The Bioengineering
ONE HEALTH ALLIANCE IN 2050

A One-Day Voyage into the Future

White paper

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1.EXECUTIVE SUMMARY

This white paper is the result of the Symposium “The Bioengineering – One Health Alliance in 2050: A One-Day Voyage into the Future”, which took place on the 27th of October, 2022, at the Galeria da Biodiversidade (Biodiversity Gallery), in Porto. 59 participants from different sectors (academia, companies, hospitals and health organisations) and countries joined together to debate the health challenges we expect to be facing by the middle of the century and how bioengineering can contribute to solving them.

The meeting addressed four major societal challenges, each tackled by one of four panels - Aging: living longer, healthier and socially active; Infectious diseases: anticipating, preventing and treating; Food: in search of sustainability and environmental safety; Digital health: the power to transform society.

The format followed by each panel was as follows. Firstly, the Chair introduced the topic and major issues at stake. Second, experts from different disciplines (including from the social sciences) were invited to present their predictions and express their perspectives, which could be futuristic but required a sound rationale. Finally,

a science journalist moderated a debate, highlighting the areas of agreement and (particularly) disagreement between the speakers' views to identify major challenges while allowing other participants to voice their views. This white paper summarises the highlights of the Symposium and provides a roadmap for the future and details major actions. The following top priorities have been identified:

1. Social sciences should play a central role in guiding health and research policies; social inequalities are a major obstacle to widespread access to scientifically validated information and advanced medical treatments;
2. Healthier life spans should be a major objective of technological and social developments; an aged population is not a curse but the result of technological and social progresses;
3. The sustainability of healthcare systems requires social integration of older citizens, including their participation in economic activities and revision of their contributive time span;
4. Migration of individuals from low-income countries to high-income countries should not serve to balance the lack of adequate public policies to accommodate demographic changes;
5. Research on the ageing brain should be at the forefront of basic and translational investigations;
6. The surge and prevalence of infectious diseases should be anticipated and tackled by adopting the One Health approach, bringing into the equation factors such as climate change, migration flows and zoonosis;
7. An international consensus on the implementation of guidelines and procedures to combat future pandemics should be implemented prior to their occurrence; this should involve the establishment of transnational and intersectoral platforms joining research institutions, regulatory authorities, manufacturers and society at large;
8. To effectively deal with infectious diseases, health equity (between and within countries), health literacy, infrastructures, vaccines, diagnostic tests and drugs should be essential components of health and research policies;

9. To fulfil the promises of digital health and render healthcare more person centred, accurate data interpretation will be necessary but not sufficient; health literacy among citizens and healthcare professionals will become more critical;
10. The development of digital health will require active involvement of society and reduction in inequalities;
11. Alterations in food habits (e.g. reduction in meat consumption) will be intimately related to cultural changes; however, environmental sustainability and progress towards a healthier and more equitable world require those changes;
12. Public policies in food prices are demanded to combat one of the major effects of poverty: the intake of less nutritional foods;
13. Biosensors will become instrumental in providing safety information on food, but their own safety ought to be ensured.

2.INTRODUCTION

The world is confronted with a number of serious challenges that will impact the future of the planet and living species, including humans. The magnitude of these challenges has made institutions, scientists, and policy makers aware of the need to change the paradigm of predicting and tackling emerging threats. Overspecialization is clearly falling short in solving problems that emerge at the interface of scientific domains. Some examples of these problems are zoonosis, antimicrobial resistance, climate change, food availability and safety, age-associated diseases (e.g., dementia and cancer in aged adults) - but there are many more that call for interdisciplinary, transdisciplinary and multidisciplinary approaches implemented at the global level. The artificial barriers between hard sciences and social sciences need to be knocked down and we need to pay greater attention to social determinants of disease.

The 'One Health' approach recognizes the link between people, animals, plants and the environment (physical, social and emotional) and aims to contribute to a multidisciplinary response, through synergy between specialists and organisations (health, research, monitoring, regulation, policy) of the different areas of knowledge. In other words, 'One Health' aims to prevent, detect and respond to agents and events that represent a threat to Public Health.

It is therefore becoming abundantly clear that the One Health approach needs to be adopted if we want to overcome the challenges ahead. A number of international gatherings have established a series of priorities in the area of One Health, namely the One Health Congresses (Osterhaus, Vanlangendonck et al. 2020).

In the scientific literature a number of papers provide projections on the magnitude of the societal challenges that will impact our lives. They attempt to answer the question: what is expected by 2050? We give some examples below.

The world population will be older, more numerous and undernourished. For instance, the number of Americans over 65 will double (from 43.1 million in 2012 to 83.7 million) and increase as a percentage of the population (from 13 to 20%) (Keeler and Bernstein 2021). Almost 800 million of today's 7.3 billion people are undernourished and perhaps half of the world's people — most, but not all, in poor- and middle-income nations — lack access to one or more essential nutrients (Ehrlich and Harte 2015). Failure to feed humanity makes the prospects seem slim for making the projected 9.7 billion population food-secure and healthy in 2050, and perhaps billions more beyond that (Ehrlich and Harte 2015). Food system projections to 2050 show a decrease in disability-adjust-

ed life years (DALY) incidence from both chronic and hidden hunger. However, population growth is projected to outpace these improvements and leads to increasing total chronic and hidden hunger DALYs globally, concentrated in Africa south of the Sahara. Climate change will increase per-capita chronic and hidden hunger DALY incidence compared with no climate change (Sulser, Beach et al. 2021).

The importance of age-associated diseases will increase. For instance, it is estimated that the number of people with dementia will increase from 57.4 million in 2019 to 152.8 million cases in 2050 (Collaborators 2022). Also, by 2050 there will be 4758 million people with myopia (49.8% of the world population) (Holden, Fricke et al. 2016). Furthermore, it is estimated that 6.9 million new cancers will be diagnosed in adults aged 80 years or older worldwide (20.5% of all cancer cases) (Pilleron, Soto-Perez-de-Celis et al. 2021). Lung cancer, which is already a global public health threat with close to 2 million cases and deaths already in 2020, will increase to 3.8 million incident cases and 3.2 million deaths globally (Sharma 2022). Finally, the utilisation of hip implants in OECD countries continues to grow by a compound annual growth rate (CAGR) of 1.2%, leading to an increase from 1.8 million per year in 2015 to 2.8 (2.6–2.9) in the year 2050 (Pabinger, Lothaller et al. 2018).

Antimicrobial resistance and new viral infections will increase. Antimicrobial resistance (AMR) is estimated to be responsible for 25,000 deaths per year in the EU alone and 700,000 deaths globally. Inaction is projected to cause millions of deaths globally: it has been estimated that AMR might cause 10 million deaths per year in 2050 (de Kraker, Stewardson et al. 2016), more deaths than those caused by cancer (Commission 2017).

Even before the COVID pandemic, health specialists called for effective collaboration between environmental, physical and social scientists to tackle health challenges, such as those indicated above. (Barnosky, Ehrlich et al. 2016). However, one of the major difficulties in doing this is the fragmentation of scientific domains, which is a barrier to the dialogue between specialists. Some sectors of the academic community took action to overcome these obstacles. This led to the emergence of new areas of knowledge at the interface between existing sciences. Bioengineering is one of such areas, acting as a platform for the dialogue between biological and engineering sciences, not just for improving human health. In fact, its action extends to animal and environmental health, thus encompassing the three cornerstones of One Health. Aware of the fact that Bioengineering will likely play a crucial role in the coming decades in fighting, diagnosing and treating disease (human, animal and environmental) this symposium had the objective of providing a forward look into the future.

3.AGEING: LIVING LONGER, HEALTHIER AND SOCIALLY ACTIVE

Chair: Lino Ferreira (University of Coimbra)

Moderator: Teresa Firmino (Jornal Público)

Rapporteurs: Júlio B Santos (i3S).

GUEST SPEAKERS

Teresa Rodrigues *(Nova University Lisbon) - "Demographics of ageing";*
Jennifer Elisseeff *(Johns Hopkins University) – "Regenerative immunology";*
Tiago Outeiro *(University Medical Center Göttingen) – "Challenging the brain: ageing and neurodegeneration";*
Bruno Jesus *(iBiMED) – "Reversing the aging process"*

Overview of the panel:

The panel addressed the topics of demography, regeneration, neurodegeneration and molecular reversing of the process.

A central question was if we want to live longer or/and healthier. There was no consensus in answering this question, namely because of the demographic differences between countries. However, by looking at developed countries and using Portugal as an example we can forecast that sooner or later countries will see changes in their demography such as: losing the younger population; the mean age will increase significantly, with a clear impact on the health system.

In fact, as we live longer, it is clear that we need to reduce disabilities that are invariably linked to longer life spans. Other challenges will arise: How to create conditions for a social support system? How to adapt to a new framework to further encourage activity, autonomy and contributive status of the elderly?

It was agreed that we have a global problem of an ageing population that brings other problems to our current structure of society, namely the need to reframe the working-age, contributive status, and the answer to ageing-related diseases.

It was pointed out that we need a new framework to answer to health, economy and social architecture/structure, avoiding dependence and isolation, for which digital competencies may contribute.

Regarding bioengineering, the panel first addressed what the classical approach to regenerative medicine is. These are not old technologies but are approaches that are already in use but need more development. An example is the use of biomaterial scaffolds to generate an adequate microenvironment for tissue repair/regeneration. Although these approaches are well developed for bone and cartilage repair, they are not valid for soft tissues like muscles, tendons, and ligaments.

A new development in this field is to modulate the immune system in order to improve tissue repair and regeneration. For instance, we need to understand the regulatory pathways of T-cells, which respond to infection but also participate in the regenerative process. We also need to understand what happens with immuno-related processes that participate in repair during ageing and in related comorbidities. It is clear that what we see in young animal models does not happen with older ones.

In fact, the immune system changes with age and those changes impact our response to regenerative medicine. We need to look at the communication between cells, including immune system cells. We need to work in combination therapies using classical scaffolds functionalized in a manner that triggers an ageing immune system.

The panel also noted that engineering is already deeply incorporated into our habits if we consider how we use smartwatches and smartphones and how they interact with health indicators (e.g. heart rate and blood pressure) and behaviour. We can further imagine that these technologies will give us much more information about our health status and that this could be extended to provide information about very challenging neurological diseases that we still do not fully understand and need to be diagnosed, monitored, and treated.

These aspects are crucial in neurodegenerative diseases, which remain an important challenge in ageing societies. For instance, Alzheimer's disease is increasing all over the world. It is an ageing-related neurodegenerative disease and, considering demographic data presented in this panel, the numbers are rising and will continue to do so. The same is true of Parkinson's disease. It's expected that many more neurodegenerative diseases will fall under the category of ageing-related health issues.

In recent years thousands of molecules were tested and only one was developed that was capable of changing disease progression in Alzheimer's. We have some drugs able to mitigate the symptoms but we can not reverse the progression of neurodegenerative diseases.

How can human diversity help us understand neurodegenerative diseases and, eventually, other age-related diseases? Several areas need to be brought onboard to tackle this. Diversity is not only from a genetic perspective, but also environmental and cultural factors that may impact epigenetics.

For instance, food processing depends a lot on the food available in the area and on the cultural habits of cooking. But food processing changes the folding status of proteins that are in the food. It may lead to protein misfolding that can render food proteins either toxic or cause them to suffer a function change.

Consumption of proteins and the quality of proteins need to be looked at and understood. We need to understand the complex biochemistry of proteins, understand how we can read them and how to use those readings as a diagnosis. In fact, these readings can be very important for diagnosis and we need to develop therapies to treat the causes of disease. In this context, we can think of "domesticated proteins" as a strategy.

The panel also addressed the question "how to reverse ageing?" which prompted the basic question "what is biological ageing?".

We went through a short voyage to the animal kingdom to understand that we, as mammals, are a group of animals that lost the repair mechanisms that maintain youth.

But ageing, even in humans, is a plastic process that can be manipulated, as demonstrated by work showing that improving telomeres in mice reversed the ageing process to some extent. This didn't necessarily translate to a change in lifespan, but mostly in the recovery of the regenerative capacity of ageing mice. Several telomerase-based therapies are already being developed. However, other strategies are being pursued,

like those addressing senescent cells that impact the ageing process in the tissues where they accumulate. The scientific community is also looking into personalised medicine strategies targeting cancer cells and other age-related diseases.

Highlights:

a. There is a need to distinguish between lifespan and health span;
b. Some members of the audience argued that ageing should be treated as a disease, while others consider ageing a natural biological process;
c. The fact that we live longer is the result of improvements in health care;
d. We need healthier lives to maintain the sustainability of healthcare systems and society at large;
e. The biological age limit for humans should not be a central question, but rather how to tackle health quality, considering the current life span that we have already achieved;
f. This also brings questions about the healthcare system, education, economic dynamics and the contributive span of each individual;
g. High-income countries should adjust their public policies to manage ageing of the population and not rely on the migration of young individuals from low-income countries to maintain the stability of their social security system;
h. We need to reorganise the social security system to accommodate the reality of our ageing populations;
i. From the biological research point of view, it was stressed that we need better research models for ageing;
j. The prohibitive cost of new therapies may intensify inequalities. Some argued that prices should not be an obstacle for research because eventually prices will decrease for those new technologies;
k. The brain is a difficult organ to tackle from an ageing, therapeutic, and regenerative perspective. The brain is an organ that is largely impacted by ageing. Therefore, the impact of ageing and regenerative approaches on the brain needs to be investigated more deeply;
l. A central question to some of the issues above is how to balance individual and societal interests.

4.INFECTIOUS DISEASES: ANTICIPATING, PREVENTING AND TREATING

Chair: Fabíola Costa (SWORD Health);

Moderator: António Granado (Nova University Lisbon);

Rapporteur: Joana Coelho (INESC TEC)

GUEST SPEAKERS

Rogério Gaspar *(WHO) – "Preparedness and response in a pandemic: how COVID-19 changed the future of regulatory reliance and convergence in anticipation of future public health threats";*
Maria João Amorim *(Gulbenkian Science Institute) – "Viral challenges";*
Raquel Duarte *(ICBAS - University of Porto) – "Lessons from the COVID19 pandemic"*

Overview of the panel:

We need to reflect on how factors, such as climate change, migration flows or diseases on animals will impact the infectious diseases humanity has been dealing with.

At the core of infectious diseases is uncertainty. But uncertainty should not keep us from preparing knowledge, technology, or manufacturing infrastructures.

COVID pushed the systems to the limits, but the fact is that every year we have been in emergency mode responding to diseases such as Ebola, Zika, Monkeypox, Cholera, Yellow fever, etc. Cholera, for example, is a disease that currently has outbreaks

in more than 30 countries. What COVID did was to set up rules and procedures, joining regulatory authorities, manufacturers, etc., in a joint effort to fight the disease.

With COVID, the WHO managed to gather over 70 countries, more than 100 regulatory authorities and ruled over 500 regulatory procedures. But there are inequalities. For example, if we look at the manufacturing capacity over the world we see that Africa and Latin America have low manufacturing capacity. There is also the issue of WHO not supporting the manufacturing of vaccines in countries where regulatory issues are not properly addressed. However, the WHO is providing regulatory capacity not only to its member states, but also to other countries.

There are opportunities and challenges that we need to consider when facing a new infectious disease or a pandemic, such as the one we have faced with COVID:

- Technology transfer mechanisms
- Excessive infrastructures will not be sustainable
- Proper infrastructure and know-how

Viruses shape the world and are a serious threat to human health. With COVID-19 we have been able to witness how a virus is able to change behaviours in society, in economics, health, or even at an educational level. However, we need to be able to prepare for these aspects in the future.

One thing we know for sure is that the probability of the source of the next pandemic being a zoonosis is quite high. While we can respond to current outbreaks, in the future, we need to work on:

- Surveillance and preparedness
- Virus transmission dynamics
- Diagnosis and treatment
- Ecology and epidemiology
- Public attitudes and practices
- Existing barriers and challenges to outbreak prevention

So prevention, detection, and cure are the key aspects we need to consider in any future response. Prevention through monitoring and vaccines. Cure through antivirals and other types of treatments. All of this is possible if we keep investing in fundamental research, information and communication, and implementation measures. When we talk about preparedness, we should look at the four S's: staff, stuff, space and systems.

But we should be aware that there is no one-size-fits-all solution and that there are still many viruses for which there is no vaccine, such as HIV and dengue.

In the next 30 years we need to expand from a human disease-centric view, and we need to be able to anticipate spill-over events, monitor viruses in real-time, report, and act. One aspect of high importance is investment in research, even in what we believe are non-threatening human viruses. If we look at the example of SARS COV 1 or MERS it is easy to understand that if we had invested more in the research of these viruses, perhaps we would not have been dealing with so many unknown factors when the COVID-19 pandemic appeared.

Predictions must take into consideration aspects such as climate change or even the direct effect of floods. For example, floods all over the world are increasing the number of mosquitos and the number of diseases that come from mosquitos. One thing we cannot forget for the future: viral infections will require multidisciplinary research. One aspect that allowed us to respond quickly in the past was the research we had already done.

One of the problems that occurred during the COVID-19 pandemic was the lack of common strategies - countries, or even regions in the same country, defined and adopted different strategies. The population was then confused and could not understand the rationale behind those decisions. This led us to another debate, the lack of coordination between entities – public, private and social sectors – and the lack of data sharing. At some point, the information existed, but no access was provided. The fact is that entities managed to overcome this lack of coordination at some point and stop working in silos, thus leading to the establishment of means to work together.

We cannot prepare for all the challenges that will arrive in the future, but we need to be prepared for another pandemic. So we need to implement changes that will help us to respond. Collaboration is a key aspect in this process: the creation of networks of response, to adjust responses between hospitals and health care infrastructures.

Prevention is also key. We need to look at the past and prepare for the future. We also need to look at our vulnerable populations and see how we can contemplate their special needs. Regarding this social inequality, it is important to look at what

happened during the COVID-19 pandemic. The first vaccines that arrived in the market should have been administered to vulnerable populations. However, what happened was that the high high-income countries, including Portugal, did not respect those procedures. These countries managed to buy all the vaccines available. So, countries such as Nigeria, for example, still have less than 2% of their population vaccinated.

Social inequality was also quite evident in terms of communication. The WHO had a department fully dedicated to what they called "infodemics" – information about the pandemic. Here, social media played a huge role in giving information about the pandemic to countries that might not have had the proper health capacities but at least they had information. Portugal, for example, was one of the only countries that had people every day talking and informing the population. In future pandemics, another lesson learnt has to do with communication. We need to increase the literacy of our population and we need to learn how to communicate in a proper manner about this type of disease. The recommendations provided for COVID-19, for example, built upon past recommendations for the Ebola virus.

However, we also need to be aware that we were quite lucky during the pandemic in having vaccines that worked in their first clinical trials. Only that gave us the opportunity of having the capacity to deliver them to the market in 9 months. The amount of money made available by the countries also contributed to this reality. For example, Germany spent 400 billion euros. We did not fight the pandemic properly due to magical powers. All these factors played an important role, as well as our capacity to translate scientific knowledge to the market, manufacturing capacities, and coordination between countries in sharing information.

Highlights:

a. Infectious diseases shape the world and with COVID-19 we saw how a virus could impact every aspect of society, from social to education, to economics, and particularly health systems.
b. Climate change, migration flows, zoonosis will impact future infectious diseases prevalence and the rise of new infections, emphasising the need to adopt the One Health approach.

c. The COVID-19 pandemic accelerated the international consensus on the implementation of rules and procedures, joining regulatory authorities, manufacturers, etc to tackle communicable diseases;
d. Future responses should be focused on prevention (health literacy and vaccines), detection (monitoring and investing in fundamental research to expand from a human disease centric view) and cure (drugs and non-pharmacological treatments).
e. Outbreaks demand the creation of multidisciplinary networks of response, with coordination and data sharing between entities in the public, private, and social sectors.
f. Infectious diseases also highlight the importance of striving for health equity, not only between countries but also within countries: ensuring access to health literacy (including timely updates during emergency situations), infrastructure (both health and manufacturers), vaccines, and drugs.

5.DIGITAL HEALTH: IMPROVING HEALTHCARE

Chair: Daniel Vasconcelos (INESC TEC);

Moderator: Vanessa Ribeiro Rodrigues (Jornal Observador);

Rapporteur: Isabel Lourinho (ICBAS)

GUEST SPEAKERS

Harro van Lente *(Maastricht University) – "Sociology of expectations";*
Ana Sofia Carvalho *(ICBAS - University of Porto); "Paradigm shifts in bioethics involved in digital health";*
Fernando Correia *(SWORD Health) – "How digital health is changing us?";*
Carme Carrion Ribas *(Universitat Oberta de Catalunya) - "Health will be digital…or it won't be…"*

Overview of the panel:

'How digitised will humans be in 2050?' Nowadays, smartphones count the number of steps we walk in a day, how many litres of water we drink, are capable of measuring our cardiac performance, etc. But will they be able to digitalise our minds in the future? How far will this process go?

There are some facts: 1. Technologies are 'neutral'; what matters is the application and the use we make of them; 2. The evolution in this area is fast; 3. Technology is

related to evolution but also to democracy – we should be able to ensure democratic access to technology; 4. Technology, particularly in healthcare, raises several challenges, such as: control (who controls what?) and data access.

Sociology of expectations - The promise of digital healthcare is everywhere. There is immense scope for the use of digital health solutions. But when we talk about digital healthcare, we talk about a new paradigm. For instance: new ideas of what is normal; what to expect from a doctor but also from patients, which means a change of responsibility; new dependencies (who pays what and who takes care of what); new definitions of patients, diseases, care, and health. The tendency is for everyone to become a patient before they even get sick because they are being monitored before being diagnosed.

Promises of digital healthcare are not innocent, they 'do things'. According to the philosophy of language we find descriptive statements that say something about the world, but we also have normative statements that explain how things should be, as well as performative statements that explain how we do things. What promises do in the first place is helping to legitimise decisions, act as a guide to search activity and coordinate decisions.

Digital healthcare opens a range of opportunities, but also risks. All these possibilities place us before a new paradigm that raises questions related to bioethics.

Digital health will challenge our concepts of ethics - Ethics is a branch of philosophy concerned with right and wrong. It explores the nature of morality and examines how people should live their lives in relation to others. Ethics guides us on how to organise our practices and supports us in creating fair institutions and systems. It is also about frameworks: consequentialism, deontology and virtue ethics. Based on that, the only way to combine a utilitarian perspective with deontology elements is a virtue.

Digital health allows medicine to be more person-centred – It will change the focus from the disease to the person with the disease. For that, we must ensure that people know how to behave but we also should work on soft skills because the patient is no longer part of the process but is the centre of the process. For this to occur soft skills are essential in the doctor/patient relationship.

To build a future supported by digital technologies, we should consider human centricity as the starting point. By placing the human being in the centre of our

thinking, we will understand that technology is not the end but the means to improve well-being.

How is digital health changing us? - Are we becoming swamped by data because data is everywhere, particularly in the digital world? Data surrounds us, and is apparently the new gold. This can be both good and bad. We need to ask ourselves: Why do we need data? What are we going to make of the data? Will data be useful or not?

We are collecting more data now than ever before in the history of humanity, but we do not know what to do with it. Access to information and data is guaranteed, is real, but we need to know what to do with it. We also need to reflect on how to deliver healthcare interventions in a world where everyone has access to data. Now is the time when we shift from teaching people how to collect data to teaching them to analyse and interpret data. We need to focus on content and soft skills.

It is now possible to deliver health care through calls and apps, and so discover what patient-centred care means. Before this explosion of technology, maybe before COVID-19, we thought that patient-centred care was arriving at the hospital to be received by the doctor, having assistant nurses and several specialists waiting for us, going from door to door until we had the diagnosis. That was what person-centred care meant. But that is not what it really means and this new technological reality has shown that patient-centred care means time, means professionals – patients have become more demanding, and we expect health care to be delivered to our door. And that makes us more demanding but also implies a world where health care is delivered without personal contact. But can we do it without losing humanity?

But where do we stand right now? Does the digital world kill biodiversity or respect it? That takes us to AI. If we have data of millions of people, I will find people like myself, but I'm also starting to realize that I'm similar to others but also unique. AI is opening the door to personalising medicine. Imagine that in health care, every treatment can be personalised based on billions and billions of data, that is respecting biodiversity? Possibly it is improving biodiversity because it will enable us to deliver more care to more people. Digital health can be used to render the delivery of health care more effective and make it more accessible because technology can scale. Also, by being patient-centred we remove barriers to access and we can deliver care to people who didn't have access before.

What should be the path and where are we now? Before COVID we lived in a society with a lot of health issues, but also overburdened health systems. After COVID we learned important lessons:

a. The importance of universal healthcare;

b. Data sharing is essential for improving health public policies;

c. Prevention strategies are needed;

d. The value of digital healthcare, which must be patient centred, personalised, proactive, predictive, preventive and coordinated; in essence, digital health is an opportunity.

To implement digital health some critical barriers must be overcome:

a. Costs;

b. Heterogeneity in healthcare systems;

c. Organisations culture;

d. Standard evaluation frameworks.

There are also some important challenges:

a. Ethical;

b. Digital competences;

c. Implemental (cultural change);

d. Equitability.

Digital health has impacts on several aspects of society: healthcare professionals, people/patients, governments and healthcare systems.

a. Where will we be in 2050? We will have to deal sensibly with more data. We will probably have better gene therapies, better predictive medicine, and more data-driven decisions;

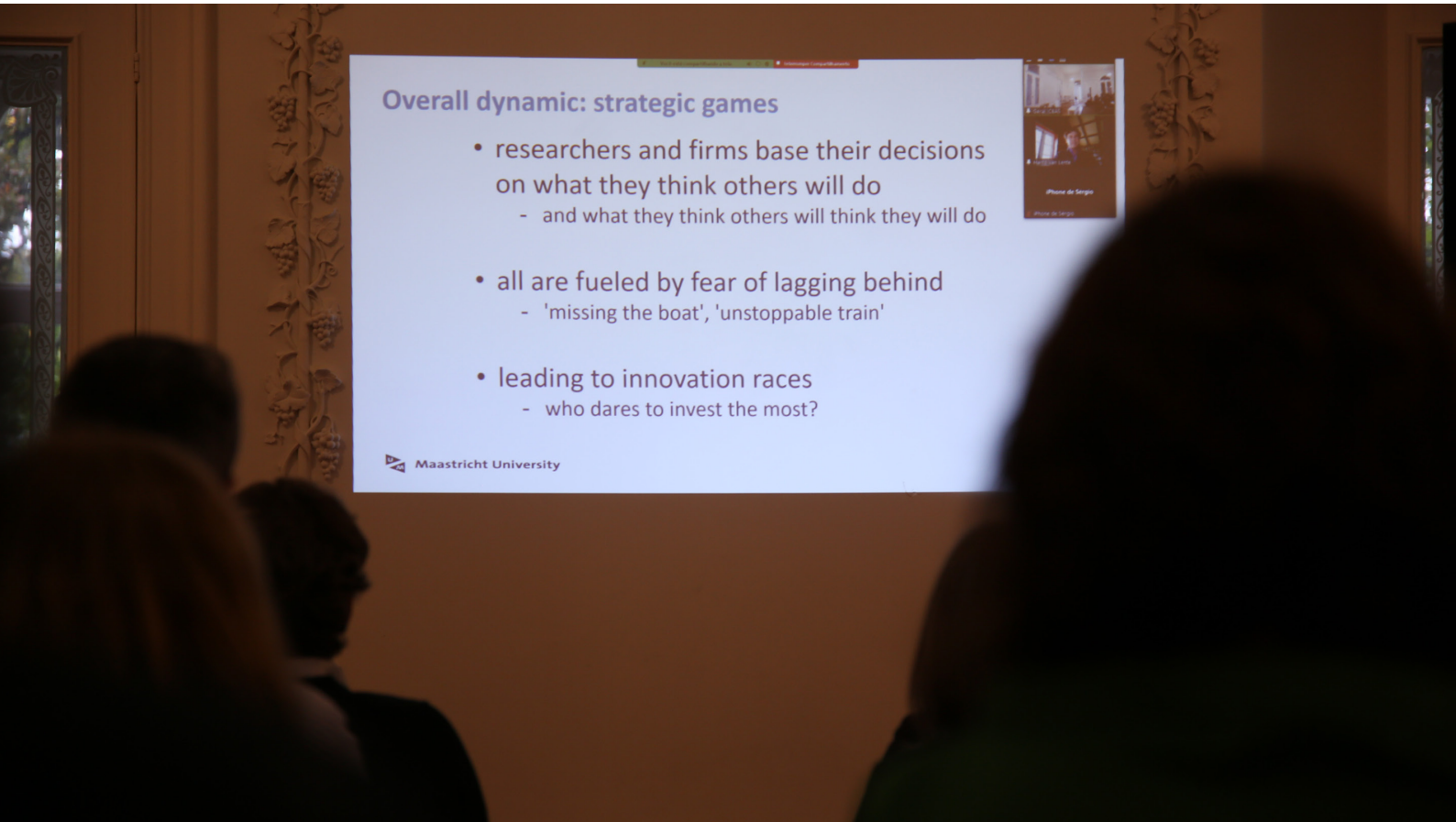
b. What is going to happen to society? Probably worst inequalities (between countries); the health sector will be more business oriented; better-empowered people (self-knowledge);

c. What is going to happen with the healthcare system? Healthcare systems and professionals will meet a new role; artificial intelligence collaborating with healthcare professionals; a higher gap between digitally skilled people and non-digital ones; more healthcare services at home;

d. The next question we should ask is where do we want to be? We have to think globally and act locally; we need more transparency, equity, justice and awareness of social determinants of health.

Highlights:

a. Digital health is a reality but it is more than that – it is a new paradigm, full of opportunities and challenges;
b. Data will be king. We will have a lot of data available, implying that we need to learn how to interpret that data and have more and better soft skills;
c. Healthcare will be person centred, implying more and better soft skills again;
d. Health literacy among citizens and healthcare professionals will become more critical; it is essential to communicate, giving more information to citizens with transparency;
e. We also need to actively involve society in order to develop digital health and to increase the confidence of the population in new technologies; for that scientifically validated information will be a must; Also, reducing inequalities will be essential to promote digital health.



6. FOOD: STRIVING FOR ENVIRONMENTAL SUSTAINABILITY AND SAFETY

Chair: Eduardo Silva (University of California, Davis);

Moderator: Daniel Cardoso Dias (Jornal Público);

Rapporteurs: Bárbara Silva ICBAS) and Sara Amaral (CNC)

GUEST SPEAKERS

Tiago Santos Pereira *(Centre for Social Studies; University of Coimbra) -"Sociotechnical imaginaries for the food sector: Engaging societal visions with science and technology innovations";*
João Pedro Conde *(INESC MN; University of Lisbon) – "Biosensors for food safety";*
Luísa Valente *(CIIMAR; ICBAS - University of Porto) – "New sustainable protein sources";*
Joana Silva *(Catholic University of Portugal) – "Impact of economic policies in employment, well-being and social inequality".*

Overview of the panel:

Thinking about the future is also thinking about how we can find solutions that will ultimately help us eradicate hunger and poverty, reduce malnutrition, and accelerate climate action. In 2015, the United Nations endorsed this universal call with The Sustainable Development Goals (SDGs). We believe that advances in Bioengineering could play a critical role in this context. Indeed, it could be argued that Bioengineering

is already making efforts that have contributed to solving/dealing with some of these challenges. Examples of some ongoing efforts are:

a. Lab-grown meat or seafood – that contributes to reducing gas emissions;
b. Recombinant polymers - which decreases dependence on petrol-based plastics;
c. Degradation of plastics.

The main question for discussion in this panel is: How future Bioengineering efforts and advances' could lead the way in increasing food quality and nutrition, protecting against plant and animal pests and diseases, improving and protecting agricultural yields, and making alternative food sources?

Discussion:

From an economic perspective, we must consider some social factors, such as economic policies in employment, well-being, and social inequality.

Employment patterns have changed over the years, for example, with the increase of people working in the service sector and the continued decrease of workers in agriculture. This has an impact on production and food quality. When considering food availability, we must consider the inequality across and within countries.

People are more vulnerable than we think:

a. 50% of Portuguese earn less than 950€ /month;
b. 90% of Portuguese earn less than 2200€ /month;
c. This means that small changes in food prices have a large impact on people's lives;
d. After the pandemic, poverty increased in developing countries, as well as in Portugal;

We may be entering a long period of economic stagnation in this context. The prospects for the future could be brighter. We face several risks: geopolitical tensions, stagflation, energy and food insecurity, financial stress, social pressures, weaker longer-term growth prospects (inflation, long-term economic weakness), climate-related disasters, COVID-19 outbreaks, additional supply disruptions, etc.

In this scenario, what can we do from an economic point of view? We can act at different levels, for instance:

a. Policy responses: reduction in fuel taxes, the introduction of fuel subsidies; Export restrictions; Measures to boost energy supply;
b. Policy recommendations: avoid export bans and price controls; prioritise income support; reduce waste; investment in renewable energy.

A central issue is how can we deal with the food supply problem, ensuring high-level nutrition and quality standards? We can:

a. Provide more access to nutritious food to improve citizens' well-being;
b. Ensure affordability in a context of high inflation; we have to think about innovative solutions, social policies, and regulations, as well as need policies that improve productivity; they include technology, better management practices, and the use of resources; this implies that we have to make improvements in measuring, evaluating and testing at all levels.

We also must remember that we are responsible for combating poverty and inequality through public policies and education and monitoring the implementation of these policies.

From a social perspective, it is important to stress that people generally feel engaged in food issues. Recently we have witnessed an interesting social phenomenon: food is a hot topic. Food is much more than a need: food is seen as a product, a promoter of health, the result of technology, an economic sector, a practice, an experience, and a culture.

In general, according to data from Google Trends, people in Portugal care about food, but food is not their primary concern. Instead, there is a more significant concern with issues related to ageing or education. An analysis of the comment box of food-related news (food technology, such as insect production or vegetable eggs) allows us to understand that people relate to food in a personal way in Portugal.

We do not think of food technology as a standard technology but as a social system. Therefore, we must involve society and think together about our shared future.

But technology can be applied to food security through biosensors/chips that can be used for bio and chemical diagnosis, analysis of food safety, or environmental diagnostics. These sensors must be fast, portable, sensitive, integrated, easy to use, and low-cost. The question is, how do these devices impact food? For example, they allow us to detect abiotic stresses in plants and with that data we can work to improve productivity; a food producer can use these devices to detect micro-toxins in food. Sensors and bioengineering can help us to look at food differently: we can understand if food is good to eat, if the production process is performed correctly, and therefore if it is possible to decrease waste or even be 100% sure of the origin of the food or potential diseases.

Talking about food and sustainability means also talking about protein sources. We need to produce food for all, which means safe food at a reasonable price and whose production does not compromise the planet's sustainability (circular economy and zero waste). The circular economy perspective is the future because by selecting good animal nutrients, we are protecting humans, reducing waste, and protecting the environment.

We need to do more with less. For that, we need to increase efficiency through the following:

a. Technology, like sensors, but also through a better understanding of the data provided by technology. For example, to control some external variables that can compromise production, namely water temperature in aquaculture;
b. Genetic selection, which helps animals to grow faster and be more resistant to diseases, can also be beneficial in the fight against antimicrobial resistance (improving human health).

Animals need nutrients, not food. We must ensure that we provide and feed animals with all essentials to meet their needs. We can also use technology for that. But what kind of resources do we have to accomplish this goal? We should avoid competition for human food consumption (for example, insects for animals because most humans do not eat insects, and animals do).

In this area, we must also consider energy costs and legal issues. Technology is crucial to do that, but we need new laws and regulations accordingly.

Highlights:

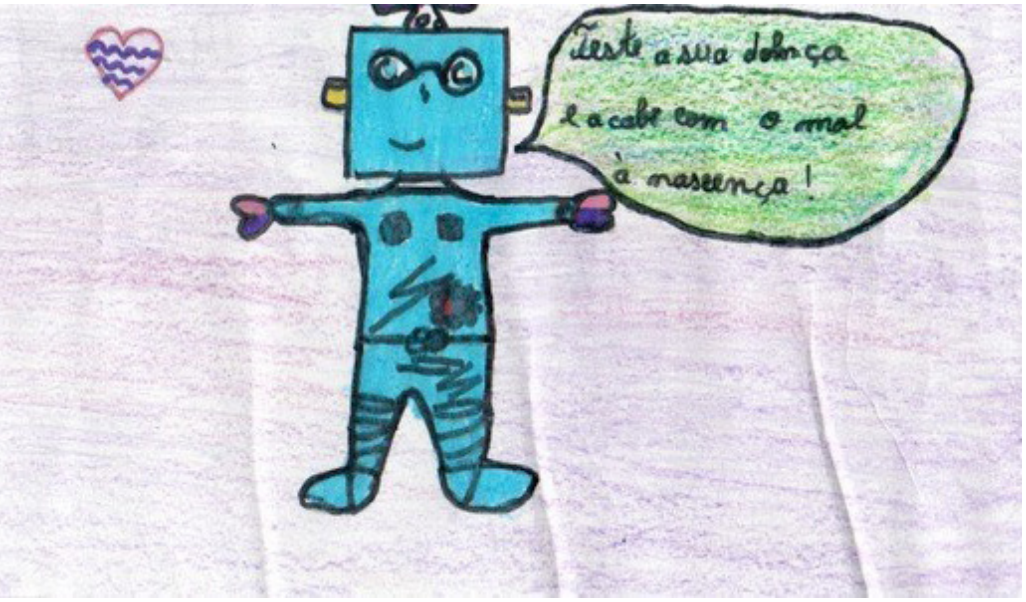
a. We need more straightforward legislation;

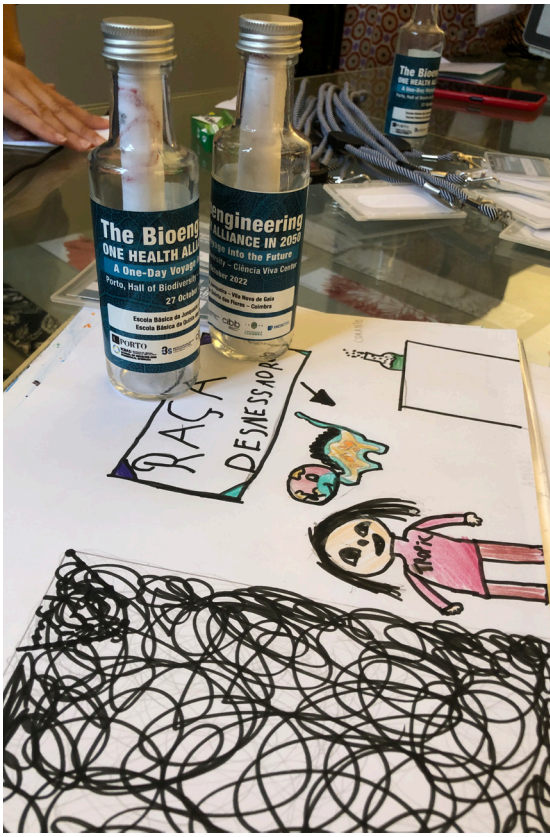
b. Some people are afraid of consuming alternative sources of food because the relation with food is cultural; we need to work together to change people's perceptions (it is all about engagement); Food price is related to our consumption and our preferences;

c. Three main aspects of food preferences are taste, price, and convenience;

d. When we need to make choices, we should not go to less nutritional foods; however, for poor people, a slight change in price causes a significant difference, which demands public policies in food prices;

e. Biosensors may provide safety information, but possible negative impacts on health should be considered (such as the safety of the biosensors) and food costs.





Drawings, offered to the participants, made by children aged 8 and 9, from Escola Básica Quint das Flores and Escola Básica da Junqueira, about their wishes for 2050.

REFERENCES

Barnosky, A. D., P. R. Ehrlich and E. A. Hadly (2016). “Avoiding collapse: Grand challenges for science and society to solve by 2050.” Elementa-Science of the Anthropocene 4: 1-9.

Collaborators, G. B. D. D. F. (2022). “Estimation of the global prevalence of dementia in 2019 and forecasted prevalence in 2050: an analysis for the Global Burden of Disease Study 2019.” Lancet Public Health 7(2): e105-e125.

Commission, E. (2017). “A European One Health Action Plan against Antimicrobial Resistance.” from https://ec.europa.eu/health/system/files/2020-01/amr_2017_action-plan_0.pdf.

de Kraker, M. E. A., A. J. Stewardson and S. Harbarth (2016). “Will 10 Million People Die a Year due to Antimicrobial Resistance by 2050?” Plos Medicine 13(11).

Ehrlich, P. R. and J. Harte (2015). “Opinion: To feed the world in 2050 will require a global revolution.” Proceedings of the National Academy of Sciences of the United States of America 112(48): 14743-14744.

Holden, B. A., T. R. Fricke, D. A. Wilson, M. Jong, K. S. Naidoo, P. Sankaridurg, T. Y. Wong, T. J. Naduvilath and S. Resnikoff (2016). “Global Prevalence of Myopia and High Myopia and Temporal Trends from 2000 through 2050.” Ophthalmology 123(5): 1036-1042.

Keeler, L. W. and M. J. Bernstein (2021). “The future of aging in smart environments: Four scenarios of the United States in 2050.” Futures 133.

Osterhaus, A. D. M. E., C. Vanlangendonck, M. Barbeschi, C. J. M. Bruschke, R. Christensen, P. Daszak, F. de Groot, P. Doherty, P. Drury, S. Gmacz, K. Hamilton, J. Hart, R. Katz, C. Longuet, J. McLeay, G. Morelli, J. Schlundt, T. Smith, S. Suri, K. Umali, J. van Aken and J. A. Wagenaar (2020). “Make science evolve into a One Health approach to improve health and security: a white paper.” One Health Outlook 2(1).

Pabinger, C., H. Lothaller, N. Portner and A. Geissler (2018). “Projections of hip arthroplasty in OECD countries up to 2050.” Hip Int 28(5): 498-506.

Pilleron, S., E. Soto-Perez-de-Celis, J. Vignat, J. Ferlay, I. Soerjomataram, F. Bray and D. Sarfati (2021). “Estimated global cancer incidence in the oldest adults in 2018 and projections to 2050.” Int J Cancer 148(3): 601-608.

Sharma, R. (2022). “Mapping of global, regional and national incidence, mortality and mortality-to-incidence ratio of lung cancer in 2020 and 2050.” Int J Clin Oncol.

Sulser, T. B., R. H. Beach, K. D. Wiebe, S. Dunston and N. K. Fukagawa (2021). “Disability-adjusted life years due to chronic and hidden hunger under food system evolution with climate change and adaptation to 2050.” American Journal of Clinical Nutrition 114(2): 550-563.

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The Bioengineering
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