

Ergonomics and Inclusive Design: Innovative Medical Devices for Home Care

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Abstract This paper discusses: Ergonomics in Design and design-oriented strategies for innovation, like Design Thinking and Human Centered Design, to orient the design of new products in order to satisfy the needs of the plurality of user profiles involved in home care. Social innovation and appropriate intervention strategies, to guarantee the adequacy of care and to increase the independence and participation of the frail in an active life, are some of the themes of social policy and research in the international context. The role of design is essential as a strategic instrument of innovation able to respond to the needs of man and, in this specific case, of persons with reduced independence. Design helps to orientate the planning of home care products by taking safety and ease of use into special consideration. This paper presents part of the research performed by the Florence University Laboratory of Ergonomics in Design (LED).

Keywords Ergonomics in design · Human centered design · Design thinking · Social innovation · Design for all · Inclusive design · Home care devices

1 Introduction

New projections on European population have recently shown how quickly the number of elderly people is growing. The economic impact of ageing will be substantial in every EU country, and will express itself through two channels: pensions and long term health care. Population ageing is therefore a very delicate

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issue for the European community, and in terms of costs, affects the whole community. “Active and Healthy Ageing” (AHA)—that is favoring active ageing and independent life for citizens, through the education of a healthy and dynamic lifestyle, thanks to prevention and early diagnostics, as well as through assistance and care—is one of the goals of the European framework program for research and innovation.

In this scenario, themes of health care and home health care are greatly important. These themes are intended as systemic design of products and services for the health and home care sectors that could ensure the autonomy and the safety of people as long as possible in their own homes. This could alleviate family tasks that often have to seek help from ‘informal’ caregivers.¹ Houses, furniture, household appliances, objects in general, medical devices included, have to be safe, user friendly, smart and accessible for all. Environment, products and equipment design are affected by the ageing population and by the increasing number of people that require home care. Also, the products for home care are or could be often used by unprofessional people and by people with motor disabilities, perceptive and/or cognitive impairments and limitations.

Design, as strategic factor in innovation, serving humans and society, that helps to identify possible scenarios and innovative solutions in every field of application, can make an important contribution in the direction of user centered design, with the user, his needs and his expectations, at the center of design [1].

Design is often associated with aesthetic features of products but the design purpose normally extends much further than this. The starting point and the focus of the design activities are the users’ needs, their aspirations and their abilities to function as independently as possible at home. These approaches to design activities have the potential to consider many design criteria such as environmental sustainability and the safety and accessibility of products, services and systems [2].

2 Home Care Design and Ergonomics

2.1 *Innovations of Objectives: A Change of Perspective*

Social innovation and appropriate intervention strategies, to guarantee the adequacy of care and increase the independence and participation of the frail in an active life, are some of the more significant themes of social policy and research in the international context.

European Community defines social innovation as “the development and implementation of new ideas (products, services and models) to meet social needs

¹Caregivers give assistance to elderly and infirm people in their home, making meals, ensuring punctual arrival to medical appointments, and generally anticipate and act on the needs of the patient.

and to create new social relationships or collaborations”. It represents new responses to pressing social demands, which affect the process of social interactions. It is aimed at improving human wellbeing. Social innovations are innovations that are social in both their ends and their means. They are innovations that not only benefit society but also enhance an individual’s capacity to act [3].

The main elements of social innovation are:

- identification of new/unmet/or inadequately met social needs;
- development of new solutions in response to these social needs;
- evaluation of the effectiveness of new solutions in meeting social needs;
- scaling up of effective social innovations.

Different user profiles are involved in the issues of social inclusion. In particular different user profiles are interested in the attention, the safeguard and the improvement of their personal autonomy at home and also in the possibility of having social relationships and an active participation in social life.

These themes involve a relevant change in the perspective in which both research and the experimental design field of the Ergonomics for Design and Design for All approach converge. The starting point and the final objectives of the design action of these approaches are based both on “user-centricity” and on the assessment of people’s needs and expectations. This change is based on the ability to turn the attention from the specific user profiles—traditionally defined by age, physical and cognitive features or limitations, such as design for elderly people, design for people with disabilities, design for the blind—to “user needs profiles” which include everyone.

Therefore, it is not about knowing the characteristics, the capabilities or the limitations of the person, but about defining their requirements for the use of a product, of an environment, or of a service within a specific context, by taking into account all the variables. For example, this would take into consideration the condition of the environment and the specific social context, the services and the available aids for the requested activity.

In operational terms it is possible to move from a design “for people who are disabled”, “for the elderly”, “for the blind” etc., to a design that aims at ensuring and/or enhancing the usability and manageability of the products, their simplicity and comprehensibility, together with the visibility and legibility of the components.

In particular, the safeguard of personal autonomy and autonomy at home, therefore represent a socially relevant objective, both regarding the reduced cost in assistance and the reduced burden for the caregivers, as well as the improvement of an individual’s life conditions in terms of their care, safeguarding their levels of autonomy and participation in social life.

The research and the experimental design process addressed to social inclusion start from the same objectives that we generally consider for the issues of social inclusion. This involves in particular the design criteria for environments, products and services. These not only guarantee the accessibility and the safety of the environment and of everyday products, but they can also support and empower

people's autonomy and their possibility to perform normal activities of daily life and to maintain their integrity in the system of social relations.

Within this framework, themes such as the safety and simplicity of the products designed for the care and the personal assistance outside of health care structures assume special importance: such as electro-medical equipment, devices for drug administration and for measuring blood pressure and body temperature, as well as accessible toilets, beds and armchairs with adjustable heights and tilts for use at home.

The risk of accidents or the incorrect use of products might be caused by devices with illegible indications or by activities that require opening or closing or by regulation using fine motor skills or considerable strength in the hands. For example, in the case of medical devices this could lead to an incorrect dosage of a drug or to errors in the reading of data.

The wide range of people with weak conditions are considered today to be an integral part of the population, giving rise to the need to address social policies which pay attention to specific needs, expectations and desires that can bring together a wide variety of people. The relationship between ergonomics and design, like the synergy between the methods of assessing the needs of Human Centered Design users and the Design Thinking approach [4], aimed at optimizing User Experience, represents a concrete opportunity in the field of social inclusion, both as a strategic instrument for the design of innovative products and services for care and assistance, able to satisfy the requirements of users (end users, caregivers, family members) and as a method of intervention to synthesize the various professional competences involved in the design and supply of health care services and social integration [1].

2.2 Product Design for Home Care

These products aim to assist personal care at home. They include medical devices, aids and furniture systems used by older people and/or people with reduced physical and cognitive abilities. They are also used by different users like relatives and caregivers, not necessarily experts who have been trained in the use of medical devices. Products for health care can be divided into two different groups: those used for hospital or hospital related care and those used by individuals on a daily basis outside of the hospital environment.

The first group is characterized by medical devices used in nursing care facilities and for home hospitalization: from heartbeat detectors to beds with variable heights and inclinations and aids for movement. These products are designed for professional use, they can be used at home without modifications and adjustments for the different users. The use of products designed for professionals when used by untrained caregivers or patients with reduced physical, cognitive and perceptual abilities, can produce high risk problems for the safety of the patient and at the same time can cause psychological problems caused by an inappropriate use of the

product which could generate a sense of fear towards these complex and potentially dangerous devices. Incorrect use of a product is often the source of error in drug administration, in the measuring of vital signs and in the regulation of equipment. Aids for personal use and specially designed furniture systems share the same critical issues: hospital beds, mobility aids, sanitary apparatus and accessories for accessible bathrooms. In addition this includes products and aids designed for private and domestic spaces, such as stair-lifts, accessible kitchens and accessories that improve the accessibility of shelves and containers. These examples suffer from image problems, due to the “hospitalization impact” of the products, creating discomfort by offering “products for the disabled” within the domestic space.

The second group consists of medical devices targeted for domestic use, such as aerosol therapy devices, blood pressure monitors, or thermometers. These products involve the same safety and security problems caused by limited legibility of instructions and by the complexity of installation and use. When patients are de-hospitalized there are numerous support and care problems. There are also consequences about the design criteria for these kinds of problems because we must consider that products for home care could also be used by nonprofessionals or by people with difficulties and limitations.

Home care differs in many ways from the assistance provided in hospitals and specialized structures. One aspect concerns the difference between products for internal use in health care assisted structures and of products for individual use. In the first case, the equipment, machinery and devices are used by specialized staff members who, depending on their role and competence, use each product for a specific purpose and, in general, adopt standardized procedures.

In the case of products for personal use, as for example medical devices or medical equipment for use, like pharmaceuticals, the reference user base is not made up of health workers, but rather of “laymen” whose characteristics and physical, perceptive or cognitive capabilities, like their knowledge or level of competence in using and understanding potential risk conditions, are unknown a priori. In this case, the device—as occurs for daily use products—can be used “by anyone, anywhere and under any conditions”.

In addition the products, devices, drugs, etc. are used outside controlled procedures in often widely diversified physical contexts. Besides the direct users (patients), relatives and home caregivers must also be considered, in other words, all those people who are directly or indirectly involved in caring for the patient. Furthermore, it must be emphasized that most of the users of medical devices or care equipment, including drugs for home therapy, are elderly persons, often with difficult or limited mobility, sight or hearing problems, memory or attention impairments.

A second aspect concerns the great evolution of products, equipment and services for health care and assistance, in part identical to that encountered in other design fields and in part strongly characterized by the specificity of the sector. Like many other product types (from household appliances to the automotive sector down to communications), over the last two decades the medical product sector has seen a

strong technological acceleration, which has led to a profound change in the functions and performances offered and the methods of interaction between user and product and, in particular, between user and the control/regulation/programming interface.

2.3 Users of Products and Services for Home Care

We need to consider the themes of the safeguarding of health, personal autonomy and the maintenance over time of retaining a relationship with the physical and social environment. It is also possible to understand these themes according to two parallel points of view. On one hand, there is increasing social attention given to the most vulnerable populations. On the other hand, we can consider the objectives of reducing the length of stay in health care facilities that lead to moving towards domestic care within the family structure. The problem transversally involves all user profiles and ages. From rehabilitation, post trauma and post surgery, to care of chronic conditions, moving the convalescence and care phases to domestic environments creates problems with the administration of drugs and the use of medical devices outside the direct control of health workers since it involves people who are not necessarily experts in health care activities.

Social inclusion of weak users, social sustainability of care and assistance, protection enhancement and maintenance of personal autonomy—as well as the creation of domestic and urban environments that are accessible and safe—are issues that not only involve the elderly population, but involve all people that are in a state—even temporarily—of weakness, relating to the environment in which they usually live. Those users struggle every day with physical, perceptual, cognitive barriers, which restrict their autonomy and impede the normal activities of daily life and social participation.

Situations of reduced capacities not only affect the elderly or people with disabilities, but also the entire range of conditions that can be defined as a departure from a condition that is commonly referred to as normal physical, perceptual, and cognitive capacity. This gap may be related to different aspects of individual skills and may have its effect on people's capacity to be independent, maintaining their ability to learn and to perform normal activities in daily living. The impact of this gap on daily life and relationships depends largely on the context in which the person lives.

Elderly people are just one example of such a condition, finding themselves constantly challenged in their relationship to the environment, and in the use of products and services which are both increasingly complex and in continuous and constant evolution. The improvement of living conditions, together with the possibilities of care and support that have extended the average lifespan have favored the numerical growth of the elderly population. This phenomena, which was marginal until a few years ago, has now become very relevant.

One aspect is the wide variety of personal situations and levels of autonomy that today characterize the elderly. The elderly population includes very different types

of users with equally different spheres of needs, desires, habits, and social behavior. The term “aged” today does not identify a person at the end of his life or someone who is no longer active, but rather describes a complex landscape, in which people from very different conditions coexist, depending not only on age, but also on health conditions, cultural level, economic means and, above all, on life conditions and on social context.

Another aspect touches persons in their seventies or eighties who today are often active people, able to manage and plan their lives, well aware of their needs and desires and with plenty of free time.

The third and final aspect, relevant to the topic of this paper, is the growing attention given to the safeguarding of the health and the wellbeing of the young and the ‘not so young’ as well as to the promotion of lifestyles that can ensure a long autonomy for people. The social policies of European Countries are heading in this direction and they aim to promote health and to reduce the costs of an aging population.

3 Results: Innovative and Ergonomic Medical Devices for Home Care

The relation between ergonomics and design in the planning of products and services for health care and, more in general, in planning for independence and social inclusion, is one of the main subjects of research and experimentation developed by Florence University Laboratory of Ergonomics in Design.

In particular, with regard to home care, in recent years two research paths have been developed: one dealing with “furniture and accessories for home care” (Figs. 1, 2, 3, and 4) and the other with “usability of medical devices and mobility aids” (Fig. 5).

Fig. 1 MOOD. Rendering, general view





Fig. 2 MOOD. Rendering, view of the functional table



Fig. 3 360 CARE. Rendering, backside



Fig. 4 360 CARE. Rendering, prospective view of the frontside



Fig. 5 a Sphygmomanometer. Rendering, general view of the monitor. b Sphygmomanometer. Rendering, grasp simulation

Research was carried out by means of a detailed analysis of the requirements of the various groups of users involved in home care, together with an evaluation of the various devices available on the market. The Human Centered Design and Design Thinking approach provided important clues not only for incremental innovation, but also for the radical innovation of existing products. Design experimentation also showed that there is still much to be done to improve user experience in this sector and to simplify and improve usability of human-machine interaction.

The research and design experimentation experience represented an initial concrete opportunity for interdisciplinary confrontation on the subject of design for health care, open to collaboration with firms and operators in the pharmaceutical and health sector.

Knowledge of the use context—starting point of the Human Centered Design process—derives from an analysis and evaluation of the context variables, including all factors contributing to defining the relationship between individual and product/environment/system. In other words, this context is defined by the users, the activities performed and their objectives, and by the physical, organizational and technological environment of reference together with the products under study.

In the case of products and aids for home care, it is a question of identifying the capacities, requirements and expectations of the main user profiles (direct users, family members, external assistants, home assistants) and, for each of them, to describe and evaluate the various activities and objectives with whom and for whom the products are intended.

The survey stage was conducted through a task analysis, developed for each user category, and by direct observation, questionnaires and interviews. Furthermore, from a design point of view, the key aspect is knowledge of possible conditions of risk and of the most frequently recurring adverse events, particularly regarding the description of exemplifying cases through evaluation of the causes leading to the incident and to possible corrective intervention. In other words, an understanding of the reasons—often complex, sometimes quite trivial—that lead to the failure to comprehend the information and/or the stages of correct usage of the product or equipment, to difficulties or impediments in their use, or to erroneous reading/interpretation of instructions, information, warnings, etc.

The following concepts have been reached by starting with a survey developed through evaluation by experts, analysis of tasks, trials and comparative analyses by users of various devices already present on the market. The projects concern the design of medical devices for personal use and the design of furniture specifically intended for home care.

3.1 MOOD, Modular System for Home Hospitalisation: Design by Irene Catalano, Ester Iacono

Mood is a modular system for convalescence at home designed to fit to users' needs. The product consists of a fixed structure on which can be added additional elements, depending on the needs of the patient and the caregiver. The analysis of similar products on the market highlighted problems, both functional and aesthetic. Several problems emerged from the task analysis regarding those solutions in use today and the emotional impact that these have on the end users. These products generally highlight the uncomfortable state of the patient because they are intended for a hospital and do not fit the users' needs within the domestic environment. The consequences are negative psychological impacts on those who use them.

The project has the following objectives:

- to enable those who are ill to be as independent as possible;
- to reduce the workload of caregivers;
- to encourage independent use by the elderly;
- to be compatible with the electro-medical products present on the market.

Mood consists of a fixed structure with some accessories that can be positioned according to specific requirements. The fixed structure, which is anchored to the wall in relation to the height of the bed, is composed of modular panels including a track that allows for the insertion of additional elements depending on the need.

The basic configuration of the system takes into consideration functions related to food, ambient lighting, chrome-therapy, and home control.

The system can be implemented with additional accessories, making operation even easier in the care and in the hygiene of the sick person: dressings organizers, drip stand, shelves, bath with integrated headrests and convertible multifunction trolley.

Mood is customizable in terms of color and finish. It fits discreetly into a home environment, moving away from hospital solutions, increasing wellbeing and comfort of the sick person and of those who look after him.

3.2 360 CARE, Bed-Head Unit for Home Hospitalisation: Design by Elisa Vannini

The number of people that need home care and long-term care, is increasing. The possibility of managing potentially critical situations also in domestic environments is much improved, both in terms of the reduction of the costs of health service, and of the positive effects on the patient, who now has the ability to maintain his habits and stay in touch with his relatives.

The analysis phase shows that most of the bed-head units on the market are strongly characterized by a very impersonal look, typical of the hospital environment which makes them a suitable tool for specialist caregivers only. This represents an important limitation for their use by informal caregivers and infirm people.

360 CARE, is a proposal for a bed-head unit, for home care, which aims to offer the patient more independence and comfort in managing his own condition. The single component beam regulates different functions, such as: lighting, power distribution, diagnostic and communication alarms, and elements for distribution and monitoring oxygen.

The main objective is to increase comfort and to give the patient an active role in managing his own condition, through:

- personalization of finishing for better integration in the home environment;
- introduction of systems for lighting management and for chrome-therapy;
- introduction of a system for the use of functional accessories.

The bed-head 360 CARE consists of a central aluminum body, featured by a rectangular individually customized plaque, which hides the lighting system.

All the functional elements are located inside the unit: plugs for the supply of oxygen, switches and connectors for the emergency remote control cable. The cross section of the beam has an inclined profile in order to discourage improper use, for example as a shelf. A track for the insertion of a rod, supporting the control panel of the lights and other accessories such as shelves or drip support, is located on the back of the lower side of the beam.

Through the control panel users can manage independently the overhead lighting and the chrome-therapy system. The panel is also equipped with other functions: alarm clock, timers, electronic agenda, music playing devices.

3.3 Compact Sphygmomanometer: Design by Ma Jing, Qiao Mengdi

The goal of this project is to simplify the task flow for measuring and reading data, through:

- reducing the operative buttons and offering appropriate sizing of the digital interface elements;
- giving feedback for the device's preparation and for reading results;
- providing compact size to facilitate handling.

For correct use of the device, the user holds it with his left hand, and slides the bracelet along the left forearm with the right hand. The orange stripe helps to identify the correct placement. The start button is highlighted with a different color and finish. Proper cuff placement ensures more precise measurements. The size of

the icon on the LCD screen guarantees an immediate reading, using colorful graphics ranging from light green to dark red. The LED strip, which lights up during measurement, gives clear visual feedback of the outcome of the test.

References

1. Tosi, F., Rinaldi, A.: *Il Design per l'Home Care: L'approccio Human Centered Design nel progetto dei dispositivi medici*. DIDA Press (2015)
2. Commission of the European Communities: *Design as a Driver of User-Centered Innovation*. Brussels (2009)
3. European Commission: *Guide to Social Innovation*. European Commission, Brussels (2013)
4. Cross, N.: *Design Thinking: Understanding How Designers Think and Work*. Bloomsbury Academic (2011)