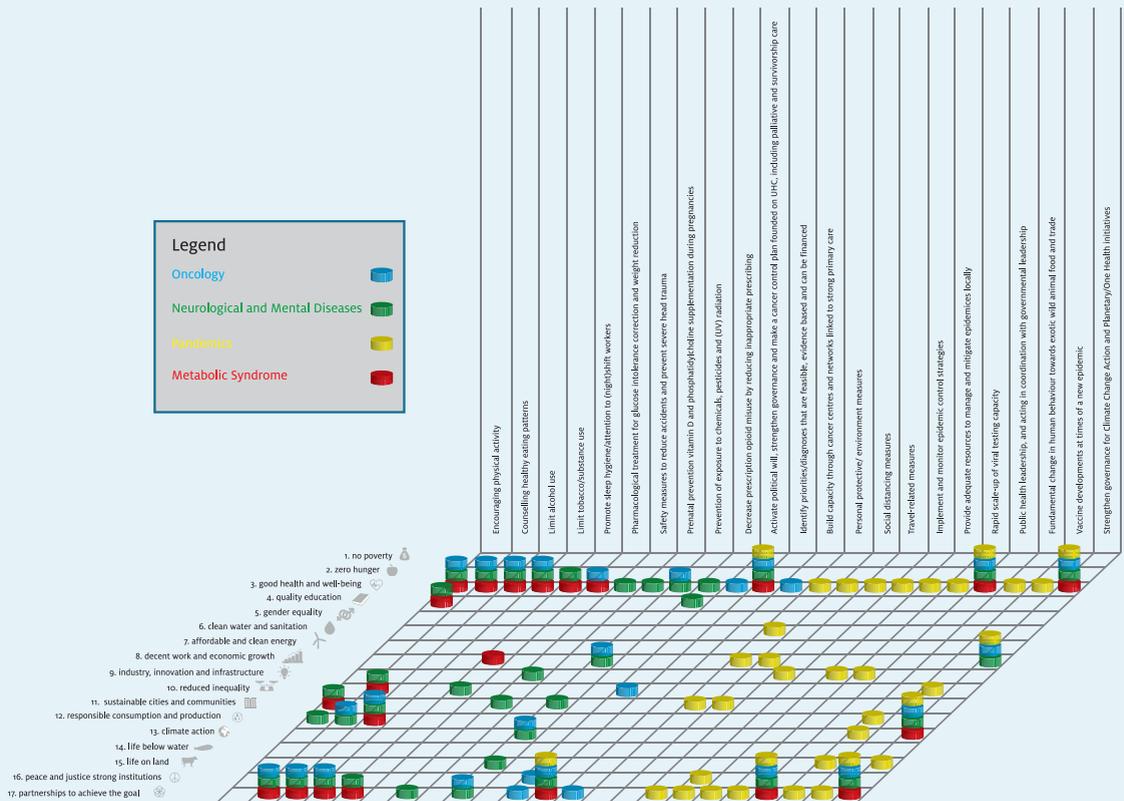
Such a multi-sectoral approach includes all important stakeholders: the regional government, local urban and rural governments, the healthcare sector (first, second and third line) and food, agriculture and water management organisations. In addition, financial stakeholders, such as health-care insurance companies, the banking sector and the Ministry of Agriculture, Nature and Food Quality are all involved. A regional team with a supervisory governance structure is created to prepare a non-profit cooperation.

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**Figure 12.2** 3D mapping of the four main physical health issues, interventions and SDGs

In this 3D diagram, a comprehensive mapping is created that summates the most relevant interventions for the four main health issues. All evidence-based interventions, specified for each main health issue, are presented on the X axis. These specific interventions are also coupled to the 17 SDGs (Z axis) and represented as checkers (differently coloured per health issue). By piling up the checkers for the four main health issues (on the Y axis), a comprehensive 3D diagram is constructed. Such a diagram gives an overview of all relevant interventions to be undertaken when a national or regional multi-sectoral plan is being developed. The interventions under each checker lead to relevant actors. Detailed information of Figure 12.2 available in online version.

Note the striking differences that are found in the patterns of recommendations for each of the four main health issues.

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Moreover, differences in national political systems and, for example, in market forces determine the role and impact each stakeholder can play nationally.

Basically, governments can substantiate this by falling back on the medical-ethical perspective of the human right to health; the right to have 'access to essential health services, vaccinations, essential medicines and technologies, at prices people can afford' is recognised in Article 12 of the International Covenant on Economic Social and Cultural Rights (ICESR). It helps to force a country to take concrete steps to ensure the availability and accessibility of quality public health and healthcare services<sup>428</sup>. The 3D map subsequently may be useful to tailor to country-specific situations.

The 2018 WHO report on the mapping of the WHO European Region governance advises on transforming the generalised multi-sectoral model to national or regional levels. This tailoring can be done by identifying inter-ministerial committees as the primary mechanism through which these forms of multi-sectoral actions are initiated, established and implemented<sup>40</sup>. The 2022 combined report of the Dutch Ministries of VWS and foreign affairs is a good example<sup>429</sup>.

Ensuring that coherence extends down to the local level is vitally important, as it is at the local level that implementation occurs. Effective implementation needs the multiple levels to be working together and numerous factors are found to enable and facilitate the implementation of multi-sectoral plans<sup>427</sup>:

- o High-level political support and commitment to multi-sectoral action
- o Focus on long-term outcomes
- o Existence of a clear mandate
- o High-quality evidence and information for policy planning and monitoring
- o Adequate financial and human resources for implementation
- o Competence of the health sector to reach out to other sectors
- o Cross-sectoral relationships based on trust and a shared understanding of the problem
- o Clear objectives and identified mutual benefits among partners
- o Engagement of the civil society
- o Public pressure
- o Media support and involvement

Setting up regional multi-sectoral health plans is the logical step forward once governments have addressed and directed themselves towards more sustainable integrative health delivery systems. Multi-sectoral health plans aim at the creation of healthy living environments as artificial blue zones. Multi-sectoral actors, together with a locally developing integrative health system, can create such healthy living environments regionally.

### **From a general model to regional multi-sectoral health plans**

As discussed in this book, the transformation to an integrative health delivery system by working with multi-sectoral health plans is a primary responsibility. For this, leadership in public health at (inter-)national and regional levels is needed to envision this transformation. Unfortunately, and despite very good reports, the WHO has, as the leading international organisation, so far been unable to fully occupy this global leadership

### **Integrative Surgery: pre- and re-habilitation and sustaining healthy lifestyles after high impact surgery**

#### **A multi-sectoral health plan for tertiary prevention, a Dutch design**

Sustainable lifestyle alterations are difficult to attain as people often lack the knowledge or intrinsic motivation. However, once a lifestyle-related serious disease is acquired, patients will have to go through an intensive period of diagnostics, treatment and physical and functional recovery. For patients who undergo high impact surgery, there exists a valuable peri-operative opportunity to guide them. Utilising this 'teachable moment' to engage the patient in a short-term health-enhancing programme, known as prehabilitation, has high programme enrolment and loyalty, which, if carried through post-operatively, potentially leads to sustained healthier lifestyles.

Healthcare professionals have become aware of the significance of prehabilitation in terms of improved clinical outcome and complication reduction after high impact surgery<sup>16</sup>. Although not well educated in tertiary prevention so far, they learn to guide the patients in their journey from diagnosis to functional recovery. Prehabilitation (the period from diagnosis to treatment) and rehabilitation (the period from treatment to medical and functional recovery) become intrinsic parts of the surgical treatment. Integrative surgery can be defined as a true integrated care programme of disease treatment and tertiary prevention.

With the concept of integrative surgery, a multi-sectoral health plan unfolds, as changes to individual patients will affect their partners and families, as well as patient's communities. Geographically, these programs are offered close to a patient's home. Open field bootcamps, sports clubs, social clubs, food initiatives, supermarkets and working environments are all involved in this transition towards sustainable healthy living environments, and many sectors are involved. For example, public health education increases the knowledge and intrinsic motivation of patients during their patient journey and beyond. Professional education in integrative medicine to incorporate (tertiary) prevention into the treatment programs is also necessary. Political will is needed to restructure financial reimbursement of integrative surgery. Combining surgical treatment with a broader health-targeting programme like tertiary prevention raises questions as to how it should be reimbursed. For integrative surgery, different financial solutions will come up with costs to be shared between various domains – for example, in the social domain, the healthcare act and the long-term care act – as both the health of individual patients as well as public health is improved.

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role. Healthcare professionals have therefore the medical and societal responsibility to stand up locally and take this role collectively.

As regards to national or regional health plans, direction and implementation through national leadership at the highest level is needed as a starting point, propagating a 'whole-of-government' approach<sup>430</sup>. In the Netherlands, good examples of reports and new legislation have come forth during the last years<sup>431-433</sup>, for example, the 'Nationaal Preventieakkoord', the 'Integraal Zorg Akkoord' and the 'Gezond en Actief Leven Akkoord' reports invite us to set up multi-sectoral health plans. The Blue Maas Valley is an example of a concrete general multi-sectoral regional health plan, mimicking the natural blue zones.

Next to the more generic multi-sectoral health plans, multi-sectoral health plans that address more specific and the most urgent local health issues can be developed. Starting with a different scope, other sectors may be involved. The following questions are helpful in developing a specific health plan:

- What is the biggest health issue in this region?
- Which major health challenges lay ahead?
- Which specific issues, concerning the related SDGs, are relevant?
- How resilient is the regional health system and how is its responsiveness to current and future challenges?
  - o It is prepared to respond adequately?
  - o Is there any pressure on the health system?
  - o Do they have tools at hand at the regional (or national) level?
  - o Are the goals and purposes of the system clear?
- Which specific integrative health efforts will work or won't be achievable?
- Which specific socio-cultural, religious or other influences are relevant?
- Which specific political issues are relevant<sup>427</sup>?
- Which specific regional ecological issues are relevant?
- Which specific regional economic issues are relevant?
- Which other constraints or opportunities are available?

To make the potential of specific, multi-sectoral health plans more tangible, an example on integrative surgery is given. Integrative surgery combines lifestyle interventions with high impact surgical procedures and is a model that results in improved regional surgical care and a more sustainable lifestyle. It is a plan based on a fundamental change of mindset and affords a truly different kind of surgical care to a community.

Multi-sectoral health plans may arise from new specific solutions that address so far unsolvable problems. The information technology industry, globally, with so many emerging new techniques (as described in Chapter 8) is set to revolutionarily transform the traditional disease care system into a virtual health delivery system. This digital transformation is already developing virtual service centres for remote care and has the potential to increase the accessibility of large population groups globally, as well as to meet increased healthcare consumption needs, while decreasing costs and democratising the system. But the digital transformation will also lead to smart hospitals that can integrate all sorts of data and leverage them in near-real time.

### **Digital transformation: a virtual integrative health delivery system, a solutions-based multi-sectoral health plan**

The information technology industry, one of the leading new industrial sectors in the sixth economic cycle of global sustainability, will transform healthcare completely. In the early years of this cycle (2005-2020), hospitals in HICs invested in Electronic Health Records (EHR) and digital infrastructures (e.g., digital connected patient journeys with remote monitoring, wireless nurse calls, smart beds, teleconsulting and privacy secured health apps).

Already, 10 years from now, patients will be accompanied by their own personal digital doctor. Combining wireless sensors, personal digital medical histories, Patient Generated Health Data (PGHD) with AI analytics, GPT and MedPalm2-like medical information and communication systems, will empower patients to guide them in personalised and informed medical decision making. Their digital doctor on smartphone or smartwatch will guide and advise them, before patients even meet their healthcare professionals.

By 2040, many virtual integrative health delivery systems, as results of regional multi-sectoral health plans will have been implemented.

In such virtual-smart health systems all sorts of data will be leveraged in near-real time. Both near-real time data and a personal dig-

ital doctor will be able to guide people to maintain health and can also be their guide during follow up, without the need for the routine physical or tele-consultations of healthcare professionals. Digital technologies enable the transformation of the whole medical process by affording telemedicine at home, unless specialised facilities are needed.

Regional virtual healthcare frameworks connect hospitals, nurses, physicians, families and patients, as well as first line healthcare providers. To develop such virtual-smart integrative health delivery systems, a multi-sectoral approach involving all relevant stakeholders is needed: regional governments, information technology industries, as well as financial stakeholders.

Virtual health delivery systems not only transform traditional healthcare in HICs. In LMICs, virtual services can also be made accessible and affordable. Digital educational programs teach children healthy lifestyles and primary prevention. Adults, via the child-parent axis, are educated in prevention measures and how to start using digital health services. Also, via digital public campaigns, even the most remote living areas can be accessed.

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In line with this main stream development, a third example of a specific multi-sectoral health plan is presented. As discussed before, the WHO, as well as many other national and international policy making agencies, have argued that developing multi-sectoral health plans will be the way forward to integrative health delivery systems. A future regional integrative healthcare system, composed of a virtual 'smart' hospital, digitally connected to all care providers – first line healthcare, paramedical work, social work and family care – will be presented, to visualise how integrative health will be recreated in next decades.

### Key points

In our examples, **four conceivable components** form a basic and practical model that is indicative of a multi-sectoral health plan.

Suggested components include:

- Today's warning flags of our **main health issues**: neurological and mental diseases, pandemics and infectious diseases, oncological diseases and the metabolic syndrome.
- Evidence-based **recommendations, guidelines and medical legislations** on health promotion, disease prevention and well-being.
- The health-related **SDGs** (one, two, three, and six), but also all other SDGs.
- **Stakeholders** that are relevant for a multi-sectoral approach, such as: governments, policy sectors, industrial sectors, scientific and policy-making institutions and the healthcare sector itself.

In order to improve human health and to transform traditional healthcare towards a sustainable integrative health system, national or regional **multi-sectoral health plans** that create **healthy living environments** are needed.

# Notes

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# Appendix

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## KEYSTONES OF MULTI-SECTORAL NATIONAL/REGIONAL HEALTH PLANS

In this appendix, a summation of keystones is listed to help building multi-sectoral health plans<sup>40, 42, 423-425, 427, 430</sup>. Existing plans and reports are summarised into keystones to come to a multi-sectoral health plan. We used the SDGs as a starting point, defining and reducing the globally set targets. The existing SDGs provide a roadmap for countries to address health challenges, promote equity and strengthen healthcare systems worldwide. Throughout the book we have referred to various international treaties, national health plans, collaborative actions, agreements and roadmaps, that are combined here and reduced to 10 keystones that are crucial to a sustainable and multi-sectoral health plan. Realisation of this plan requires a holistic approach that integrates economic, social and environmental dimensions, while promoting collaboration among stakeholders at the national and international levels.

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**1) Adopt integrated policies to develop quality, sustainable and resilient infrastructures:**

- By the year 2030, ensure that safe, inclusive and easily accessible green and public spaces are available to everyone.
- By 2030, foster inclusive and sustainable urbanisation through participatory and integrated human settlement planning and management worldwide.
- Establish robust and sustainable infrastructure, including regional and cross-border systems to facilitate economic progress and enhance the welfare of individuals, emphasising accessible and affordable services for all.
- By promoting national and regional development planning, strengthen the positive economic, social and environmental connections between urban, peri-urban, and rural regions.
- By 2030, halve the number of national (regional) deaths and injuries from road traffic accidents.
- By 2030, substantially increase the number of cities and human settlements that adopt and implement integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change and resilience to disasters and that also develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels.
- Aid the least developed nations in constructing sustainable and resilient building using local resources.

- Effectively implement the technology bank and capacity mechanism for science, technology and innovation in the least developed countries, while enhancing the utilisation of enabling technologies, particularly information and communications technology.

**2) Enhance partnerships to strengthen the scientific and technological capacity between regions/countries:**

- Promote research and development for vaccines and medicines targeting both communicable and non-communicable diseases that predominantly impact developing nations, while ensuring affordable access to essential medications and vaccines for all, in accordance with the Doha Declaration on the Trade-Related Aspects of Intellectual Property Rights Agreement<sup>434</sup>.
- Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in the least developed countries.
- Foster the empowerment of women through technology.
- Assist countries in need in strengthening their scientific and technological capabilities to transition towards more sustainable patterns of consumption and production.
- Strengthen the global partnership for sustainable development through multi-stakeholder collaboration that mobilises and exchanges knowledge, technology and financial resources.

- Enhance North-South, South-South and triangular collaborations in the fields of science, technology and innovation, while facilitating knowledge sharing.
- Encourage the development and dissemination of environmentally friendly technologies to assist developing countries.

**3) Strengthen the institutional capacity to provide learners with the skills and knowledge needed for the development of sustainable lifestyles, inclusive of human rights and planetary values:**

- By 2030, ensure that all learners acquire, through education, the knowledge and skills needed to promote sustainable development, including sustainable lifestyles, human rights, gender equality and the promotion of a culture of peace and non-violence. This also involves the perception of global citizenship, the appreciation of cultural diversity and of culture's contribution to sustainable development.
- By 2030, guarantee that everyone in the world has the necessary information regarding sustainable development and lifestyle that align with nature by enhancing education, awareness campaigns and the capacity of individuals and institutions in mitigating climate change.
- By 2030, reduce, through prevention and promotion of mental health and well-being, by one-third, premature mortality from NCDs.

**4) Adopt and implement National Frameworks for sustainable food consumption and production:**

- Implement a 10 year framework of programmes on sustainable consumption and production in which all countries act and with developed countries taking the lead, taking into account the limited development and capabilities of developing countries.
- Enhance both domestic and global backing to combat the illegal activities of both poaching and the trafficking of endangered species.
- Enable local communities to achieve sustainable livelihood opportunities by fostering their qualities.

**5) Promote attention to air quality, waste management and hygiene in order to sustain environmental livelihoods and public spaces:**

- By 2030, achieve access to adequate sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.
- By 2030, combat hepatitis, water-borne diseases and other communicable diseases.
- By 2030, reduce the adverse environmental impact of cities by paying special attention to air quality, as well as municipal waste management.
- By 2030, significantly decrease fatalities and illnesses caused by chemicals and pollution.

- By 2030, ensure the responsible handling of chemicals and waste products at all stages of their life cycles, aligned with established international frameworks. Drastically minimise their release into the environment.
- By 2030, enhance water quality by reducing pollution, eliminating improper waste disposal, minimising the discharge of hazardous substances and by boosting water recycling and safe reuse.

#### **6) Strengthen the prevention and treatment of substance abuse:**

- Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and the harmful use of alcohol.
- Strengthen the implementation of the WHO Framework Convention on Tobacco Control in all countries, as appropriate.

#### **7) Strengthen partnerships to address the nutritional needs of people in vulnerable positions:**

- By 2030, address the nutritional needs of people in vulnerable positions, including adolescent girls, pregnant and lactating women, and older persons. Respect the International Covenant on Economic, Social and Cultural Rights (ICESCR), Scaling Up Nutrition (SUN) Movement, Zero Hunger Challenge and National Nutrition Policies and Programs.
- Achieve the internationally agreed targets for reducing stunting and wasting in children under five.

#### **8) Promote international partnerships to support national plans for sustainable development:**

- Boost international support for capacity-building in developing countries to implement sustainable development goals, utilising North-South, South-South, and triangular cooperation.
- Enhance international policy coherence and integration for sustainable development by assessing policy impacts across sectors and addressing interlinkages to achieve synergies and avoid unintended consequences; collaboration among entities can help align policies, avoid duplication and address global challenges more effectively.
- Enhance the representation of developing countries in global economic institutions for improved effectiveness, legitimacy and policy coherence.

#### **9) Strengthen the national resilience and adaptive capacity to climate-related hazards and natural disasters:**

- Incorporate climate change actions into national policies, strategies and plans.
- Fulfil the commitment of developed countries under the United Nations Framework Convention on Climate Change and mobilise \$100 billion annually from diverse sources, supporting developing nations in their mitigation efforts and ensuring transparency in implementation. Swiftly capitalise and operationalise the Green Climate Fund<sup>435</sup>.
- Foster mechanisms for raising capacity for effective climate change-related planning and management in the least developed countries and small island states.

**10) Empower the resilience of people in vulnerable positions:**

- By 2030, enhance the resilience of individuals in poverty and vulnerable situations, reducing their exposure and susceptibility to extreme climate events, economic shock, social disruptions and environmental disaster.
- By 2030, significantly reduce the premature loss of life and the impact of disasters, including those related to water, on individuals and communities.
- Achieve universal health coverage, ensuring financial risk protection and providing access to high-quality essential healthcare services, safe and effective medicines and affordable vaccines for all.
- Recognise and value unpaid care and domestic work through the provision of public services, infrastructure and social protection policies, while promoting shared responsibility within households and families, tailored to each country's specific context.
- Protect labour rights and promote safe and secure working environments.
- Adopt policies, especially fiscal, wage and comprehensive social protection policies, to progressively achieve greater equality.
- By 2030, ensure access to adequate, safe, and affordable housing and basic services and undertake slum upgrading activities.



**About the author:**

Kees van Laarhoven is a professor of surgery at Radboud University, the Netherlands and chair of the Department of Surgery at Radboudumc (2008 – present). He holds a MSc in Evidence-Based Healthcare from Oxford University (2005) and also completed the leadership programme Organisational Transformation in Health, at Duke University, USA, in 2019. He was a member of the supervisory board of Haaglanden MC (2013 - 2021) and is currently on the board at the Diakonessenhuis Utrecht (2021 - present).

In his professional journey, travelling through an upcoming field of surgery with apparently unlimited possibilities, Kees van Laarhoven witnessed major milestones and breakthroughs. Already as a medical student, he was amazed by surgical courage. During residency, he experienced hard work, diligence and perseverance of surgical professionals. Today as a surgeon with over 25 years of clinical experience he now looks at pieces of art in surgery with professionals compassionately bringing hope to patients.

But he also sees inconvenient truths in our healthcare system, with patients evolving from one predictable and preventable disease to the next and with professionals following disease trends rather than applying their knowledge to redirect disease into health. The modern disease-oriented care system becomes undesirable and unsustainable.

And there are more inconvenient truths that have progressed rather than diminished in time. Healthcare is not easily accessible to the major half of the global population and for those who have access, with a growing global population, healthcare may become unaffordable in the future. Moreover, from an environmental perspective, both human and planetary health are compromised and ask for a 'One Health' approach.

Being fascinated by the questions of how and why did this all happen, Kees van Laarhoven took up a scientific survey to comprehend and learn how things still can be changed. He found that clear solutions are there! Please join him on his journey.



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