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IMPROVING AGEING RESILIENCE OF CURRENT AND FUTURE HOUSING

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Abstract *The World Health Organisation reported that people aged 65 years or above will account for 1.5 billion of the world's population by 2050, rising from 524 million in 2010. Ageing population brings together a series of implications and co-morbidities: non-communicable diseases; elderly related impairments; physical or cognitive impairments. Current demographics make architects to reflect on the future of housing. The question is: How to design houses able to support social inclusivity for elderly people? How to adapt the housing stock considering the increasing dependency of the ageing population? The relationship between the built environment and health has been widely studied in the general population. Furthermore, studies on the effect of the built environment, especially on elderly people are spreading. This project aims to identify the features of the home environment able to support elderly people to age positively and live independently in their community. Existing evidence on the impact of the built environment and housing on elderly people were interrogated and the adaptation of existing dwellings were investigated to identify current models and trends. Initial findings show that, even if interesting projects have been developed, there is still the need to support innovative housing models to enable current and future housing stock to support elderly people to age positively and live independently in their community.*

INTRODUCTION

Demographic changes strongly characterize society, dictating its needs and directions for development. It is estimated that in 2050 the number of people over 65 in the world will be about 1.5 billion, compared to the 524 million registered in 2010 [1]. The 2017 OECD [2] (Organization for Economic Cooperation and Development) "*Preventing Ageing Unequally*" study presented data that confirm this global aging positive trend. Italy is one of the most affected countries by this challenge, since, according to the study's projections, it is the third country in the world by number of elderly people in 2050 (74 over 65 years of age for every 100 people between 24 and 64 years old), after Japan and Spain (Fig. 1).

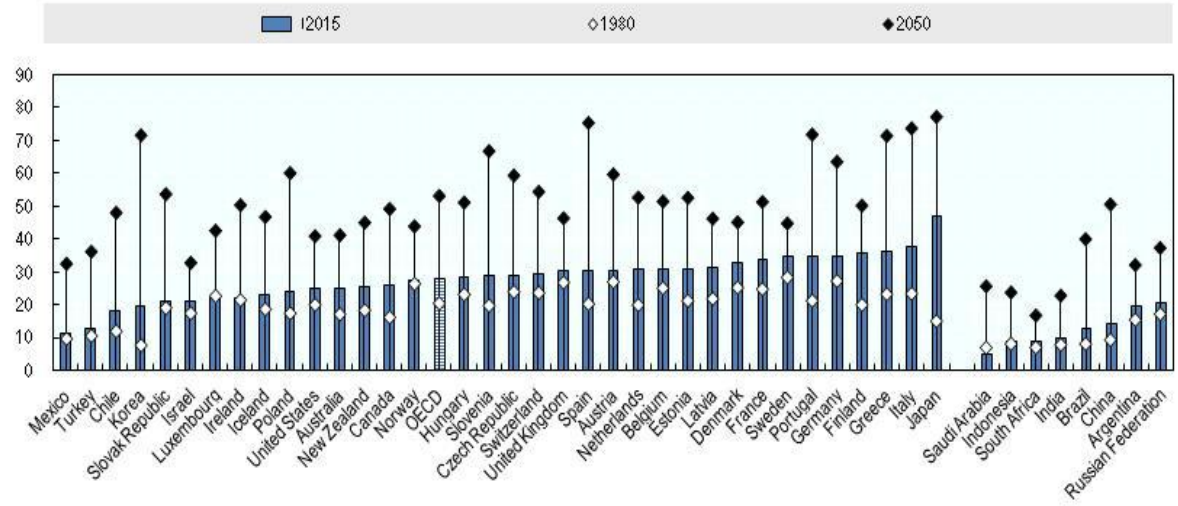

Fig. 1. The old-age dependency ratio will almost double in the next 35 years on average.
Source: OECD (2017), *Preventing Ageing Unequally*, OECD Publishing, Paris

The OECD projection is a great achievement for our society, also facilitated by medical progress and high living standards, despite it is associated to the birth rate decline (according to ISTAT in Italy from 2008 to 2016 the number of births has decreased progressively). The World Health Organization identifies ageing population and urbanization as the main results of the development undertaken in the last century [3]. Qualified as "output" in the XX century, ageing and urbanization now become "input" of the studies that investigate the continuously transforming relationships between man and environment.

Ageing is a complex process where physiological, behavioural, social and environmental changes combine [4]. It includes many variables and the links between them generates different levels of well-being, health, disability, independence and social involvement. This results in the need to divide older age into different representative phases that, instead of relying on the age of the individuals, regards their physical and cognitive abilities [5]. The distinction between third and fourth age, for example, aims to group the elderly by personal characteristics. Indeed the third age identifies the phase of life, generally close to 65 years, characterized by a satisfactory state of health and an active social life, whereas the fourth age identifies the phase of life marked by cognitive and functional decline [6]. The two phases are

dynamic, meaning that they are not definable according to quantitative parameters such as age.

Evaluating the health status of the elderly, strictly related to their quality of life, is certainly a complex operation regardless of the used analysis model. The analysis is multidimensional: within it coexists measurable factors (age, degree of disability, geriatric syndromes, co-morbidities, social and economic status) and intangible factors, devoid of empirical findings (independence, autonomy) [7]. The underlying notion of ecological models, for example, is that health and wellbeing are influenced by the dynamic interaction between biological, behavioural and dynamic factors throughout the lifetime of individuals [4]. Among these, the "*general ecological model of aging*" by Lawton [4] draws the link between person's "*competence*", interpreted as physical and functional health, and the "*press environment*" that is the physical and social environment demand. Correct relationship between individual competence and environmental factor allows the achievement of adaptation and therefore of well-being, according to a dynamic process that changes with increasing age. Outside the "equilibrium" area that favours adaptive behaviours, there are the representative relationships of altered P-E systems (person-environment) that determine the decay of the individual and the onset of adaptive behaviours. Thus, the ecological model represents the theoretical foundation of the studies aimed at defining the characteristics of the environment that promote healthy lifestyles but not limited to the spatial and architectural features.

Scientific literature has extensively investigated the relationships between health and environment: it appears that land use mix, high quality design, proper maintenance and responsiveness to community needs can promote healthy lifestyles with extremely positive consequences on physical and mental human health [8]. By delineating the spatial analysis to the neighbourhood, the positive effects that some urban components (sidewalks, cycle paths, shopping streets, parks, urban furniture) have on the physical activity of adults, and then on the achievement of well-being, have been highlighted [9]. Even the perception of one's state of health, strictly dependent on the functional one, has been traced back to the characteristics of the built environment in which the elderly lives. At macro level- that is the neighbourhood- the main factors are: the presence of green spaces, the land use mix, the efficiency of road connectivity, socio-economic background and emotional connection [10]. However, according to M. M. Baltes et al. [11], the elderly spend most of the day at home alone. This can be traced back to the lower physical and relational skills, to the weakened state of health and to the greater vulnerability to the challenges posed by the environment [12, 13]. House is not simply the privileged location within which the ageing process takes place as, in addition to being a physical place, it bears witness to the experience of each individual [14]. It can be considered as a place of individualization in which a person meets his needs and resources. The way of living and perceiving one's own home varies over time due to changes of family relationships and the development of needs and skills [15, 16].

According to the ecological model, with the reduction in individual competence the relationship with the environment must be even stronger to reach health and wellbeing. A lot of studies, such as the European ENABLE-AGE project, have focused on the meaning of housing and the influence that objective factors, such as environmental barriers, and subjective factors have on the wellbeing perceived by the elderly.

The role of home environment in healthy ageing, however, is not the only factor promoting the research. It is often flanked by the concept of "*aging in place*" that is "*enabling the person to continue living in their own homes as long as they are able to make that adaptation to their own homes that will allow them to do so*" [17]. The concept of ageing in place starts from evidence of studies that estimate that elders want to stay in their own home for as long as possible and preserve their independence [18]. This represents a possibility to face the challenges of demographic changes, by promoting home care policies with less impact on the infrastructural and economic resources of national health systems. Home care provided by informal caregivers makes it possible to delay hospitalization and furthermore, it allows to optimize health expenditure. This is also facilitated by the development of ICT that permit, for example, the transmission of clinical patient data to physician located elsewhere (*telemedicine*) as well as the development of applications for the surveillance and management of diseases through mobile devices (*mobile health*). *Smart house* is an "intelligent box" that is an adaptive environment within which monitoring household activities and environmental parameters is possible through the sensor technology.

The European Community is investing to promote ageing in place and it is supporting several supra-national studies such as ENABLE AGE, SHARE - Survey of Health, Aging and Retirement in Europe, AAL - Active and Assisted Living and continuing to allocate research funds with specific calls in the HORIZON 2020 program (source: https://ec.europa.eu/research).

The aim of this research is to compile and analyse the state of art by presenting a review of the studies focused on the home environment of the elderly, focusing on architectural and design aspects and identifying the issues to be addressed in the future.

METHODS

This research was carried out through an extensive literature review. Four databases were consulted, three multidisciplinary (Scopus, Web of Science and Emerald Insight) and one medical (PubMed) with the aim of diversifying the results by scientific area.

The definition of the keywords took place in stages by selecting the words among the numerous ones relevant to the topic. The process has led to the establishment of eight words that, put in relation with each other through the boolean operators AND and OR, have univocally identified the research topic. The keywords chosen are: ag *, senior, old *, elderly, home, hous *, architecture, "built environment". The presence of wildcards allowed to further extend the research field (for example in the case of ag * the wildcard allowed to include the results written in British English -*ageing*- and in American English -*aging*-).

The query used is: *TI* ((*old * OR ag * OR senior OR elderly) AND (hous * OR home OR "built environment" OR architecture*)). This query did not always generate a good number of results therefore it was followed by other research questions, each defined in relation to the syntax of the database. Two levels of research were then carried out: the first, generic, allowed to frame the problem and record statistical data; the second, more focused on the topic, was the starting point for the subsequent screening stages. Only for Emerald Insight the two levels of research coincide.

Therefore, the selection of the articles was carried out at the second level of the research by using exclusion criteria. More specifically, as a result of abstracts reading, the following were excluded:

• Articles prior to 2007;

• Articles with a medical focus;

• Articles with assisted living as settings;

• Articles in a language other than English, French and Italian;

• Articles concerning home care solutions for specific diseases (heart problems, Alzheimer's etc.).

All the articles deriving from the second level research were however recorded and the following data were extracted from them: title, relevance to the topic (through an accepted-not accepted filter), setting, year, scope. The latter, with the aim of identifying different area of interest, has been divided into: *medical, built environment, assistance, social sciences, engineering, energy, health professional, menagement, unrelated*. Furthermore, a control filter was introduced to indicate the already-read articles.

The accepted articles underwent a second review in which the whole paper was analysed to extract and record further information: *subject, author keywords, available text, link full paper, method, method explication, simple, results*. The subjects, which examine in depth the scopes, are: *digital control system, home modifications, relationship built environment-health, policy, energy*.

Finally, in the last screening phase, after the reading of the full papers, the "*spot-on*" articles were identified

RESULTS

First level research

The first research level returned 8492 results. The resulting histogram (Fig.2) gives an overview of the research per year, whereas Fig.3 and Fig.4 report data on the breakdown of results by geographical context and by scope. At this stage, the contribution of PubMed was not considered, given that the generic query set on this database provided only one result irrelevant to the topic and, therefore, directly rejected.

Second level research

The second level of research generated 1788 results divided into: 777 results from PubMed, 42 results from Emerald Insight, 545 results from Scopus and 424 results from Web of Sciences.

Following the reading of the abstracts, 159 articles were selected: 56 texts from PubMed, 42 from Emerald Insight, 70 from Scopus and 27 from Web of Sciences. The final screening identified 42 articles focused on the topic (Fig. 5).

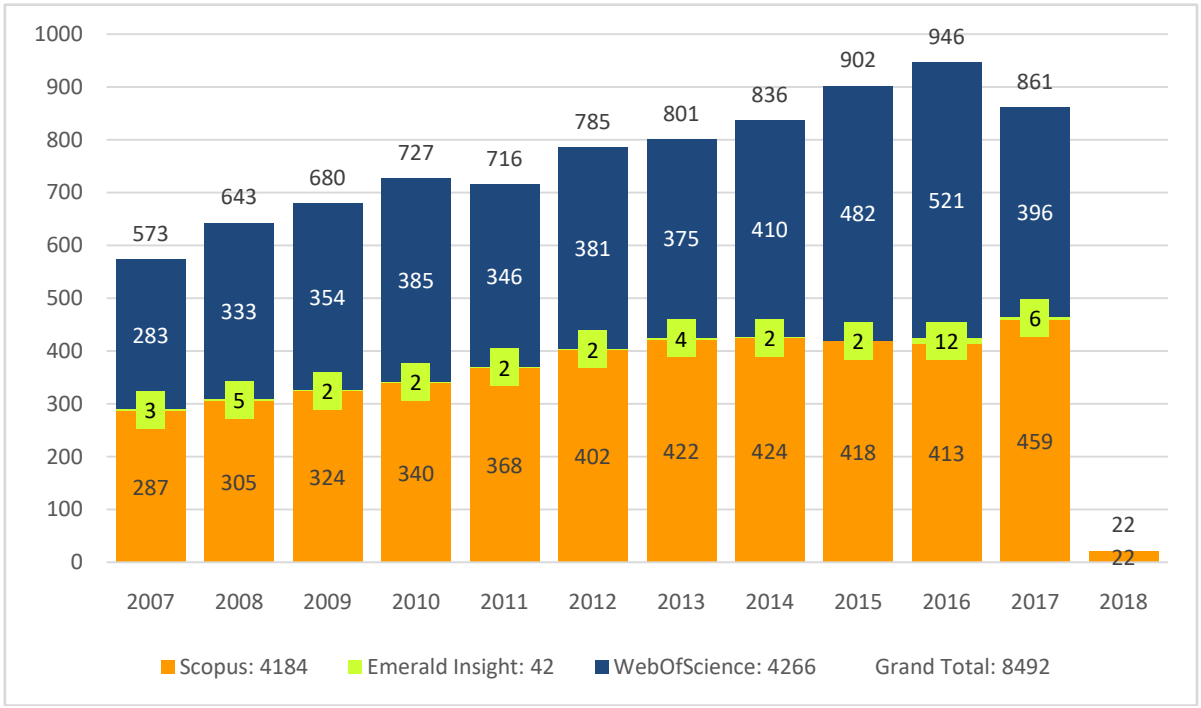

Fig.2. Time trend of scientific production in the last decade.

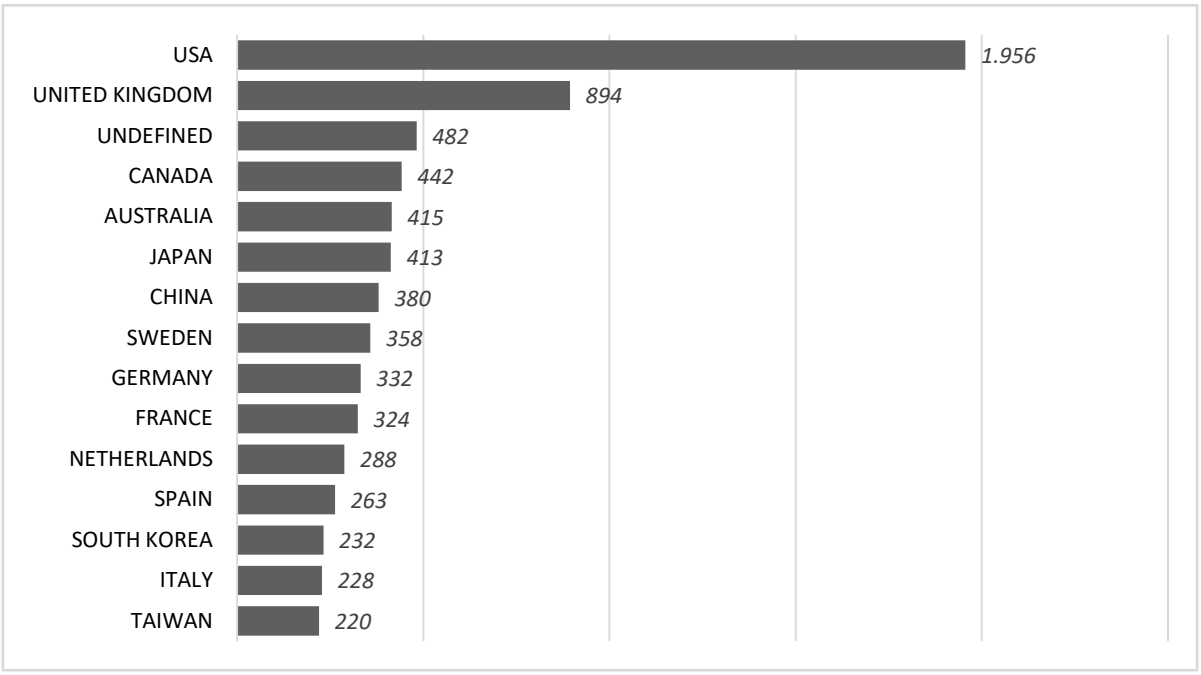

Fig.3. Ranking of the top fifteen countries.

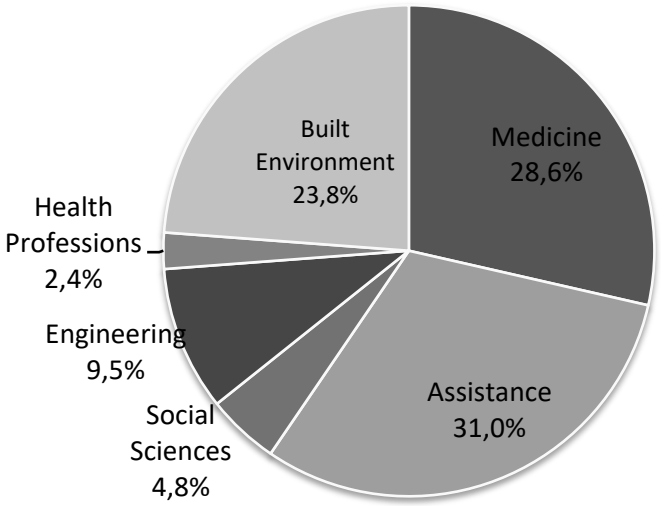

Fig.4. Distribution of results by scope.

ANALYSIS

The 42 articles analysed were grouped by subject in order to provide a clearer analysis of the results (Fig. 6).

Relationship built environment-health

Several studies show the accuracy of the ecological P-E fit model [20, 23, 24, 25, 26, 27]. Physical activity, which has a positive impact on the health of older people, is strongly influenced by the features of home environment. Accessibility is one of the main obstacles to mobility [23, 24] and it is produced not only by the number of environmental barriers, but by the functional abilities that the elderly have to overcome them [23, 24]. Starting from the results of the study conducted by Gitlin et al. [22] which identifies the kitchen and the bathroom as the environments in which most of the risks and obstacles to the daily activities are gathered, Ahrentzen and Tural [23] evaluated the impact of other environmental characteristics on the promotion or inhibition of sedentary lifestyle: inaccessibility of rooms or objects necessary for self-care tasks, clutter, lack of needed grab bars and malfunctions that compromise safety or interfere with the performance of daily activities such as plumbing problems or window failures. The spatial organization of the house is also considered to be important in conducting basic ADLs (activities of daily living) [13, 23]: big houses, long corridors and services far between each other do not promote autonomy. Kylen et al. [25] identify, instead, in the "use requires hands" and "controls in high / low / inaccessible position" the most common architectural barriers reported by a sample of 371 elderly and present in 100% of the houses surveyed. A 2016 study conducted in the United States with the support of data provided by the American Housing Survey (AHS) [19] estimated that less than 4% of the 142,665 recorded homes could be considered liveable by people with reduced mobility and only 1% is wheelchair accessible. The authors also report that newly constructed buildings do not differ in terms of accessibility from those built in the 1990s, showing the poor sensitivity of the housing

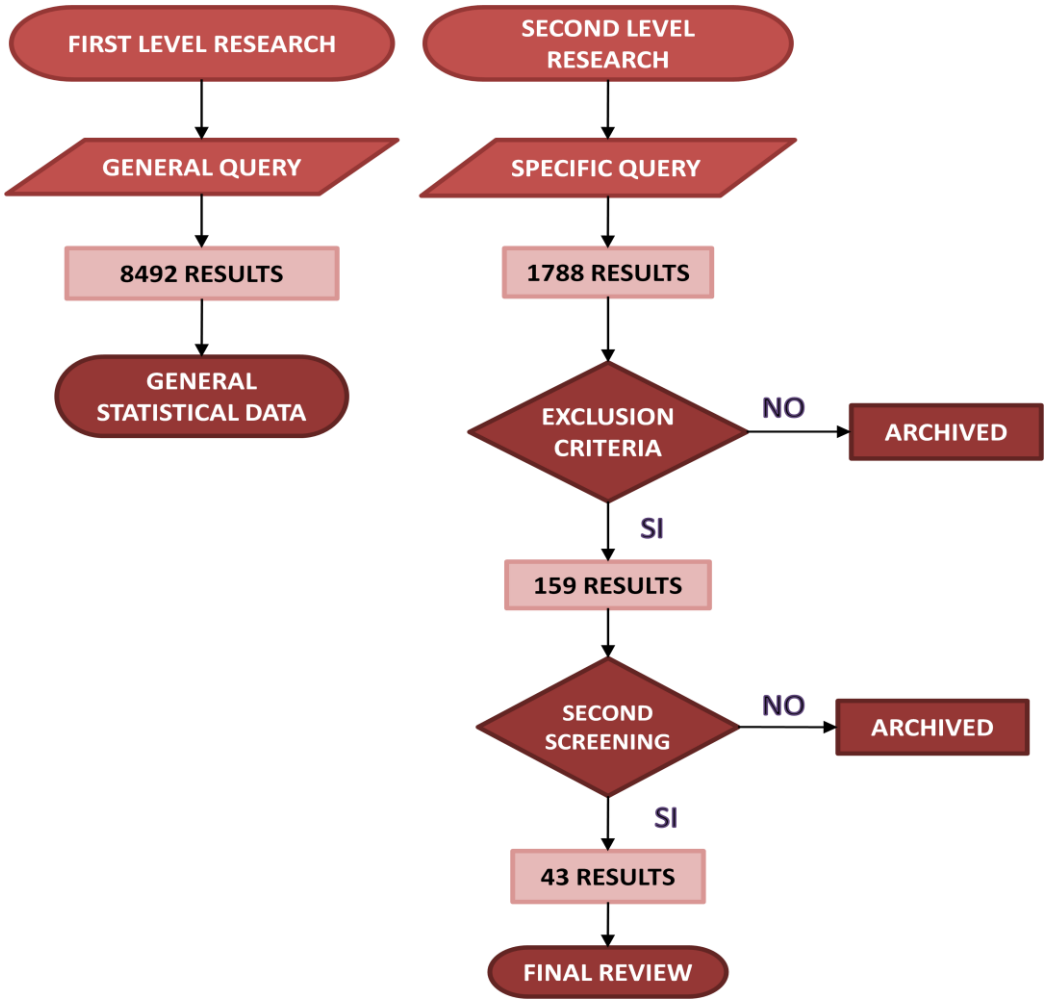

Fig. 5. Flow chart – Screening phase.

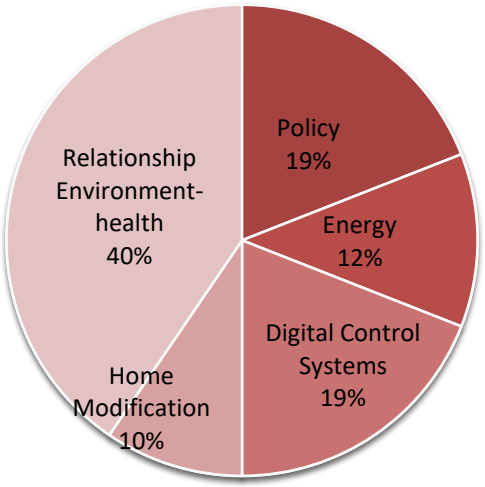

Fig.6. Second level search. Distribution of subjects.

market to the issues of aging in place. In Sweden too, an assessment of the accessibility of dwellings [20] has revealed the presence of a high number of architectural barriers; differently from the US case, however, an improvement in the usability of the recently built homes was identified, probably due to the introduction in 1999 of a disability action plan also applied to private residences [21]. According to this study the three most common barriers are: stairs, presence in the kitchen of wall cabinets and shelves placed too high and the lack of grab bars in the shower or in the bathtub.

The implications of home environment for the health of the elderly are not just those that the physical and architectural features of the home have on their lifestyle. Also the perception of the home environment is an important aspect of wellbeing influencing particular domains of health: depression, headaches, gastrointestinal pains and tension [14].

Home modifications

Modifying home environment represents a possibility to reduce the difficulties and improve the independence of the ageing population [17, 19, 28, 29, 30]. According to Meucci et al. [28] the most common home modifications are: grab bars in the shower, shower seats, raised toilet seats and grab bars near the toilet. However, the lack of preventive culture of home modification is found: the interventions are carried out when the disability has already appeared with a curative and non-preventive purpose, not fully exploiting the potential of a safer environment for all [19]. One of the obstacles to the implementation of home adaptations is the perception of them by the elderly that, in some cases, identify them as the symbol of their fragility and their physical and cognitive decay. Each intervention, to be effective from the practical and perceptive point of view, must optimize the person-environment balance "*in the direction of the person desires*" without generating unfamiliar and unreflective environments [15, 27].

The choice to modify one's own home is also influenced by socio-demographic factors and by state of health [28, 30]. Older age, more health conditions, any previous health event, poor self-rated health, greater ADL limitations are factors associated with a greater likelihood of implementing changes to the home environment. Furthermore, in a study by Kim et al. [30], it was found that people with hypertension or heart disease included in their research sample were more likely to change their living environment. The consequences of illness, such as long periods staying at home before hospitalization, the rapid advancement of functional and cognitive decline and the need for intensive care, require the improvement of the environment in order to be able to manage the symptoms [30].

The economic aspect is not fundamental in the choice of home adaptation unless the interventions that require large investments (such as the construction of ramps, elevators, the enlargement of corridors, etc.) [28]. The decision-making phase is however guided by family caregivers who share the domestic environment with the elderly and offer them assistance [30].

Energy

The energy sector is also involved in the definition of the conditions that make the environment "*affordable and appropriate*" to ageing [31] by referring to the dual layer on which one must operate: on the one hand the need to guarantee adequate temperatures for the achievement of good levels of wellbeing, on the other the need to have the least possible economical impact on the low income of the old cohort through an efficient management of resources. Poor health conditions, physical inactivity and the alteration of the thermoregulation due to the assumption of drugs may affect the perception of temperature of the elderly. Therefore the provisions to be adopted must be tailored to the ageing population and must consider the extreme weather conditions (such as heat waves). An experimental study [32] confirms that controlling internal temperatures determines, in addition to reducing energy consumption, the general improvement of perceived health by the elderly.

Digital Control Systems

"*Smart home*" is a home environment in which, thanks to technology, it is possible to monitor the activities carried out by an individual, his/her level of well-being and replace him/her in performing certain activities. The objective is the general enhancement of living conditions, the prevention of emergencies and the promotion of independence [18, 33]. The interdisciplinary areas of *gerontechnology* and *domotics* are spreading to meet the needs of an ageing population [18, 33]. About the monitoring, Smart Home and Ambient Assisted Living (SHAAL) systems use different devices, such as sensors and wearable devices, to collect data on the activities carried out by the elderly. The analysis of data collected through continuous observation in a real contest such as the domestic one, provides important input to medical research for the study of the relationships between man, environment and health. The management of monitoring systems, the simplification of data extraction processes and the study of ethical implications on the lives of the elderly are fields on which further investigation is needed [33, 34, 35].

The dissemination of technology in the independent living has several obstacles including high costs, use of settings far from reality, the central role of the market that leads the choice of systems to be produced and the use of technology-driven approach rather than the need and preferences of adults-approach [36].

Smart home technologies are not enough to support aging in place. Home environment must however be physically adapted and respond to the minimum accessibility requirements promoted, for example, by *design for all* [18].

Policy

The European Union is promoting ageing in place. The most involved countries are the UK and the Netherlands, whose policies are aimed at the implementation of housing supply for senior citizens [37]. Adapting the current housing stock is one of the strategies to promote healthy aging in the home environment [29, 38]. Establishing national funds for this cause is the crux of the matter. A British study in 2017 [29] estimated that the funds needed to cover all the adaptation measures in 2005 were about ten times greater

than the total allocation for Disabled Facilities Grants in 2013/2014. The gap has increased significantly in recent years due to more and more requests from aging population. The welfare policies should primarily be targeted at the poorest segments of society for whom the maintenance costs are a major concern [39].

The UN Committee on Economic, Social and Cultural Rights (UN-CESCR) indicates seven criteria for the definition of "adequate housing": *Security of tenure, Affordability, Habitability, Availability of services-materials-facilities and infrastructure, Accessibility, Location, Cultural Adequacy* (40). In line with these criteria, other international frameworks (MIPAA, WHO Age-Friendly Cities and SDGs) suggest a number of outcome indicators to measure housing and the living environment of the elderly [41]. In order to support national policies, it is necessary that data sets are differentiated by age of the population. This will provide accurate information on the levels of adequacy of homes for the elderly and then targeted policies can be implemented [41].

DISCUSSION

The transition of elderly care from the institutional sphere to the domestic one involves numerous research areas. The multidimensionality of the problem engages, in many ways, scientific research in the medical, welfare, social sciences, environmental sciences and engineering fields. Therefore, the design of spaces suitable for the ageing population is only one of the necessary requirements in achieving high quality lifestyle for the elderly. The Ecological Model of Ageing is the theoretical foundation of studies that investigate the relationship between environment and well-being. The evidence that health is influenced by the physical environment has the consequence that home, a place where the elderly spend most of their time and that is linked especially closed to them, is the focus of numerous studies. Aging is a dynamic process that involves both functional and perceptive aspects. Home environment must, therefore, adapt to the evolution of the process by designing flexible spaces.

Enabling ageing in one's own home means first of all making it accessible. Architectural barriers are not only a health hazard for the elderly, increasing for example the risk of falls, but also hinder the performance of the ADLs. Failing to perform daily activities involves adopting a sedentary lifestyle and reducing one's autonomy. The implications in terms of health and perception of the well-being of the elderly are strongly negative. Adapting the existing housing stock is therefore one of the main challenges to be faced. The process must be supported by appropriate government policies that ensure, especially for the poorest elderly, the allocation of funds with which supporting the costs of home modifications.

The development of domotics, gerontechnology and ICT in general, is a tool to support aging in place. Monitoring internal conditions of the homes and health of the elderly allows the activation of automatic self-regulation and emergency processes. From the studies included in this review it is clear that the smart home model alone is not enough for enable ageing in place. The technological devices are only a "qualitative regulators" of the environments that must however respond to the principles of design for all. The market, however, has not yet reached maturity to allow the massive diffusion of technology for home care.

The assessment of the quality of the houses, despite the drafting of international frameworks, is still fragmented. Including in national policies actions that support home adaptations is the

first step for the spread of the culture of aging in place. In this regard having specific quality standards to achieve, as was done for example in the field of energy, can help with standardizing the strategy of interventions and raising the levels of age-friendly city.

CONCLUSIONS

The processes of demographic transformation, which are currently beginning in our society, will result in the presence of an increasing number of ageing people. The consequences affect different areas of scientific research in different ways. In the field of built environment, the raising of the number of the elderly implies the reformulation of the design standard in terms of accessibility and usability. Home environment is the place in which most of the life of the elderly takes place. It plays a key role in the aging process because it can be configured as a family and care place at the same time. This means that home have to fit to the continuous needs of the elderly through resilient and flexible spaces. Triggering the mechanism is complex but is necessary to face the continuous challenges of this global development.

Further studies are required on the impact that ageing in place can have on rural environment. Rural areas are generally characterized by a high percentage of elderly population and are far from the services provided by cities. Adapting the house stock may be an important solution to promote healthy ageing far from health facilities .

Moreover, research is needed to set up an age-friendly home rating system that can be used as a tool to draw up future national regulations in the field of home adaptation.

LIMITATIONS

The research does not offer a complete knowledge of ageing in place, having investigated only scientific production indexed by four databases. Moreover, of the 159 selected articles, only 86 were analysed since the others were not accessible by the scientific community of the University of Naples Federico II.

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