More-than-human health for the responsible innovation of wearable medical devices

GIULIA TEVERINI[1, 2], ANNAMARIA RECUPERO*[2], PATRIZIA MARTI[2], ANNA CAPONI[2], SEBASTIANO MASTRODONATO[2]
[1] Università degli studi della Campania Luigi Vanvitelli
[2] Università degli Studi di Siena
* Corresponding author

Keywords: more-than-human, wearable medical device, compression stockings, co-design, responsible innovation, product lifetime.

Abstract

The more-than-human is an emerging perspective that enlarges the focus beyond the human subject, to consider the connections between the human beings and other entities in the material world and in the natural environment. When this perspective is adopted in the design of wearable medical devices, it increases the complexity of the elements to consider and this requires the definition of a new unit of analysis beyond the patient-device interaction. To guide the design practice in this domain, we propose to focus the analysis on three levels: the human, the socio-cultural context and the natural environment. Through the discussion of a case study for the responsible innovation of compression therapy in treating venous disease, we propose some key lenses to guide the future design of medical wearable design for a more-than-human health.

Introduction

The more-than-human perspective applied to healthcare calls for a paradigm shift from the centrality of the human subject towards the interrelated connections between the human beings and other entities in the material and natural environment.

Today, the innovation in healthcare relies on the use of emerging technologies to personalise the treatments, improve the health outcomes and provide equitable care, from a human-centred perspective. Only recently the healthcare sector started to consider the sustainability issues related, for example, to the waste of medical devices, not just from an economic point of view but also considering the impact on the environment (Ertz & Patrick, 2020).

In light of this, the more-than-human perspective represents a way to pursue responsible research and innovation (European Commission, 2014) that promotes the development of smart, inclusive and sustainable solutions (Camocini & Vergani, 2021).

With this paper we describe a case study illustrating the more-than-human perspective in the design of wearable medical devices that focuses the analysis on three levels: the human, the socio-cultural context and the natural environment. A particular focus is on the level of the natural environment since it is still overlooked compared to the other two levels of analysis.

For each level, we refer to some key concepts to stimulate in thinking and designing for a more-than-human healthcare. To operationalise this framework, we discuss a case study of the compression stockings for the treatment of venous disease. The key concepts related to the human, the socio-cultural context and the natural environment emerged during the co-design with stakeholders as critical issues of the current therapy, and initiated the discussion about the role of design in dealing with responsible innovation.

Current approach of the compression therapy in treating venous disease

Venous insufficiency is a form of venous disease which slows down blood flow from legs back up to heart because of damaged vein valves. In order to prevent more invasive treatment or to follow conservative therapy after surgical intervention, people are prescribed compression therapy using the graduated elastic compression stockings (GECS).

One of the cornerstones of this therapy is patients' compliance expressed through daily wear time for extended periods of time, which often correspond to the person's lifetime. Scientific evidence reports low compliance to the therapy due to the poor acceptance of GECS by the patients (Raju et al., 2007; Rastel, 2014). The reasons for the non-compliance cover a wide range of aspects which have partly been explored within the scientific community (Chitambira, 2019; Gong et al., 2020).

First of all, the poor wearability of the device is the primary factor that prevents the compliance. The manufacturing process of GECS follows the model "one size fits all" by developing compressive garments based on standard anthropometric data, without considering the diverse body anatomy and gender. To design personalised compression clothing, one of the prominent strategies is based on 3D acquisition techniques to obtain digital scanned data useful for parametric modelling and for body-shape textile production (Kuzmichev et al., 2019; Wang, 2020).

Secondly, the patients frequently report difficulties in donning on and off the stockings as higher compression rates at feet level limit the movements, causing pain and discomfort. For this reason, a great effort has been made to design stocking aids such as foot slip and slip-on stocking aid (Wang et al., 2007).

Lastly, compression stockings are made of inactive and extensible knit fabrics which provide unvaried pneumatic compression. Recently, some studies experiment with active materials which can deliver a dynamic compression achieved by shape and stiffness changes (e.g., Pettys-Baker et al., 2022).

Considering the state of the art described above, the research on compression stocking appears as unidimensional since it focuses on the interaction between the patient and the device from a medical perspective, aiming at maximising the product performance to improve the therapy efficiency. By focusing only on functional aspects of compression stockings as a mere device for cure we miss the opportunity to reflect on the complex entanglement of human needs, social meanings, and cultural symbols related to the medical device. Indeed, stereotypes and stigmatisation generated by the poor aesthetic of the device and the lack of a gendered design, deeply affect the individual and social acceptance of the medical device (Marti, & Recupero, 2022).

Since people meet multiple barriers in using compression stocking and tend to selectively use or completely abandon them, a key factor to innovate the compression therapy is to work at different levels of the human experience of care and to frame it in a wider network of interconnections among the individual, the social context and the natural environment (Bar et al., 2021).

Case study: responsible innovation of compression therapy

The analysis of the scientific literature pointed out the limitation of the current knowledge about the multifaceted experience of people using compression stockings.
To fill this gap, we started a co-design project to envisage a transformation of the compression therapy by designing a service ecosystem around the wearable medical device. The project is currently ongoing, moving from the exploratory phase to the concept generation.

Methodology

The project adopts a co-design approach to explore the needs, desires and values of the GECS wearers who are engaged as design partners. The "Context Mapping" methodology (Visser et al., 2005) serves as a guiding methodological framework, and we use generative techniques to understand what the GECS wearers currently experience and to collaboratively envision future solutions (Van Mechelen et al., 2014).
In the exploratory phase of the project, the co-design participants were involved in a workshop to understand their daily practices and behaviours in private and social contexts. The workshop was organised by the team of the Santa Chiara Fab Lab of the University of Siena, and it took place in a public library in Cecina (Italy) in May 2023. The activity involved five people, aged 27 to 61, representing diverse user groups: two people use GECS regularly every day because they live in a chronic condition of venous insufficiency; one person has had first varicose vein evidence and wears GECS only occasionally; two people have never used GECS but they know the disease being in contacts with people wearing the stockings.

Co-design activities

One week before the workshop, the participants took part in a preliminary activity serving as a sensitising assignment by taking four photographs: a) the moment when they wear compression stockings; b) a place where they would never wear them; c) the place where they store the compression stockings after using them; d) how they dispose of them when they are worn-out. These photos were used during the workshop to stimulate the discussion among participants. The workshop included a sequence of four activities:

1. the participants discussed their experience using the photographs as stimuli;
2. the participants wrote down the keywords that emerged during the discussion on special sticky notes (Figure 1): black-side sticky notes serving as hindrances-card, green-side sticky notes serving as opportunity-card;
3. the participants explored a set of multi-material items (e.g., different patterns and coloured fabrics, tiny adornments, bio-inspired texture and technologies) as inspirations to envision "future compression stockings";
4. the participants "materialised" the ideas by sketching their future compression stockings and shared the envisioning scenarios with the others (Figure 2).

Figure 1. Writing down the keywords on the sticky notes.

Figure 2. Envisioning future compression stockings

Results

The outputs of the workshop, together with the field notes and transcripts, were elaborated to map key findings through a User Journey Map (Kalbach, 2020). The User Journey Map allowed us to highlight diverse barriers, as described below, which lead to the poor compliance and to the abandonment of GECS in diverse phases of the experience.

Then, we identified some challenges for designers to innovate the compression therapy towards smart, inclusive and sustainable solutions (Figure 3). The initial barrier is related to the difficulty in selecting the proper GECS: finding the proper stockings to fit the body and to meet the therapy requirements is complex and demanding because often the person takes some trials and errors. A factor which contributes to increasing these difficulties is the conflicting information about the GECS sizing system: some manufacturers use shoe size as baseline measurement, others use weight and height rather than legs' size circumferences.

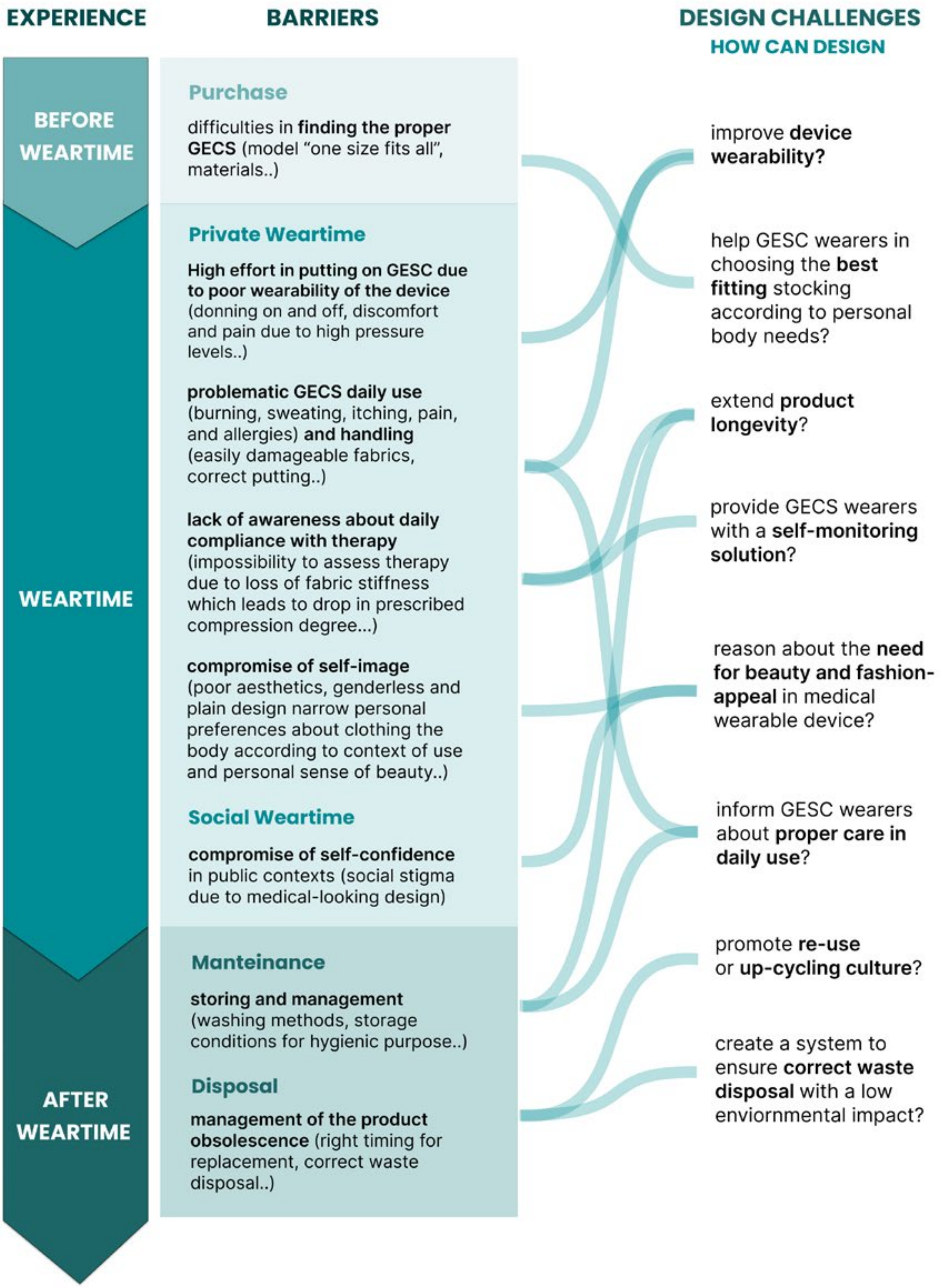

Figure 3. Pain points and design challenges.

As for other wearable medical devices (e.g., Dunn et al., 2019; Harper & Aflatoony 2021; Marti & Recupero, 2022; Seim et al., 2022), the GECS should meet the therapy requirements as well as the need for comfort when donning on, wearing and donning off the stockings. This requires to consider not just the form of the body but also the posture and movement in everyday situations (Gemperle et al., 1998).

When the purchased stockings do not meet these requirements, they are "abandoned" in the trash bin or in a drawer, without ever being used. This cycle of purchase-trials-abandonment-trash is repeated several times during the life of the person due to the long-term therapy of the chronic disease, and this makes the therapy expensive and unsustainable.

The barriers perceived during wear time are several: the person struggles to understand when the current stockings need to be replaced with the new ones; the proper handling and care of the GECS is challenging but essential to maintain the functionality of the stockings and avoid damages.

The poor wearability of GECS (related to texture, shape, weight, freedom of movements, and perspiration) represents just one of the barriers pointed out during the co-design workshop. The aesthetics and the ungendered design of the device is an additional barrier for acceptance and long-term adoption. Both in private situations and in social situations, GECS wearers feel ashamed, they find compression stockings appearance unaesthetic as they are genderless, medical-oriented designed, and they are associated with the concepts of ageing and illness. GECS wearers also complain about the fact that, as compression stockings represent a garment to be worn daily, they often don't match with their style of clothing.

Moreover, in some cases the compression stockings are perceived as underwear clothing, so people tend to avoid exposing them in public situations. This limits them in feeling self-confident in intimacy and in interaction with other people.

The barriers listed above have a critical impact not only on the compliance but also on the amount of GECS which are disposed, since the obsolescence of the compression stockings happens in diverse cases: when the purchased device is not suitable for the person and it is discarded without being used; in case of improper care or handling that damages the device; after a certain period of use when the GECS lose their stiffness and need to be replaced.

Discussion

The outcomes of the co-design workshop enabled us to explore the interplay of factors related to the human, the socio-cultural context and the natural environment which should be considered when designing the more-than-human wearable devices (Figure 4).

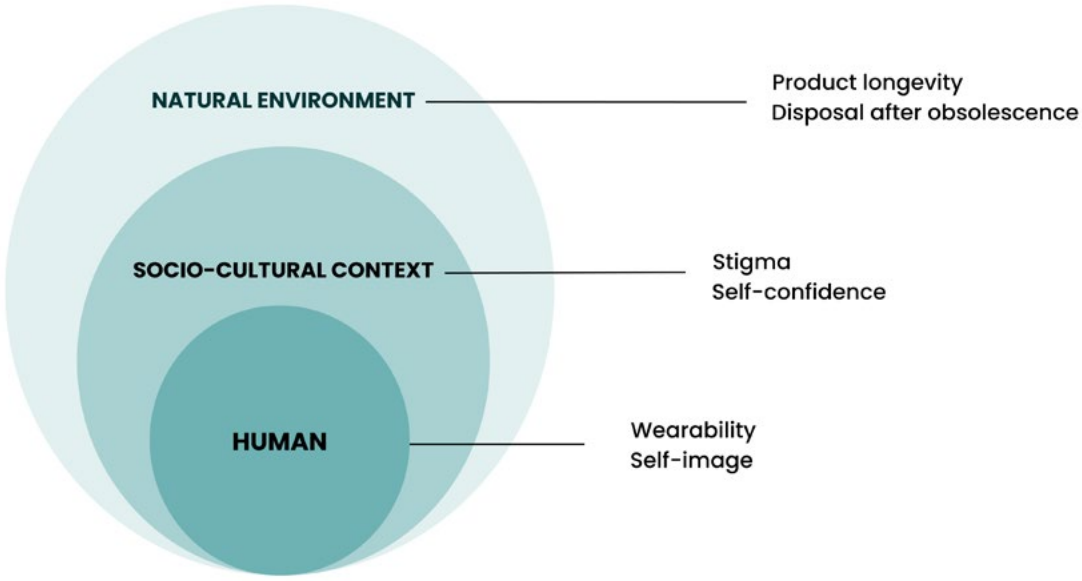

Figure 4. *Three levels of analysis with key concepts.*

At the human level, the focus should be on the wearability to ensure that the device is comfortably wearable considering the diverse body shapes and daily situations (e.g., wearing GECS in the different seasons, under different clothes), as well as on the aesthetics to ensure that the device does not compromise the self-image of the person (Motti & Caine, 2014; Hemapriya et al., 2017; Marti & Recupero, 2022).
At the level of socio-cultural context, the concept of social acceptability should be deeply investigated since the wearable medical device is related to stereotypes and stigma which reduce the self-confidence of the person in public situations (Sehrt et al., 2022).
Indeed, when the medical devices are worn on the body every day, they can act as distinctive marks that label the person with stereo-

types (e.g., illness, aging) and thus they can stimulate negative attitudes by the user towards themselves and by other people towards the user (Farrington, 2016; Profita, 2016).
Finally, at the level of the natural environment, the concept of product lifetime (also called product lifespan) refers to the period during which the product is considered useful or significant by its users, before it becomes obsolescent (Den Hollander et al., 2017). In light of the responsible innovation, the design challenge is to increase the lifetime of the wearable device. Following the classification proposed by Den Hollander et al. (2017), there are diverse approaches to address this challenge which are detailed below.

Design approaches for product longevity

The strategy of "recovery" relies on the use of biodegradable material, or the use of waste bio-based material to produce the textile component of the wearable device (e.g., Vasquez & Vega, 2019).
From a systemic perspective, this strategy requires changes in the production process in terms of resources, machines and chains for collecting and transforming the raw material into the product. Moreover, the material design deals with the regulatory framework since the medical device that is worn in contact with skin should be compliant with the diverse regulatory national and international requirements (McDermott et al., 2022). The strategy of the "extended use" aims to postpone obsolescence by retaining or restoring the device in its functioning state. When the restoring of the functional capabilities of the device is not possible, as in the case of GECS, the strategy can be providing information to the person for the right management of the device (e.g., laundering technique to avoid damages) to maintain the functional capabilities as long as possible.
The strategy of the "long use" aims at extending the emotional durability of the product, in addition to its physical durability (Den Hollander et al., 2017). The emotional durability is related to what Burns (2010) defined as "aesthetic obsolescence" which occurs when fashion changes and the device becomes outmoded. In a life-long perspective, the aesthetic obsolescence is not only related to the changes in fashion trends, but it is strongly connected with the changing self-image of the person while ageing. This is relevant for the wearable medical devices for chronic diseases which are used during diverse life stages, when the body anatomy changes together with the personal sense of style.

Service design to address the product longevity

Another strategy to deal with the product lifetime is to design a service ecosystem in which the technologies are not only enabling artefacts, but they are agents co-performing with the humans and the other entities (Giaccardi & Redström, 2020).

Our approach for the responsible innovation of compression therapy implies a design proposal that takes care of human needs and desires as well as of environmental issues. The project aims to increase compliance by empowering therapy self-management. At the same time, the project addresses the challenge of waste disposal by preventing still-usable compressive fabrics from ending up in landfills after short wear time or untimely product end of life and by offering disposal options. The service scenario is based on three main touchpoints (Figure 5). The smart compression stockings are capable of generating data to keep GECS wearers informed about the remaining lifespan of the device. This kind of interaction will be performed through the development of an e-textile that will collect data by measuring the stiffness degree of the fabric.

The mobile application serves as a medium for GECS wearers to monitor prospective drop of fabric compression capacity compared to the prescribed compression degree, and to make them aware of the correct moment when the GESC have to be disposed of and replaced with the new ones. The design challenge in this case is related to the data visualisation that should be comprehensive and reliable, as well as creative and engaging.

The city-distributed locker serves as a collection point for the unused or obsolete GECS. GECS wearers will be able to find the closest locker in their city through the mobile app that will also act as a smart key to open the locker and place the disposed garment.

As mentioned above, the long-term compression therapy produces a huge amount of waste disposal due to the recurring obsolescence of the device. Expanding compression stockings through wearable technology would lead to the production of another kind of disposal: e-waste. Therefore, lockers represent an essential service touchpoint to ensure a correct waste disposal system.

This service ecosystem is based on the co-performance of people and material/digital things, where the GECS are no longer a mere device to wear on the body: rather they become “some-thing more” to connect human and non-human entities, sustaining the agency of the connected entities to create new value for the interest of the people

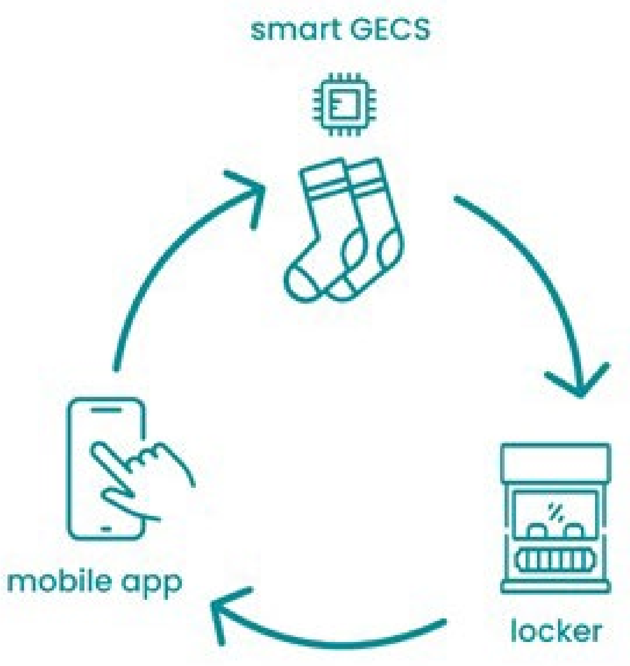

Figure 5. Connections between the service touchpoints.

and the environment (Giaccardi & Redström, 2020). Thus, the goal of the designer is to improve the agency (in terms of power and capabilities) of the human beings who are no longer conceived as care-recipients, and to give agency to non-human entities which act and produce the expected positive impact on the human, socio-cultural and environmental levels.

The next step of the project is to engage the co-design participants in validating this design proposal and in co-creating the agency of the human and non-human entities (e.g., by designing features of smart stockings, the app, the use of lockers).

Conclusions

The case study discussed in this paper aims to highlight the limitation of the current approach of compression therapy in treating venous disease that overlooks the diversity of human beings, since it is based on the "one size fits all" solution, and the impact of the current practices on the natural environment.

To advance the knowledge on this topic, we adopt a more-than-human perspective to deeply understand the interplay between human, socio-cultural and environmental factors which affect the success and sustainability of the therapy. When designing wearable medical devices from a more-than-human perspective, the focus on the interaction between the person and the device is no longer suitable as the only unit of analysis (Giaccardi & Redström, 2020).

In light of this, we recommend enlargement of the unit of analysis articulated on three levels: the human, the socio-cultural context and the natural environment. A wider unit of analysis can help promote a more responsible design practice that:

a) identifies multiple factors determining the acceptance and long-term adoption of the medical device, considering the peculiarities of the device to wear on the body in private and public situations;
b) acknowledges the complexity of the human beings which cannot be reduced to the notion of patient to cure, nor to static and unique anthropometric measures;
c) prevents unintended impacts of the device on the natural environment due to incorrect disposal, and promotes sustainable solutions;
d) allows non-human agencies and factors to become more and more part of any design practice;
e) allows humans to understand and be more aware of the interconnectedness and interdependencies of their practices and the environment;
f) provides a more complex and richer lenses to look into socio-environmental issues;
g) highlights the question of how protection, conservation, preservation of nature can be implemented and thought through together with human healthcare.

This approach aims at making the more-than-human perspective actionable for the future design of wearable medical devices.

Acknowledgement

This project is part of the PhD Program “Dottorato di Ricerca di Interesse Nazionale in Design per il Made in Italy: Identità, Innovazione e Sostenibilità”. The study was funded by the European Union under the Next Generation EU Programme, in the context of The National Recovery and Resilience Plan - Investment 1.5 Ecosystems of Innovation, Project Tuscany Health Ecosystem (THE), Spoke 3 “Advanced technologies, methods and materials for human health and well-being”, CUP: B83C22003920001.

References

- Bar, L., Brandis, S., & Marks, D. (2021). Improving Adherence to Wearing Compression Stockings for Chronic Venous Insufficiency and Venous Leg Ulcers: A Scoping Review. *Patient preference and adherence*, 15, 2085–2102. https://doi.org/10.2147/PPA.S323766

- Burns, B. (2016). Re-evaluating obsolescence and planning for it. In *Longer lasting products* (pp. 65-86). Routledge.

- Camocini, B., & Vergani, F. (2021). *From Human-centered to More-than-Human-Design: Exploring the transition.* FrancoAngeli.

- Chitambira F. (2019). Patient perspectives: explaining low rates of compliance to compression therapy. *Wound Practice and Research*, 27(4), 168-174. https://doi.org/10.33235/wpr.27.4.168-174

- Den Hollander, M. C., Bakker, C. A., & Hultink, E. J. (2017). Product design in a circular economy: Development of a typology of key concepts and terms. *Journal of Industrial Ecology*, 21(3), 517-525. https://doi.org/10.1111/jiec.12610

- Dunn, J. L., Nusem, E., Straker, K., Gregory, S., & Wrigley, C. (2019). Human factors and user experience issues with ventricular assist device wearable components: a systematic review. *Annals of Biomedical Engineering*, 47, 2431-2488. https://doi.org/10.1007/s10439-019-02303-3

- Ertz, M., & Patrick, K. (2020). The future of sustainable healthcare: Extending product lifecycles. *Resources, Conservation and Recycling*, 153, 104589. https://doi.org/10.1016/j.resconrec.2019.104589

- European Commission. 2014. Rome Declaration on Responsible Research and Innovation in Europe. Available at https://digital-strategy.ec.europa.eu/en/library/rome-declaration-responsible-research-and-innovation-europe (Accessed June 20, 2023).

- Farrington, C. (2016). Wearable technologies and stigma in diabetes: the role of medical aesthetics. *The Lancet Diabetes & Endocrinology*, 4(7), 566. https://doi.org/10.1016/S2213-8587(16)00075-9

- Fotiadis, D. I., Glaros, C., & Likas, A. (2006). Wearable medical devices. *Wiley encyclopedia of biomedical engineering*, pp. 3816-3827. https://doi.org/10.1002/9780471740360.ebs1326

- Gemperle, F., Kasabach, C., Stivoric, J., Bauer, M., & Martin, R. (1998, October). Design for wearability. In digest of papers. Second international symposium on wearable computers (cat. No. 98EX215) (pp. 116-122). IEEE. https://doi.org/10.1109/ISWC.1998.729537

- Giaccardi, E., & Redström, J. (2020). Technology and more-than-human design. *Design Issues*, 36(4), 33-44. https://doi.org/10.1162/desi_a_00612

- Gong, J. M., Du, J. S., Han, D. M., Wang, X. Y., & Qi, S. L. (2020). Reasons for patient non-compliance with compression stockings as a treatment for varicose veins in the lower limbs: A qualitative study. *PloS one*, 15(4), e0231218. https://doi.org/10.1371/journal.pone.0231218

- Harper, A., & Aflatoony, L. (2021, February). Always On: Unpacking the challenges of living with insulin pumps, to design novel solutions. In *Proceedings of the Fifteenth International Conference on Tangible, Embedded, and Embodied Interaction* (pp. 1-13). https://doi.org/10.1145/3430524.3446075

- Hemapriya, D., Viswanath, P., Mithra, V. M., Nagalakshmi, S., & Umarani, G. (2017, March). Wearable medical devices—Design challenges and issues. In 2017 *International conference on innovations in green energy and healthcare technologies* (IGEHT) (pp. 1-6). IEEE. https://doi.org/10.1109/IGEHT.2017.8094096

- Kalbach, J. (2020). Mapping experiences. O'Reilly Media.

- Kuzmichev, V., Tislenko, I., & Adolphe, D. (2019) Virtual design of knitted compression garments based on bodyscanning technology and the three-dimensional-to-two-dimensional approach. *Textile Research Journal*, 89(12), 2456-2475. https://doi.org/10.1177/0040517518792722

- Marti, P., & Recupero, A. (2022). Body adornment and interaction aesthetics: a new frontier for assistive wearables. *International Journal of Business and Systems Research*, 16(2), 163-182. https://doi.org/10.1504/IJBSR.2022.121142

- McDermott, O., Foley, I., Antony, J., Sony, M., & Butler, M. (2022). The Impact of Industry 4.0 on the Medical Device Regulatory Product Life Cycle Compliance. *Sustainability*, 14(21), 14650. https://doi.org/10.3390/su142114650

- Motti, V. G., & Caine, K. (2014, September). Human factors considerations in the design of wearable devices. In *Proceedings of the human factors and ergonomics society annual meeting* (Vol. 58, No. 1, pp. 1820-1824). Sage CA: Los Angeles, CA: Sage Publications. https://doi.org/10.1177/1541931214581381

- Raju, S., Hollis, K., & Neglen, P. (2007). Use of compression stockings in chronic venous disease: patient compliance and efficacy. *Annals of vascular surgery*, 21(6), 790–795. https://doi.org/10.1016/j.avsg.2007.07.014

- Pettys-Baker, R. Granberry, R. Subash,N. Clarke, M. Woelfle, H. Shah, S., Abel, J. & Holschuh, B. (2022). Wearability and Comfort Improvements to Active Compression Stockings for Lower Leg Compressive Therapy. In *Proceedings of the 2022 ACM International Symposium on Wearable Computers* (ISWC '22), 127–130. https://doi.org/10.1145/3544794.3560812

- Profita, H. P. (2016). Designing wearable computing technology for acceptability and accessibility. ACM SIGACCESS Accessibility and Computing, (114), 44-48. https://doi.org/10.1145/2904092.2904101

- Rastel D. (2014). Treatment by medical compression stockings among 144 consecutive patients with non-complicated primary varicose veins: results on compliance. *Journal des maladies vasculaires*, 39(6), 389–393. https://doi.org/10.1016/j.jmv.2014.09.001

- Sehrt, J., Braams, B., Henze, N., & Schwind, V. (2022). Social Acceptability in Context: Stereotypical Perception of Shape, Body Location, and Usage of Wearable Devices. *Big Data and Cognitive Computing*, 6(4), 100. https://doi.org/10.3390/bdcc6040100

- Seim, C. E., Ritter, B., Starner, T. E., Flavin, K., Lansberg, M. G., & Okamura, A. M. (2022). Design of a wearable vibrotactile stimulation device for individuals with upper-limb hemiparesis and spasticity. IEEE Transactions on Neural Systems and Rehabilitation Engineering, 30, 1277-1287. https://doi.org/10.1109/TNSRE.2022.3174808

- Van Mechelen, M., Gielen, M., Abeele, V., Laenen, A., & Zaman, B.,. (2014). Exploring challenging group dynamics in participatory design with children. In *Proceedings of the 2014 conference on Interaction design and children* (IDC '14), 269–272. https://doi.org/10.1145/2593968.2610469

- Vasquez, E. S. L., & Vega, K. (2019, September). Myco-accessories: sustainable wearables with biodegradable materials. In *Proceedings of the 2019 ACM International Symposium on Wearable Computers* (pp. 306-311). https://doi.org/10.1145/3341163.3346938

- Visser, F.S., Stappers, P.J., van der Lugt, R., & Sanders, E.B. (2005). Contextmapping: experiences from practice. CoDesign, 1, 119 - 149.

- Wang, J. S., Hung, C. H., Chang, B. C., & Wang, S. J. (2007). An assistive device for donning compression stockings. *Ostomy/wound management*, 53(9), 34–37.

- Wang, Y., & Gu, L., (2022) Patient-specific medical compression stockings (MCSs) development based on mathematic model and non-contact 3D body scanning, The Journal of The Textile Institute, https://doi.org/10.1080/00405000.2022.2111644

GIULIA TEVERINI

PhD candidate in Design for Made in Italy at the University of Campania “Luigi Vanvitelli”. Her research focuses on designing inclusive wearable technology enabled solutions to enhance individual and collective experience of care.

ANNAMARIA RECUPERO

PhD in Psychology, is a Junior Researcher at the University of Siena. She collaborates with the Santa Chiara Fab Lab in research projects applying design thinking and co-design methods for the development of new products and services.

PATRIZIA MARTI

Associate Professor at the University of Siena where she teaches Human-Computer Interaction, Experience Design and Design Thinking. She is Director of Santa Chiara Fab Lab. Her research activity concerns designing systems facing cultural, aesthetic and social issues through embodied experiences.

ANNA CAPONI

Researcher in Experience Design at the University of Siena. Her focal point is the design of products and services for Renewable Energy Communities to enable new distributed energy systems, autonomous but interconnected, in order to improve the quality of life and the entire ecosystem’s - people, environment and animals - wellbeing.

SEBASTIANO MASTRODONATO

Industrial designer and a Fellow Researcher at the University of Siena. He collaborates with the Santa Chiara FabLab on development and prototyping of new products. His current research is focused on designing inclusive and wearable technologies.