Case Report DOI: 10.53681/c1514225187514391s.35.312

RESEARCH IN DESIGN FOR THE HEALTH EMERGENCY. INCLUSIVE, PERSONALIZED, AND SUSTAINABLE SOLUTIONS FOR PEOPLE WELLNESS

Investigação em Design para a Emergência em Saúde. Soluções inclusivas, personalizadas e sustentáveis para o bem-estar das pessoas

ABSTRACT

The paper explores the research line on One Health, an innovative concept that, according to the World Health Organization (WHO, 2016), refers to "a state of complete physical, mental, and social well-being." This definition fits within a paradigm that goes beyond the mere absence of disease, embracing the complexity of environmental, physical, and psychological aspects. The WHO has indeed established a significant link between the environment and human health by introducing the concept of "Eco-Health" (WHO, Regional Office for Europe, 2016). In this context, the research project "Smart&Safe2. Design for Inclusive Smart Protection Systems (S2PI)" is situated. This project won a competitive funding call from the Campania Region (2022-2023) in response to the emergency related to the Covid-19 pandemic. One Health provides the reference framework for the project, which aims to analyze and address the issues arising from the prolonged use of personal protective equipment (PPE), particularly face masks, focusing on the dermatological effects associated with them. The primary goal is to promote prevention, protection, and care strategies at the social level, aiming to address the emerging problems during the pandemic period.

KEYWORDS

Design for Health; Eco-Health; One Health; Sustainability; Textile Research.

RESUMO

O artigo explora a linha de pesquisa sobre One Health, um conceito inovador que, de acordo com a Organização Mundial da Saúde (OMS, 2016), se refere a "um estado de bem-estar físico, mental e social completo". Esta definição se encaixa em um paradigma que vai além da mera ausência de doenças, abrangendo a complexidade dos aspectos ambientais, físicos e psicológicos. De fato a OMS estabeleceu uma ligação significativa entre o meio ambiente e a saúde humana ao introduzir o conceito de "Eco-Saúde" (OMS, Escritório Regional para a Europa, 2016). Nesse contexto, situa-se o projeto de pesquisa "Smart&Safe2. Design para Sistemas de Proteção Inteligentes e Inclusivos (S2PI)". Este projeto ganhou uma chamada de financiamento competitivo da Região da Campânia (2022-2023) em resposta à emergência relacionada à pandemia de Covid-19. One Health fornece o referencial para o projeto, que visa analisar e abordar as questões decorrentes do uso prolongado de equipamentos de proteção individual (EPIs), particularmente as máscaras faciais, com foco nos efeitos dermatológicos associados a elas. O objetivo principal é promover estratégias de prevenção, proteção e cuidado a nível social, visando lidar com os problemas emergentes durante o período da pandemia.

PALAVRAS-CHAVE

Design para a saúde; Eco-saúde; Uma saúde; Sustentabilidade; Investigação Têxtil.

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Data de submissão: 10/01/2025

Data de aceitação: 25/02/2025

1. INTRODUCTION

This paper presents the results of the research project "Smart&Safe2. Design for Inclusive Smart Protection Systems (S2PI)," funded as a priority under the Covid-19 Proposal Call from the Campania Region (FESR funds). The previous project, "Smart&Safe1," winner of the first regional Covid-19 call in 2020, focused on managing the contagion in the absence of a vaccine, developing advanced intelligent personal protective solutions for the safety and monitoring of vital parameters of medical and paramedical staff. In its early stages, the project urgently responded to the need to create personal protective equipment (PPE), such as suits and masks, involving local manufacturers who quickly retooled their production lines to produce PPE, with significant investments in technological systems for managing production and distribution. The project led to the creation of new protective devices, including suits, masks, and smart t-shirts equipped with sensors and wireless data transmission systems, for which patents were registered. Despite the urgency linked to the health crisis, the research did not neglect the development of new materials and remote monitoring systems, by extending the applicability of such solutions to broader social contexts. The subsequent research proposal, in response to the new Covid-19 call (2022-2023), focused on issues of protection and prevention, examining the effects of long Covid on human health and social and environmental systems. During the development of the project, the research benefited from contributions from the national and international scientific community, which enriched the theoretical-critical analysis and methodological-application approach. The One Health and Eco Health framework (Harrison et al., 2019) provided the theoretical foundation of the research, guiding the integrated and multidisciplinary approach, which strengthened the results, specified the objectives more precisely, and consolidated the project path.

2. NEW PERSPECTIVES. SELF-DETERMINATION, EMERGENCY, AND WELLBEING

The research project addresses issues related to the prevention and management of Covid-19 virus spread, providing individual protection and care solutions that ensure well-being, extending the benefits from the individual to the community. "Health as a common good" (WHO, 2016) represents a central concept in promoting a better quality of life, within a holistic approach that integrates various scientific disciplines. This vision is based on the idea that access to healthcare services should be a fundamental right, recognized and respected for every individual, thinking of prevention as a collective and widespread process, implemented through the adoption of sustainable and inclusive models.

Fig. 1
The therapeutic landscape and local resources.

Age demographic and declining birth rates contrast with population growth in many global areas. This phenomenon leads to an increasing demand for services and resources to ensure healthy living. Advanced technologies, big data, and artificial intelligence represent innovative solutions for monitoring and improving health. The Covid-19 pandemic crisis accelerated the need for a systemic approach that integrates research, innovation, and development, aiming to create a society focused on well-being. This paradigm implies the active involvement of all social actors (institutions, operators, patients) in promoting adaptive practices to address emergencies. Design culture plays a fundamental role in this process, acting as a mediator between various sectors to build inclusive and sustainable solutions. Global dynamics, such as climate change, depletion of natural resources, and increased demand for healthcare services, require a radical revision of the economic and social model, centered on prevention and health as a shared resource. The state of health includes a complex set of factors that influence quality of life, from housing to available services, to the relationship with the natural environment and the community (Fig.1).
Design assumes a strategic role as a co-creation tool between users, healthcare systems, and protection and care policies, contributing to responding innovatively to future challenges.

2.1 Research thematics

The research project, aimed at providing effective solutions to address emergencies and ensure well-being, focuses on specific themes to experiment with concrete approaches in the sectors of textile applications for well-being and the design of product-service systems for personalized care. The research responds to highly diverse needs, with the goal of offering targeted responses to the challenges posed by the pandemic, while contributing to the continuous improvement of collective living conditions. The themes that guided the phases of the research project played a crucial role in defining the following aspects: the configuration of the involved research community; the development processes of research activities; the methodological and criteria approaches; data collection and management; sociological analyses; the participatory design and prototyping process; access to innovations. Therefore, the specific themes that guided the research project are defined as follows: 1. Configuration of the national and international research community; 2. Active prevention measures to counter the virus spread; 3. Strategies aimed at personalized care; 4. Tools to facilitate participation of heterogeneous users; 5. Research and development of innovative products and services in the health field; 6. Definition of incremental levels of well-being guarantees in the broader social sphere; 7. Access and diffusion of innovations; 8. Environmental data monitoring and control.

3. ECO-HEALTH APPROACH AND THE NEW DIMENSION OF DESIGN FOR HEALTH

The Eco-Health or One Health approach considers the interdependence between the environment and health, promoting an integrated system that involves various disciplines. In Italy and some European regions, collaboration between public health departments and environmental agencies facilitates the exchange of databases concerning social, health, and environmental aspects, aiming to strengthen resilience to environmental and climate risks. This approach emphasizes the need to understand the relationships between human health and ecosystems, recognizing that health depends on ecological balance. The concept of "exposome" (Wild, 2005) supports this relationship, defining non-genetic environmental exposures to which an individual is subjected throughout life. The exposome, which quantifies environmental exposures, encourages the scientific community to systematically assess the causes and effects on health, offering a holistic and complex view of well-being (Vrijheid, 2014). The goal is to reorient these exposures to protect health, recognizing the role of natural environments as preventive and therapeutic factors, highlighted by practices like

healing gardens and plant-based treatments (Moon, 2020). Design for health is based on guiding criteria that identify priority convergences in relation to expected outcomes, aligning with the National Recovery and Resilience Plan (NRRP) and the National Research Program (PNR 2020-27). The main research areas include: Health and technology in the development of digital health technologies, such as telemedicine and wearable devices for monitoring vital parameters; Data collection and management, from the integration of heterogeneous data to monitor and predict health status, expanding observation to broader social contexts; Health and personalization in creating protective solutions against new Covid-19 variants, with an individual-centered design; Health, inclusion, and accessibility in ensuring and accepting technological innovations, promoting well-being and healthy lifestyles in respect of sustainability.

4. CROSS-DISCIPLINARITY. RESEARCH AND DESIGN OBJECTIVES

The European strategy links health to overall well-being, as highlighted in the European Commission's communication on the "EU Biodiversity Strategy for 2030." This strategy promotes a deep connection with nature while respecting local contexts. The Horizon RIA call "Resilient, Inclusive, Healthy, and Green Rural, Coastal, and Urban Communities" focuses on biodiversity protection through the development of nature-based therapies, aiming to transform the ecological transition into opportunities for health, well-being, and the creation of green jobs. Expected results focus on a systemic vision of well-being through clear management of the natural base, understood as an external environmental system (green spaces, agriculture, forestry, etc.), linked to the health, social, and education sectors. This connection directs policymakers, healthcare operators, and citizens toward greater awareness of the benefits of natural products and health treatments, especially if conceived as forms of preventive medicine and complementary treatments. Research and innovation across disciplines seek to develop a long-term vision that addresses the varying impacts of climate, environmental, and socio-economic changes in urban, rural, and coastal settings. The approach supports bottom-up innovation, enabling communities to access useful knowledge for making "informed choices." The choice occurs in a cross-disciplinary environment characterized by active exchange of knowledge and practices, while the implementation of innovations will be specifically local, aiming to develop methods to establish, recover, and improve resilient processes in local artificial and natural systems.

4.1 Research Project and Specific Goals

The research program has highlighted how design choices can benefit from engagement with the community of interest, steering the project based on the feedback received. Active participation was realized through surveys (in Google Form format) distributed in multiple stages, accompanying the conception, design process, and definition of design variants to permit the customization of the product-service. The product-service concepts presented are the result of a co-design phase conducted in collaboration with the community of interest. The primary objectives are as follows: Co-participatory active prevention systems to ensure comfort and safety; Creation of a personalized product-service system centred on the user; Communication system for service design; New fabric configurations for well-being; Development of therapeutic applications related to the user's symptoms; Design for visualization and use of data; New types of personal protective equipment (PPE).

4.2 Research Project and Expected Results

Cross-disciplinary research and innovation in the Smart&Safe2 project outline long-term goals to address the diverse impacts of climate, environmental, and socio-economic changes in urban, rural, and coastal contexts. The results of the co-design phase required the involvement

of researchers and experts in the following scientific fields: technical and functional textiles; organic chemistry; electrical engineering; technical physics; cosmetics; medicine; services. In addition to design disciplines, which include an essential component of product-service design, communication, material design, and result dissemination. The project results are as follows: Cause-effect-remedy analysis of symptoms; Preparation of formulations of active biomolecules of plant origin; Functionalization and characterization of bio-based fabrics with plasma pre-treatment and climatic chamber; Definition of specific needs via Google Form surveys; Data set for co-designing new PPE types; Design of Total Facial Mask and personalized variants; Design of Smart Facial Mask with Medical IoT application; Design of services for care customization; Packaging and communication system design; Hybrid prototyping process; Product exhibition and result dissemination.

5. SMART&SAFE2. DESIGN FOR SMART PROTECTION AND WELL-BEING SYSTEMS: INCLUSIVE, PERSONALIZED, AND SUSTAINABLE

The Eco-Health approach promotes cross-disciplinary guidelines, defining new research areas in Design for Health and developing strategies for creating innovative products and services (Zinsstag, 2012). The Smart&Safe project has focused its strategy on effective temporal planning and cross-disciplinary sharing, key elements for achieving optimal results in a competitive research context.
This approach has fostered the creation of a national network of researchers, companies, and communities that actively collaborate.

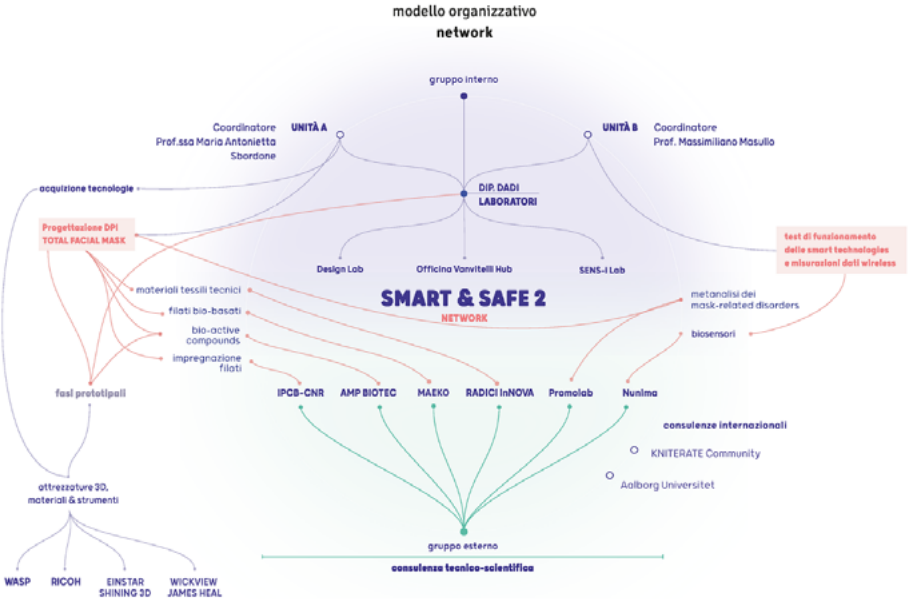

Fig. 2
Research ecosystem.

Continuous interaction guided the project through its crucial phases, including the critical analysis of Design for Health, the conceptualization, configuration, and application of prototypes, as well as the definition of the respective patents.
The research project development phases can be summarized as follows: Configuration of a network model as a "research ecosystem" (Fig.2); Development of participatory preventive approaches in relation to identified users; Research and testing of plant-derived biomolecules; Development of personalized solutions in the well-being sector; Creation of solutions with smart fabrics; Dataset creation; Co-design for Total Facial Mask and face mask; Medical IoT applications with sensors; Definition of product-service systems and related communication strategies (Fig.3).

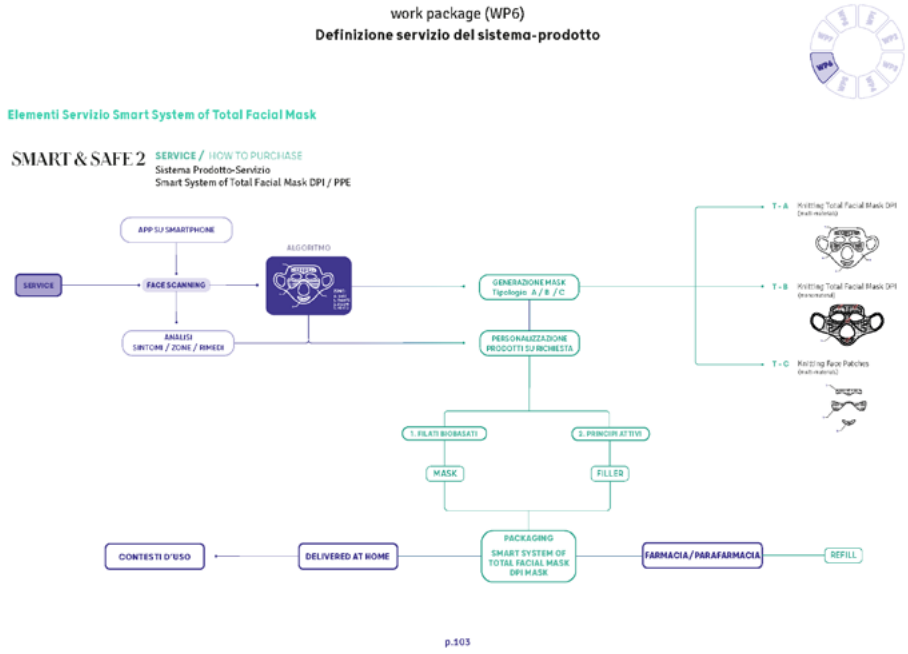

Fig. 3
Product-service flow definition.

5.1 Smart&Safe2 Experience. Approaches and Methodologies Adopted

Systemic Design for Health: The design process in a complex research project comprises interconnected phases, often reoriented based on continuous revisions. The concept of Design for Health is based on the Eco-Health and One Health approaches, promoting a holistic analysis of health (Zinsstag, 2012). This systemic approach requires the analysis of heterogeneous factors related to territories, enhancing local resources, and identifying symbiotic production chains. Engaging stakeholders creates participatory networks that foster the integration and resilience of local economic systems. Territorial investigation revealed opportunities to develop the medicinal plant supply chain, from which molecules for bioactive compounds are extracted; Digital Health: The design phase of wearable devices and PPE involved: analysis of the state-of-the-art literature on wearable systems, assessing existing ones (strengths and weaknesses); identification of vital parameters to define desired well-being levels; benchmarking of commercially available devices in relation to selected parameters and biofeedback executed. The design and prototyping of wearable systems involved the placement of biosensors, data acquisition/transmission systems, sensor-to-acquisition system connections, and specific lab testing. Testing of the Total Facial Mask PPE prototypes aims to ensure the correct functioning of wearable smart systems and, especially, the performance of Wellness Textiles subjected to various treatments, including plasma pre-treatment (Fig.4) and infiltration in a climatic chamber.

Fig. 4
Plasma pre-treatment: application.

Material-Driven Textile Design Methodology (MDTD): The first application concerns the design of "functionalized" textiles applied to the PPE Total Facial Mask, designed to exert a specific biological action on the wearer, promoting a state of overall well-being for the user. Wellness textiles are capable of gradually releasing bioactive molecules, typically plant-based, into direct contact with the skin, utilizing appropriate technologies. Textile matrices serve preventive, maintenance, and restorative functions, through preventive actions and adjuvant treatments. Advanced wellness textiles are therefore configured as technical-functional elements that, combined with smart devices (biomarkers or biosensors), constitute an exciting series of well-being applications, thanks to the release of bioactive compounds providing personalized solutions (Ribul et al., 2021); ***Product-Service System Design for Inclusion:*** New wearable PPE, such as the Total Facial Mask, are designed using the Design for Health methodology, ensuring safety and reliability in monitoring well-being. The mask is user-friendly, comfortable, and recyclable, integrating a smart component for vital parameter monitoring and a wellness fabric with bioactive compounds. Safety is ensured through user participation and customization. The knit textile matrices are made with bio-based plant yarns in the TexLAB, using Kniterate equipment. The research developed a product and communication system promoting data visualization and active prevention for personalized well-being measures. The product communication system "PPE Total Facial Mask" includes; brand image, communication materials (packaging, flyers, labels, etc.), user manual, new circular packaging to reduce waste, and a product-service system for selecting and creating the Total Facial Mask. Furthermore, the results were disseminated through product exhibitions and the production of a video, accessible via the following link: https://youtu.be/inNqJWhk4iI?si=cx9wqVi1gHsS-Pzc.

5.2 Smart&Safe2 Experience. Applications and Prototype Configuration

The urgency of adopting containment measures in response to health and environmental emergencies highlighted the crucial role of design as a mediator in such contexts. Design must provide innovative solutions that address not only the immediate issue but also the need for multifunctional, inclusive, personalized, and sustainable protective devices. In the case of facial masks, various types of devices have been developed to effectively respond to health emergency challenges. The configurations of the Total Facial Masks include multi-material and single-material solutions, integrating natural materials and advanced technologies. Each type is designed to optimize protection, comfort, and sustainability, thus addressing emerging needs in an innovative and concrete manner (Fig.5; 6; 7): ***Typology A*** This type includes 9 multi-material masks, each made with natural plant-based yarns. The masks are completed with a biocompatible TPU frame, ensuring the device's strength and durability, and an inner mask, also made of biocompatible TPU, with a 3-layer filter. This configuration provides advanced protection while maintaining a low environmental impact using natural and biocompatible materials. The design ensures easy adaptability and comfort for long-term protection needs; ***Typology B:*** The second type of masks consists of 7 single-material masks, made with a single natural plant-based yarn. These masks are designed to maximize functionality, using materials that ensure breathability and comfort. The distinctive feature of these masks is the presence of 3D-printed micro-channels where bioactive compounds can be inserted to enhance protection effectiveness. This intervention further customizes the device based on the user's specific needs and environmental conditions; ***Typology C:*** The third type features a configuration of multi-patches made of a single plant-based yarn. Each patch is designed to address specific needs, such as protecting particularly vulnerable areas of the face or managing specific physiological parameters. This modular system is complemented by a filler pack, allowing the addition of compounds or targeted treatments, and an intelligent frame equipped with a Medical IoT system. The device is equipped with sensors for real-time monitoring of the user's physiological parameters, such as body temperature, heart rate, and blood oxygen level. The integration of IoT technologies enables the dynamic adaptation of the mask's features based on individual needs, ensuring optimal personalized protection.

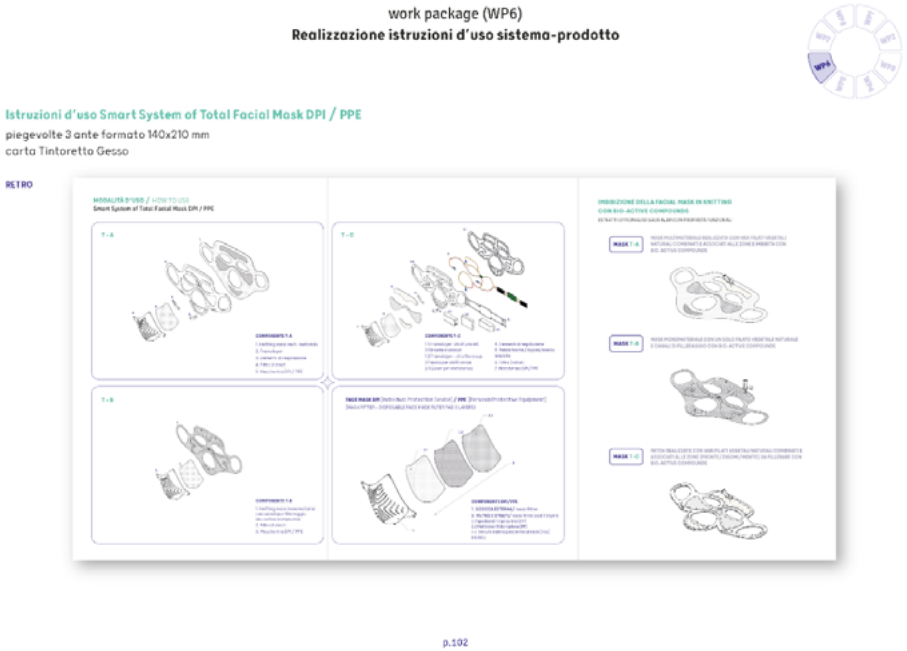

Fig. 5
Total Facial Masks - Technical sheets for each typology: A - B - C.

Fig. 6
Total Facial Masks – Shooting and contexts of use.

Fig. 7
Total Facial Masks Shooting: typologies A and B.

6. CONCLUSIONS

In the context of Design for Smart Protection and Inclusive, Personalized, and Sustainable Well-being Systems, the integration of advanced technologies such as 3D printing, bioactive materials, and IoT monitoring allows for overcoming traditional concepts of physical protection. The theme that oriented the research made use of the theory of the Therapeutic Landscape (Uwajeh et al, 2019; Dzobo, 2022). Eco-design, through the use of natural, biodegradable, and recyclable materials, optimizes production processes to reduce environmental impact and improve quality of life. This approach implies a transformation in the concept of health, care, and interaction with the environment. The research focused on designing Total Facial Masks integrated with personal protective equipment (PPE), within an inclusive healthcare system based on a smart product-service. This theme aligns with the Therapeutic Landscape theory and the European strategy for overall well-being, as outlined in the "EU Biodiversity Strategy for 2030," which promotes a deep connection with nature and harmony with living contexts. The extended benefits fit into the new 'co-benefits belt' model, activated through design, promoting systemic improvement and an interaction logic that transcends the digital. The use of new functional textile materials, enhancing local resources, represents an innovative paradigm for territorial development. The goal is to leverage natural resources to create local-scale bioprocesses, generating broad and scalable economic impact, thereby contributing to sustainable development and greater resilience in local communities.

ACKNOWLEDGEMENTS

The authors would like to express their gratitude to the Campania Region for funding the project and for the support provided during the COVID-19 period and the subsequent follow-up phase. Special thanks go to the members of the research group at TexLAB, Department of Architecture and Industrial Design, University of Campania Luigi Vanvitelli, and their

respective university laboratories: TexLAB in the Design Lab and Officina Vanvitelli for their contributions during the prototyping phases of the wearable PPE Total Facial Mask; SENS-i Lab for data positioning and reading. The authors also thank the collaboration with external partner laboratories/companies, including AMP Biotec for support in the transformation processes of plant-based solutions and their respective bioactive extracts; ICPB-CNR for the equipment and fabric functionalization treatments; Promolab for their support in the meta-analytical research phase. Additional thanks go to Raffaele Mariniello for the photoshoot and to the communication team of Unicampania for their support in photography, video-making, and sharing, specifically Fabrizia Ruggiero, Roberta Albano, and Antonello Vermiglio.

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Reference According to APA Style, 7th edition:
Amato, I., C., Martucci, S., & Sbordone, M. A., (2025). Research in Design for the Health Emergency. Inclusive, personalized, and sustainable solutions for people wellness. *Convergências - Revista de Investigação e Ensino das Artes, VOL XVIII* (35), 63-73. https://doi.org/10.53681/c1514225187514391s.35.312