

Environmental Determinants of Health: NOVA National School of Public Health Research to Tackle Ongoing Threats and Challenges

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Determinantes ambientais de saúde: o contributo da investigação da Escola Nacional de Saúde Pública para enfrentar ameaças e desafios

Palavras Chave

Saúde ambiental · Determinantes de saúde · Saúde ocupacional · Carga de doença · Avaliação do risco

Introduction

The environment in which we live represents a major determinant of our health and well-being. The complex human-animal-ecosystem interface imposes an increasing risk to public health with population health influenced by the interaction of multiple environmental de-

terminants. Recognizing how the environment influences human health and disease allows us to identify the most relevant risk factors and the most suitable measures to mitigate environmental factors that adversely affect human health and ecological systems. Climate change represents a major threat to human health, and it is nowadays undermining every dimension of global health monitored, increasing the fragility of the global systems, and increasing the vulnerability of populations, with a special emphasis on the already most vulnerable [1].

The world is now facing frequent extreme weather events such as heatwaves, floods, droughts, and hurricanes [2, 3]. Rising temperatures and changes in precipitation patterns also affect the seasonality and geographic range of many infectious diseases, particularly those transmitted by vectors [4]. It is predictable that air quality will be negatively impacted, leading to an increase in the burden of noncommunicable diseases. Biological and chemical contaminants in food are also impacted by climate change, modifying their virulence, occurrence,

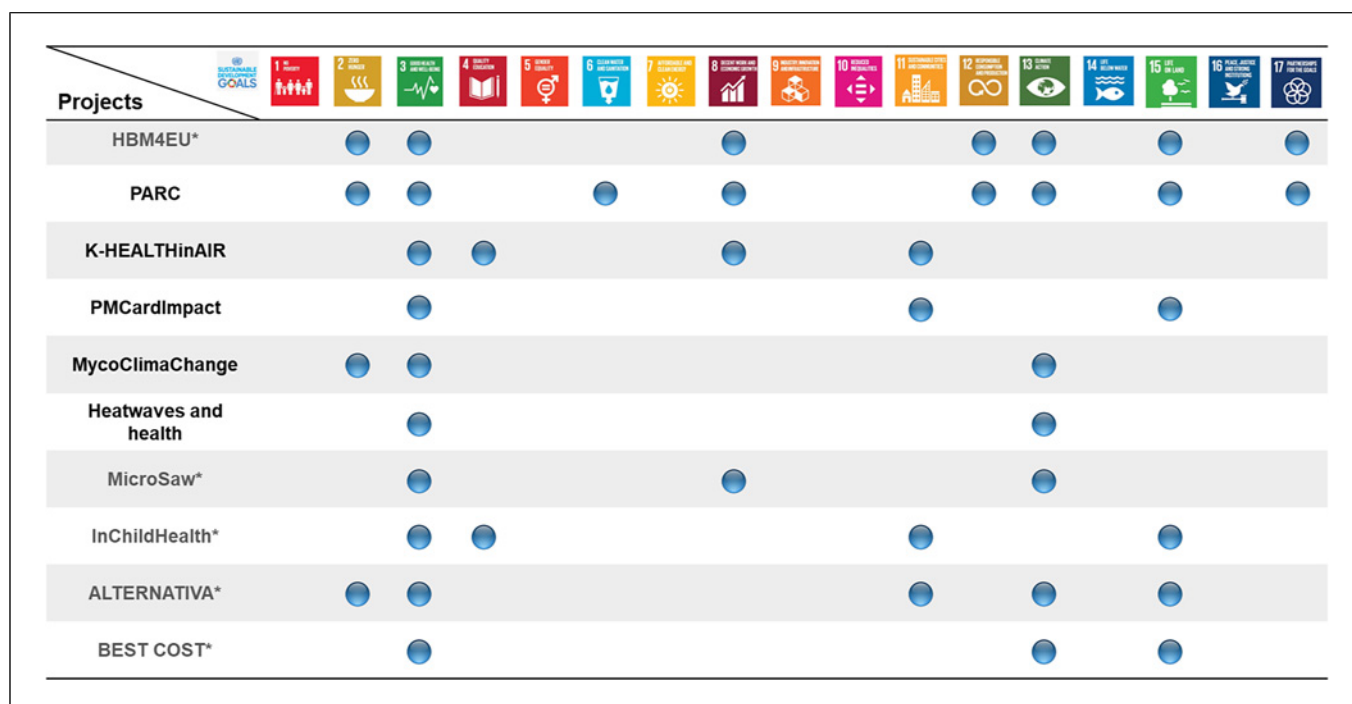


Fig. 1. NOVA-NSPH research projects and studies and their contributions for the sustainable development goals.
*Collaboration of researchers and PhD students.

and distribution patterns, which may increase the risk of human exposure to foodborne hazards [5]. Agricultural productivity and clean water availability may decrease, resulting in malnutrition, foodborne illnesses, and waterborne diseases, endangering food security and safety [1]. The transition for more sustainable and healthier diets constitutes a significant challenge for human populations already under the pressure of climate change-associated events, but is considered one of the solutions to tackle this global threat [6].

Although health is still seen mainly through the lens of human health, several efforts such as the One Health approach have been made to evolve from this strict view to a broader one, where health is considered in an integrated perspective, interconnected with environmental and animal health [7]. Considering a multidisciplinary approach, the Environmental Health scientific area of NOVA National School of Public Health (NOVA-NSPH) has made efforts to address these diverse and complex environmental challenges, by developing studies and integrating several research projects in the field of public health and environmental health focusing on different topics, e.g., heatwaves, air pollution, food safety, and occupational exposure to chemicals and microorganisms.

The development of research on environmental health, aligned with international policies and contributing for the science to policy interface, is innovative in NOVA-NSPH and in Portugal. This letter aimed to describe this research, the involvement and contribution of NOVA-NSPH for the challenges abovementioned, and to promote the engagement of other research groups.

Research of Environmental Health Scientific Area

These research projects are dedicated to human exposure assessment to different risk factors, i.e., chemical substances, air pollutants, high temperatures. Framed within the requests of the funding agencies, these research projects contribute for the science to policy interface and are fully aligned with European Union policies and frameworks, with expected deliverables that include not only the scientific outputs but also communication materials to policy actors and to promote citizens' literacy on environmental health. These outputs, based on evidence-based data, will provide significant support for new policies aiming to tackle the environmental and public health challenges posed nowadays. Figure 1 shows the

Table 1. Involvement of environmental health scientific area members in the research projects

Project	Project coordination	WP/task coordination	Responsible for deliverables	Fieldwork	Scientific publications	Funding
HBM4EU			☑	☑	☑	H2020
PARC			☑	☑	☑	HE
K-HEALTHinAIR			☑		☑	HE
PMCardImpact	☑	☑	☑			FCT (PT)
MycoClimaChange	☑	☑	☑			EEA Grants
Heatwaves and Health	☑		☑		☑	Not funded
MicroSaw	☑		☑	☑		Not funded
InChildHealth*			☑	☑	☑	HE
ALTERNATIVA*					☑	EFSA Partnering Grants
BEST COST*			☑		☑	HE

WP, work package; HBM4EU, Human Biomonitoring Initiative for Europe; PARC, Partnership for the Assessment of Risks from Chemicals; K-HEALTHinAIR, Knowledge for Improving Indoor AIR Quality and Health; PMCardImpact, health and economic impact of PM_{2.5}-related cardiovascular diseases in Portugal; MicroSaw, Microbial Occupational Exposure Assessment in Sawmills; In-ChildHealth, Improving Indoor Air Quality to Bring about a Healthier Future for Our Children; ALTERNATIVA, Alternative Protein Sources in the European Diets, Integrating Health Risk-Benefit and Sustainability; BEST COST, Burden of Disease Based Methods for Estimating the Socio-Economic Cost of Environmental Stressors; H2020, Horizon 2020; HE, Horizon Europe; FCT, Foundation for Science and Technology; EFSA, European Food Safety Authority. *Collaboration of researchers and students, without funding for NOVA-NSPH.

alignment of the different projects with the United Nations Agenda 2030 regarding the Sustainable Development Goals, and Table 1 summarizes the involvement of NOVA-NSPH.

Interlinkage with Training Offer

The research projects and studies being developed involve researchers and students with different academic and professional backgrounds (e.g., environmental health, medicine, biomedical sciences, nursing, biochemistry, veterinary medicine). These research projects are, in a first stage, included in the syllabus of different curricular units and short courses developed by the Environmental Health scientific area [8]. Within curricular units, the research projects are presented, and the deliverables (e.g., reports, scientific papers) are the basis for discussion within the group and for the assessments. In a second stage, students who are interested in these topics are engaged in the research projects to develop their dissertations, thesis, and research internships. Another important aspect is the possibility provided by fellowships funded for different academic qualification levels, that is also a significant contribute for the promotion of scientific employment and careers in public and environmental health areas.

Heatwaves

Heat waves are defined as an extended period of days with higher-than-normal temperatures [9]. In fact, heat waves are becoming more intense, frequent, and prolonged, and its probability of occurrence has increased 50 to 100 times in the past 3 decades [10]. Heatwaves represent a severe public health concern, given their association with potentially preventable excess morbidity and mortality. Heat excess can cause both direct and indirect effects on human health, leading to heat stroke, decompensation of chronic diseases, mental stress, injuries, but also disruptions and further pressure on healthcare services [11]. However, killer heatwaves are a relatively new and scantily understood menace to health. Portugal, due to its geographic location, aging population, and densely constructed urban centers, is at high risk [12]. Considering this, a study is being conducted at NOVA-NSPH to assess the relationship between excessive heat and daily hospital admissions in mainland Portugal over the last 2 decades. By studying the frequency and trends of heatwaves and the major causes of hospital admissions, the study being conducted at NOVA-NSPH will be instrumental in informing policymakers to allocate resources more efficiently and increase the preparedness of healthcare services, both in Portugal and other countries dealing with similar climatic

challenges. It will also be vital to support urban planning and green infrastructure to promote climate-resilient cities.

Ambient Air Pollution

Air pollution is the second-highest risk factor for noncommunicable diseases. Exposure to high levels of air pollution causes several health outcomes and is associated with increased mortality, premature mortality, and morbidity [13]. Among the environmental pollutants that the population is exposed to, particulate matter (PM) with a diameter of 2.5 μm or less, usually referred to as $\text{PM}_{2.5}$, is one of the most dangerous pollutants to human health. Evidence showed that long-term exposure to this pollutant is associated with ischemic heart disease and stroke [14]. The relationship between ambient air pollution and high-impact diseases, mortality, and health care costs in Portugal are the main objectives to be achieved by the PMCardImpact project (FCT, EXPL/SAU-PUB/0944/2021). For this, the environmental burden of cardiovascular diseases is being estimated, as for the direct cost per patient with a cardiovascular episode and the total economic burden for the National Health Service, linked to exposure to $\text{PM}_{2.5}$. The knowledge of these costs is a fundamental contribution to provide policymakers with information that could support the implementation of policies aiming to reduce air pollution levels and increasing gains in health. Building up on this national research project, a new collaboration in the field of outdoor air pollution and the effects on human health was set up with BEST COST project (Horizon Europe), especially in the tasks dedicated to burden of disease, disease models, and systematic reviews of exposure-response function.

Indoor Air Quality

The indoor air quality is an important environmental determinant of health as well. Some indoor pollutants are produced by resident activities indoors, in public spaces, and at work. These include carbon monoxide, volatile organic compounds, particulate matter, radon, aerosols, and biological pollutants [15]. Therefore, it is relevant to identify their primary sources, determine the concentrations in different indoor settings, develop strategies to improve indoor air quality [11], and identify the health effects associated with the presence of indoor pollutants or their harmful combinations [16]. Additionally, climate change has an impact on microorganisms' spread and

dissemination due to temperature rising and moisture fluctuations, creating conditions for microbial development and growth and posing a rising threat to human and animal health [17, 18]. Environments such as schools with poor ventilation and high moisture levels emphasize the need for contamination assessment, screening of microbial resistance, and detection of metabolites [19].

Within the European Union, several projects dedicated to indoor air quality and funded by Horizon Europe are being developed with the participation of Portuguese academic institutions. NOVA-NSPH integrates, as partner, the Knowledge for Improving Indoor Air Quality and Health (K-HEALTHinAir) project that will implement an extensive monitoring campaign of chemical and biological indoor air pollutants in representative locations (nine scenarios) together with dedicated research on sources, interactions, and correlations with health problems. These results are relevant, mainly, to the scientific, management, and decision makers' community because they will provide user-friendly and affordable IAQ monitoring solutions, technological IAQ solutions, and guidelines for IAQ improvement. The In-ChildHealth project has the participation of two PhD students of NOVA-NSPH Public Health doctoral programme and is dedicated to the integration of technical, medical, environmental, and social science research to identify determinants of IAQ affecting school-age children (6–10 years old children). This project aims to evaluate health impacts, the development of an Integrated Risk Assessment Tool, guidelines, recommendations, and training material to improve IAQ and reduce disease burdens. To achieve these ambitious goals, field measurements will be conducted in schools in seven European cities, but also including homes, sports halls, and transport modes, to identify contamination sources, exposure routes, and other factors influencing IAQ in such environments. As a spinoff of the project, it is also intended to evaluate the effects of multiple contaminants exposure through a cytotoxicity testing pipeline in vitro approach.

Food

Food is essential for life and a major determinant of health [5]. Food safety, food security, and food sustainability are a concern all over the world and demand collective efforts of all the relevant actors in the food supply chain [5]. The proliferation of mycotoxin-producing fungi, one of the most relevant food

contaminants, in agricultural settings poses a challenge for human health and nutrition, especially since it is influenced by climatic conditions (temperature, humidity, and carbon dioxide) [20, 21]. MycoClimaChange is a bilateral project which aims to assess exposure and characterize risk to multiple mycotoxins in the Portuguese and Icelandic populations in the present moment and under different climate change scenarios. Under this project, results obtained through a human biomonitoring approach for both populations are being compared, and the possible influence of climate change will be estimated. The results contribute to the body of knowledge pertaining to the impacts of mycotoxins on public health, a relatively new area of interest, and may be used to support national and international policies concerning food safety and security.

NOVA-NSPH is also a partner of the European Partnership for the Assessment of Risks of Chemicals (PARC, 2022–2028), where several food contaminants will be considered priority substances and different case studies will be developed, namely for cadmium, lead, mercury, and arsenic. These case studies will estimate the burden of disease associated with exposure to food contaminants for the Portuguese population, thus contributing for policy-relevant evidence.

Food systems are under increased pressure and are considered one of the main contributors for the exceedance of the planetary boundaries; therefore, the dietary shift for more sustainable diets is deemed as a path to decrease the environmental pressure [6]. The ALTERNATIVA project (2021–2023) funded by the European Food Safety Authority aimed to develop an integrated framework to assess the health impact of diets and simultaneously consider the social, economic, and environmental dimensions of sustainability [22]. Through a case study, the main results showed that positive impacts are estimated for health and sustainability if considering a progressive substitution of beef consumption by pulses consumption.

Occupational Exposure to Chemical and Biological Agents

Safe and healthy working conditions are fundamental to decent work as referred by the International Labour Organization in the Centenary Declaration for Future Work [23]. The exposure of workers to chemicals is also a concern and the protection of workers is essential to ensure healthy populations as well as sustainable environments to workers, their families, and wider communities [24]. One of the

occupational settings with potential exposure to chemicals is the e-waste management, where workers are exposed to a variety of chemicals including metals, particulates, persistent organic compounds, and flame retardants [25]. Nowadays, the use of electronic equipment is increasing, and most of these products require lead as feedstock. The occupational exposure represents, for workers, an important addition to the regular exposure of any other citizen being therefore important to be evaluated [26].

The participation of NOVA-NSPH in the European Human Biomonitoring Initiative (HBM4EU, 2017–2022) and in PARC made it possible to implement occupational studies combining environmental and human biomonitoring approaches for assessing exposure of workers to several chemical substances, in different occupational settings such as chromate plating, welding, e-waste, with others planned to be developed in the near future.

Another important aspect is the occupational exposure to biological agents, where data availability is still scarce. The research study MicroSaw, with the expected duration of 3 years, is being developed to assess occupational exposure of sawmill workers to (micro)biologic agents, to develop guidelines for a proper microbial occupational exposure assessment, and to recommend improved working conditions in agreement with the findings obtained with the exposure assessment exercise. Sawmill workers have an increased risk of adverse respiratory health effects due to exposure to wood dust, microorganisms, and their metabolites [27, 28]. To achieve these ambitious goals, under the study MicroSaw, field measurements will be conducted focusing on the evaluation of occupational exposure, with emphasis on the evaluation of microbiological contamination (fungi and bacteria) in environmental samples (air samples, surface swabs, settled dust, personal samplers). Additionally, the distribution of the azole-resistant *Aspergillus fumigatus* (ARAF) in Portuguese sawmills will be also characterized, since besides being the fungi with higher clinical relevance and classified as belonging to the critical risk by the World Health Organization, it is one of the most common fungi found in sawmills.

Conclusions

A multidisciplinary approach and ongoing projects serve as practical examples of the vital role that environmental health plays in the field of public health. The main goal of the NOVA-NSPH Environmental Health scientific area is to translate research findings and

scientific knowledge into actionable policies. The different projects undertaken by this group propose that knowledge based on scientific evidence supports innovation in science and technologies and successful practices through dissemination to target communities of studies. These ongoing projects will yield evidence-based research that can assist policymakers in implementing effective measures to mitigate environmental risks and enhance human health and well-being. Furthermore, these efforts are bolstered by international partnerships that facilitate the global dissemination of these crucial findings.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Author Contributions

Author 11 made the conceptualization of the paper. All authors prepared the first draft manuscript and approved the final manuscript. Author 1 reviewed and developed the editing process. Author 1 and Author 11 prepared the final draft.

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