The Transition Towards Sustainable-Smart Aging in Finnish Elderly Healthcare

Lappeenranta –Lahti University of Technology LUT

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Post-Doctoral Researcher, D.Sc. (Tech.) Miika Marttila

ABSTRACT

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Finland's ageing population increases pressure on elderly healthcare and raises environmental, social, and economic sustainability concerns. This thesis explores how Finland can transition toward sustainable-smart elderly healthcare by linking sustainability goals with smart ageing solutions. Using a backcasting approach, it develops a 2050 vision and works backwards to identify milestones and actions for 2025–2050.

The study combines a literature and policy review with survey input from older adults and healthcare professionals. The findings suggest that Finland has existing foundations for digital health and preventive care, but major system-level barriers slow progress. Key barriers relate to fragmented governance across actors, workforce shortages, unequal digital access and skills, and resource-intensive care environments. Based on the vision, the thesis proposes a transition roadmap and system-level solutions that emphasize policy coherence, cross-sector collaboration, digital inclusion, and sustainable infrastructure planning. The results support longer-term decision-making for more resilient, equitable, and resource-efficient elderly care in Finland.

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Three months before moving to Finland to begin my studies, full of hope and energy, I lost my father after watching him suffer for months from a late-diagnosed illness. The shock of his final days, together with the reality of my mother facing loneliness in her seventies, cast a shadow over my relocation to Lappeenranta.

During those difficult days, in a new city and a new life in South Karelia, I searched for a reason to stand up, move forward, and create meaning again.

For this, I would like to thank IKIGAIA and its CEO, Mikko Ruuska, for giving me “Ikigai” at a time when I was coping with the sorrow of my father’s death. I am grateful to Pasi Rantanen, the Project Manager, for brightening my days with his approach towards not just the smart aging project, but towards life, and to Tiina Ruuska, the COO, for reminding me about the full portion of the cup and helping me stay focused and positive.

My sincere thanks go to Miika Marttila for always being supportive and for helping me think about the core of the topic through his questions and advice. I also want to thank Professor Lassi Linnanen for agreeing to supervise this work.

I hope to expand this research further and do my best to bring its ideas into real practice, taking any step that could *help even one person experience less suffering during the elderly stage of life.*

ABBREVIATIONS

GDP	Gross Domestic Product
OECD	Organisation for Economic Co-operation and Development
SST	Sustainable System Transition
RQ	Research Question
SOTE	Finnish Social and Healthcare Reform (Finnish)
THL	Finnish Institute for Health and Welfare (Finnish)
EU	European Union
WHO	World Health Organization
ICT	Information and Communication Technology
PV	Photovoltaic (solar energy)

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DECLARATIONS

Turnitin

The originality of this thesis has been reviewed with the Turnitin similarity checking service.

AI usage

The author of the thesis, Paniz Sepehrian, used the following AI-tools during the preparation of the thesis:

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Responsibility

The author, Paniz Sepehrian, takes full responsibility for the content of this thesis and has reviewed and edited the content generated by the possible use of AI tools.

1 Introduction

Finland is among the fastest-aging societies in Europe. In 2023, almost one out of four Finns were elderly, aged more than 65 years old which poses increasing demands on social and healthcare systems (Statistics Finland, 2023). An increasingly aging population contributes to growing demands for long-term care and sustainability concerns, as health expenditures are estimated to increase significantly relative to gross domestic product (GDP)(OECD, 2022).

In European and Finnish ageing-related discussions, smart ageing and sustainable ageing are increasingly discussed as complementary approaches. “The Smart Ageing concept is about how digital technology, smart home and other innovative welfare solutions can help the elderly to maintain healthy and independent life” (Tavakoli et al., 2024). "Sustainable aging" instead emphasizes that the solutions adopted age-friendly are environmentally friendly, socially inclusive and economically viable (Smart Aging Project, 2025). Both of these perspectives combine to configure the sustainable-smart aging concept that fits in with Finland´s national sustainability goals and EU policy strategies (European Commission, 2020).

Although Finland has a established welfare model, the current elderly care service system is resource-consuming and institutionalized (Ministry of Social Affairs and Health, 2022). Chronic issues of workforce shortages, rising costs and environmental imperatives further challenge its sustainability. Prior literature has formed around health and smart city separately, thus there is a clear lack of integrative concept frameworks with respect of sustainability where both have been considered (Herttuainen, 2022).

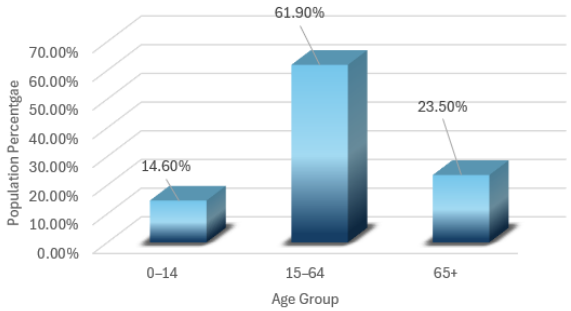

Figure 1. Share of population by age group in Finland, year 2024 (Statistics Finland, 2024)

Figure 1 shows the age structure of Finland's population in 2024. About 14.6% of people are aged 0–14 years, 61.9% are 15–64 years, and 23.5% are 65 years or older. This means that almost one in four residents is already in the oldest age group, which increases the pressure on elderly care and long-term planning.

Elderly care in Finland is now changing. Choices made in the next years will shape services for a long time. If sustainability and smart ageing are not planned together, changes may stay short term and fragmented. This study gives knowledge to support better long-term choices for elderly healthcare.

1.1 Research objectives and research questions

Earlier research also shows that digital change alone is not enough in elderly care, as systems need wider support to achieve real impact (Halmosi & Aranyossy, 2024). Sustainability in healthcare is also still developing, and many models do not yet include full environmental, social and economic measures (Thakur, 2020). Because of this gap, it is important to study how sustainability and smart ageing can work together in Finland. The research questions in this thesis follow this need and link to the background challenges: the current situation, the need for a clear future vision, and the need for steps that support long-term change.

The overall aim of this thesis is to explore how Finland can transition towards a sustainable-smart elderly healthcare system. The study is aimed at imagining what such a system could be in the future, understanding the obstacles to progress that exist today and recommending pathways forward.

To fulfil this purpose, the study initially examines the main concepts of sustainability and smart aging to build a theoretical framework. Moreover, it analyses the current situation of elderly care in Finland highlighting its successes as well as the challenges for future sustainability. Based on this foundation, the research subsequently constructs a view about what sustainable-smart elder healthcare for the future should resemble, serving as a backdrop and benchmark for long-term planning. The research also analyzes the existing gaps between the current system and the future vision, and barriers that hinder the realization of this vision, and finally, it explores possible strategies and pathways that could enable the transition.

Accordingly, the research is guided by the following questions:

RQ1. What is the current situation of healthcare for the elderly in Finland, and what sustainability issues does it encounter?

RQ2. How would a sustainable and smart elderly healthcare system in Finland look like in 2050?

RQ3. Which methods and pathways are necessary to facilitate the transition?

1.2 Scope and delimitations

These research questions were chosen as the scope because they address the key needs in the Finnish system: understanding the current challenges, forming a future vision and identifying the steps needed for transition.

The focus is on the Finnish context, specifically elderly healthcare, and is structured around the three principles of sustainability. The study does not go into detail about clinical or medical aspects; instead, it focuses on changes at the institutional, policy, and service levels. The time frame goes up to 2050, which is in line with the EU Comision's long-term planning horizon (European Commission, 2021).

This thesis is conducted in connection with the Smart Aging Interreg BSR project. Only publicly available project information, such as official summaries, and published frameworks have been used. Internal work package documents are not publicly accessible and are therefore not cited.

1.3 Structure of the thesis

This thesis has eight chapters:

Chapter 1 introduces the topic, the problem background, and the motivation. It presents the aim of the study, the research questions, and the need to view elderly healthcare through sustainability and smart aging perspectives.

Chapter 2 provides the literature review. It includes research on sustainability, smart aging, and Finnish elderly care. It presents the key theories used in the thesis, such as the three pillars of sustainability and PESTEL. This chapter builds the theoretical base for the baseline, the vision, and the transition analysis.

Chapter 3 explains the research methodology. It describes why the study uses the backcasting approach and how it fits the aim of building a sustainable future image and working backward to identify barriers and solutions. It also describes the data sources, including literature, surveys, and the barrier–enabler matrix.

Chapter 4 answers Research Question 1. It presents the baseline of elderly healthcare in Finland and identifies the current sustainability challenges. The analysis is guided by the theoretical frame and structured through PESTEL and the system-level barrier–enabler matrix.

Chapter 5 answers Research Question 2. It presents the 2050 vision for sustainable-smart elderly healthcare in Finland. The vision combines sustainability theory, smart aging concepts, and insights from the baseline analysis. It explains what a desired and human-centred elderly care system could look like.

Chapter 6 answers Research Question 3. It develops transition pathways from the baseline to the vision using the backcasting model. It identifies the system-level obstacles, key actors, and solutions needed for long-term change.

Chapter 7 brings the results together. It integrates the findings across the three research questions and discusses how the results relate to earlier studies and to the theoretical framework.

Chapter 8 presents the conclusion. It summarises the main findings, highlights the academic and practical contributions, and proposes recommendations and future research directions.

2 Literature Review

This chapter presents a review of the literature that is related to the objective of this thesis. It is structured in three parts. The first part addresses sustainability in health care and aging

emphasizing environmental, social, and economic challenges. The second part explains central aspects of smart ageing and smart ageing technologies, including living in smart homes, using products for preventive digital health application. The third section outlines the elderly health care context in Finland, covering system organisation and delimitations, demographic challenges and policy regimes at national and EU level. This section also contains part of the answer to the first research question by describing some of the features and pressures that influence the current baseline.

2.1 Sustainability in healthcare and aging

The concept of sustainability is based on satisfying human needs today without compromising those of tomorrow (UN, 1987). This concept emphasizes that there are natural boundaries that must be respected if the planet is to remain stable and liveable (European Commission, 2020). In the context of health and ageing, sustainability refers to systems ensuring that resources are used appropriately and with a view to long-term well-being and equity (WHO, 2019). These demands are amplified by demographic ageing as older people tend to make more use of healthcare services, placing a strain on resources and service delivery capacities (OECD, 2023; Moisson et al., 2008). At the same time, ageing presents opportunities for new policy models and preventive strategies that can render systems more resilient (WHO, 2019; OECD, 2023).

Sustainability in healthcare is increasingly framed around the triple bottom line: environmental, social, and economic pillars (Slaper & Hall, 2011). Since the population aging is being studied , terms and aspects such as resource usage , equality , and the system's capability of survival over time should be considered .Elderlies use healthcare service more often, meaning that the changes in demographics make sustainability challenges more intense, but they also create chances for new ideas in care models and policy design (OECD, 2023; WHO, 2019).

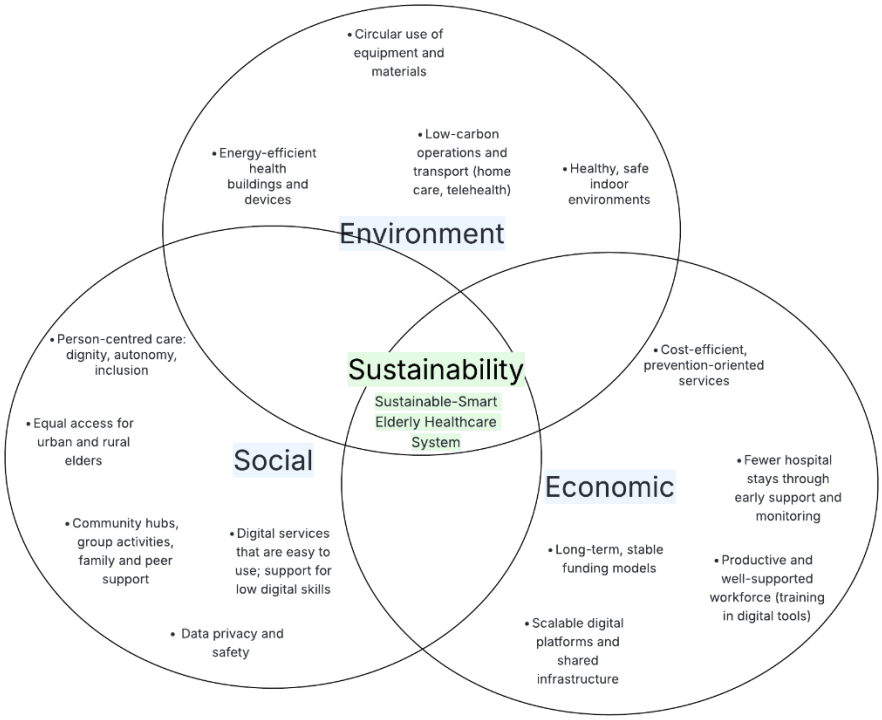

Figure 2. Conceptual framework of the three sustainability pillars for sustainable elderly healthcare.

2.1.1 Environmental sustainability

Environmental sustainability refers to the use of resources in such a way that ecosystems are neither damaged, nor threatened for future generations to meet their needs (European Commission, 2020). This involves a reduction in emissions as well as the environmental footprint of human activities including energy and material usage (Lenzen et al., 2020). Non-sustainable consumption patterns produce long-term ecological tensions that may directly challenge the stability of the planet (Eckelman & Sherman, 2016). In environmental sustainability there is a need to manage wastes and pollutions in such a way that irreversible harm to the environment may not occur (Thakur, 2020). The literature is clear that in planning and decision-making processes, it is imperative for ecological considerations to be incorporated from the beginning or there could well be a loss of environmental quality (Pillemer et al., 2010). Overall, environmental sustainability is about safeguarding ecosystems, preserving resources and avoiding long-term damage to the environment (European Commission, 2020).

Healthcare systems serve a significant role in greenhouse gas emissions and environmental impacts due to their energy use, medical waste, and resource-heavy facilities (Eckelman & Sherman, 2016; Lenzen et al., 2020). The environmental impact is especially significant in long-term care facilities for the elderly, as they typically need a lot of heating, lighting, and medication. Researchers emphasize the critical importance of integrating sustainability into policies and practices related to aging. Pillemer et al. (2010) proposed a research agenda linking aging societies with environmental sustainability, arguing that ecological concerns must be incorporated into health and housing policy for older people. The consumption of energy and indoor the environment in the Nordic region have been vital for health outcomes. Therefore, the sustainable design of housing as well as expanding indoor environmental quality are vital strategies (European Commission, 2020).

2.1.2 Social sustainability

Social sustainability focuses on fairness, inclusion, and long-term wellbeing in society (Komp-Leukkunen & Sarasma, 2024). It requires creating conditions where people can live safe, meaningful, and connected lives across all ages (Douglas et al., 2017). Research shows that respecting autonomy and recognising diverse needs are central to supporting people's dignity and everyday functioning (Komp-Leukkunen & Sarasma, 2024). Strong social networks and supportive communities also improve mental and physical health outcomes, especially for older adults (Douglas et al., 2017). Policies such as ageing-in-place emphasise independence, community participation, and equal access to services, which are key elements of socially sustainable systems (Ministry of Social Affairs and Health, 2020).

For older adults, it is important to ensure that they have secure and easily available housing, help prevent a sense of isolation, and encourage their participation in community activities. Komp-Leukkunen and Sarasma (2024) highlight that social sustainability as we age requires recognizing the diverse needs of older adults and ensuring that care systems support autonomy and dignity rather than fostering dependency. Research shows that being socially active can lead to improved physical and mental wellness for older people (Douglas et al., 2017). In Finland there is an emphasis on "ageing in place", that indicating cultural preference or social development strategy where older people can participate actively and

benefit from the society even when they become old (Ministry of Social Affairs and Health, 2020).

2.1.3 Economic sustainability

Economic sustainability means using financial resources in a way that meets current needs without creating burdens for future generations (European Commission, 2020). It needs constant variety and balanced resources to enable long-term performance of the system (Lenzen et al., 2020). Gusmano and Okma, (2018) also suggests that societies do not necessarily suffer an economic collapse because of ageing populations, rather it depends on how care is organised, costs are managed and responsibilities distributed. Preventive measures and healthier lifestyles can delay disability and reduce long-term expenditure, which strengthens economic sustainability (Mehta & Myrskylä, 2017). Scholars also note that economic sustainability depends on reducing inequalities in work and caregiving, since unequal burdens increase pressure on households and public finances (Di Novi & Santos, 2023). Altogether, economic sustainability focuses on long-term stability, fair cost distribution, and efficient use of resources to support future wellbeing (European Commission, 2020).

Economic sustainability of assisted living is a concern, especially in the welfare states where costs are growing and work forces are shrinking. This is central to the economic arm of the sustainability argument in senior healthcare. We tend to view aging populations as just an added expense, but the research indicates that is too simple. Gusmano and Okma (2018) have stated that it is fallacious to claim that welfare systems are “bankrupting” due to ageing, which could start to bring about generational conflicts. The reality is that we have to transform quite many things, such as unifying health-care finance, working a lot more on the labour market or changing pensions in a more progressive way. At the same time, the prevalence of chronic illness and long-term medication use creates substantial cost pressures for both families and governments (Di Novi & Santos, 2023). Preventive approaches that delay aging or any disability within aging, such as healthy lifestyle promotion and digital monitoring, are increasingly recognized as essential to reducing future expenditure (Mehta & Myrskylä, 2017). This could prevent the aging crisis , rather than managing it when it already has happened.

2.2 Smart aging: concepts, technologies, and practices

Sustainable-smart aging is all about merging new technology with sustainability ideas. It promotes the use of digital health innovation, smart homes and care technologies to help people live independently and well, in an environmentally friendly and economically responsible way. Unlike technology-driven approaches alone, sustainable-smart aging considers the ecological footprint of technologies, their social acceptability, and long-term viability within welfare systems (WHO, 2019; Siu & Leff, 2024).

2.2.1 Smart homes and welfare technologies

Smart homes and health technologies are increasingly important for allowing older people to remain safe within their homes as they grow older. Things like smart sensors, wearables and other communication technology are useful because they can sense whether one have had a fall, monitored health statuses and even automated house tasks. This reduces risks and makes things easier for caregivers. Research shows that wearable technologies assist in health monitoring and contribute to older adults' sense of a sense of belonging becoming independent, and interactions with others (Morozova & Gurova, 2021). Similarly, detection of falls technologies in intelligent belonging models demonstrate why community-based information and communication technologies can improve safety and quality of life for older adults (Meng et al., 2023). Researchers emphasize that for such innovations to develop, it is crucial to prioritize equality and sustainability from the beginning, ensuring that older individuals from various income levels and regions can access those (Siu & Leff, 2024). Usage of antimicrobial and recyclable materials can simultaneously improve health outcomes (Smart aging, 2025).

2.2.2 Preventive care and digital health solutions

Preventive healthcare is an essential strategy for ageing populations. Digital services such as telemedicine, mobile health applications, and electronic self-measuring devices support the early detection of chronic diseases, reducing hospital stays, and personalizing individual treatments (Konttila et al., 2019).Research indicates that maintaining healthy habits, such as

a balanced diet, regular exercise, and limited alcohol intake, is linked to a longer period of living without disabilities (Mehta & Myrskylä, 2017; Strandberg et al., 2012). Integrated care models seem to have potential. Systematic reviews suggest that as treatment of difficult elderly individuals is coordinated between primary and secondary products and services, there are reductions in hospital admissions and costs, along with improvements in sustainability (Marino et al., 2014). The COVID-19 pandemic really showed us the ups and downs of digital health. Telemedicine, on the one hand, facilitated access to care while older age groups less familiar with technology were excluded (Di Novi & Santos, 2023). This highlights the necessity for proactive models which are both technologically integrating and socially-just.

2.3 The Finnish elderly healthcare context

Finland is known for its universal and tax-funded healthcare system, which aims to secure equal access to services for all residents (Ministry of Social Affairs and Health, 2020). The system provides both healthcare and social care, and elderly services are structured around the principle of supporting functional ability and well-being in daily life (Ministry of Social Affairs and Health, 2022). The 2023 SOTE reform reorganised service responsibility from municipalities to 21 wellbeing services counties, marking one of the largest administrative changes in Finnish social and healthcare history (Ministry of Social Affairs and Health, 2023). This reform aims to improve coordination, reduce fragmentation, and strengthen service quality, although several structural gaps remain (Kangas & Nikander, 2023).

Finland's elderly population is growing rapidly, and in 2023 more than 25% of the population was aged 65 or older (Statistics Finland, 2023). By 2050, this share is expected to increase further, intensifying demand for long-term care, home care, and healthcare services (WHO, 2024). At the same time, the working-age population is shrinking, creating shortages in healthcare workers and limiting the system's capacity to meet rising needs (OECD, 2023). Older adults also experience higher rates of multimorbidity, cognitive decline, and chronic illness, which increase the complexity of care (Strandberg et al., 2012). These demographic developments create significant sustainability pressures on the Finnish welfare model.

2.3.1 Current healthcare system for seniors in Finland

Elderly services in Finland are organised into three main levels. The first level consists of home care, rehabilitation, day activities, and assistive technologies designed to maintain independence at home (Ministry of Social Affairs and Health, 2023). The second level, service housing (palveluasuminen), provides independent living with continuous support, often combining private rooms with shared spaces and staff presence (THL, 2023). The third level is 24-hour institutional care for individuals with severe illness, dementia, or significantly reduced functional capacity who require round-the-clock assistance (THL, 2023). These services aim to promote ageing in place, which is a central policy principle and a cultural preference in Finland (Ministry of Social Affairs and Health, 2020).

Digitalisation has advanced notably through the national Kanta Services (Kanta Services, 2025), which include electronic prescriptions and health records, but full interoperability across wellbeing counties is still developing (OECD, 2023). Private care providers, such as Attendo, Mehiläinen, and Esperi Care, play an increasingly significant role in elderly services, bringing flexibility but also raising concerns about equality, transparency, and service quality (Valvira, 2024). The coexistence of public and private actors requires strong regulation to secure fair access to services for all population groups (Ministry of Social Affairs and Health, 2022).

2.3.2 Demographic and social sustainability challenges

Finland's ageing process is among the fastest in Europe, and this trend places pressure on financing, organisation, and workforce availability (OECD, 2023). Workforce shortages are particularly severe in-home care and long-term care, especially in rural regions (OECD, 2023). The growing diversity of the elderly population adds new needs to the system; for example, older migrants show different mortality patterns and may require culturally adapted services (Kemppainen et al., 2024). Research also shows participation bias in national surveys, meaning that vulnerable elderly groups, such as those with poor health or limited social networks, are underrepresented and potentially underserved (Nummela et al., 2011). Social sustainability challenges include loneliness, which affects up to one in five older adults and harms both mental and physical health (THL, 2023).

2.3.3 Policy frameworks and strategies (national/EU level)

Finland's national policies guide elderly care development through frameworks such as the Quality Recommendations for Older People Services 2020–2023, which highlight ageing in place, preventive services, and integrated care (Ministry of Social Affairs and Health, 2020). The National Programme on Ageing 2030 promotes digitalisation, accessible environments, and active ageing as long-term priorities (Ministry of Social Affairs and Health, 2021). Regulatory guidelines from THL and Valvira define staffing requirements, care quality criteria, and safety standards (Ministry of Social Affairs and Health, 2022).

At the European level, the European Green Deal frames ageing as a societal challenge that must be addressed through sustainable development, low-carbon systems, and resilience-building (European Commission, 2020). The WHO Decade of Healthy Ageing 2021–2030 emphasises autonomy, community participation, and age-friendly environments (WHO, 2019). These frameworks influence national development by shaping funding priorities, digital transformation, and sustainability-oriented reforms.

Despite strong welfare structures, Finland faces regional inequalities in service availability and quality due to variations in funding, staff, and infrastructure across counties (Ministry of Social Affairs and Health, 2022). Municipalities also have different capacities to support ageing in place, even though it remains a stated national goal (Ministry of Social Affairs and Health, 2020). These variations highlight that governance improvements are just as important as technological or medical innovations when addressing sustainability challenges.

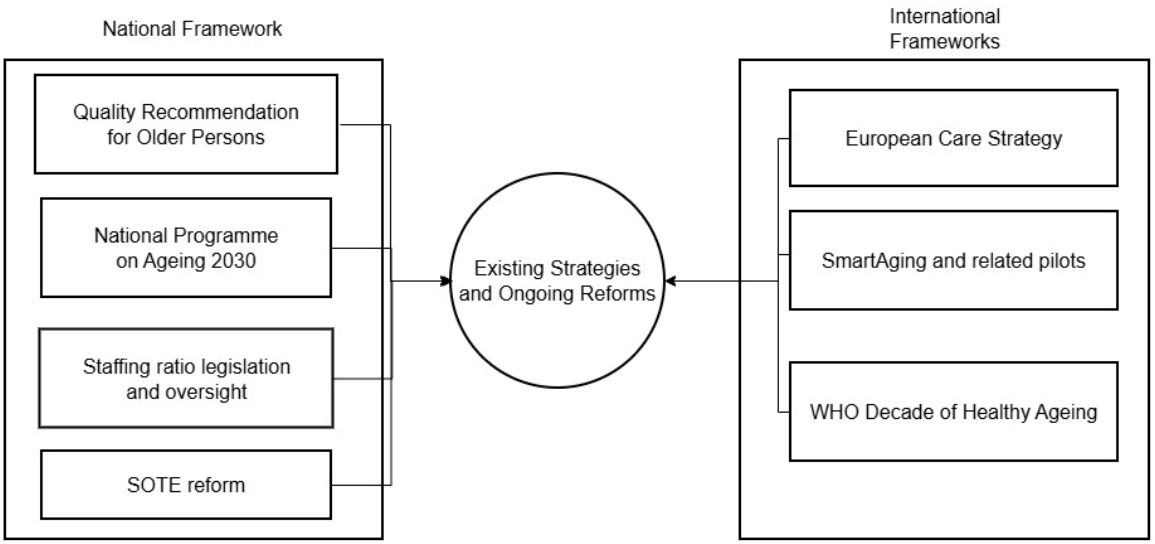

Figure 3. National and international frameworks influencing elderly healthcare in Finland.

Figure 3 is a conceptual overview of key national and international strategies shaping Finland's elderly care system. The national side includes the Quality Recommendation for Older Persons, the National Programme on Ageing 2030, staffing ratio legislation, and the SOTE reform. The international side includes the European Care Strategy, Smart Aging pilots, and the WHO Decade of Healthy Ageing.

3 Research Methodology

Backcasting is applied as the main methodology in this thesis. This methodology is future oriented approach, starting from long-term goal setting and then moving backwards to create understanding about the changes needed for reaching the fixed goals and the desired, visualized state. Backcasting differs from forecasting where past trends are simply extrapolated into the future, it is used when incremental change in the present system is not considered sufficient to realize a desired future (Robinson, 1990; Dreborg, 1996).

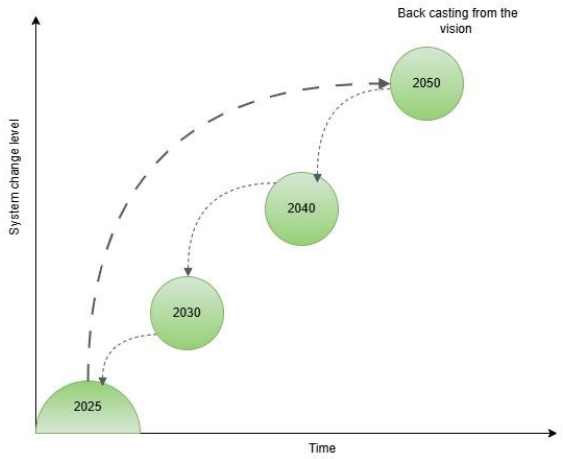

Figure 4. Backcasting roadmap from a 2050 vision to the present.

Figure 4 demonstrates the backcasting logic used in this thesis. The starting point is the desired vision for elderly healthcare in 2050. From that vision, the pathway is traced backwards to identify key milestones for 2040 and 2030, and the actions needed already in 2025. The upward direction indicates that deeper system change is required over time to reach the 2050 state.

In practice, the approach starts with conceiving of a vision that represents what we want to achieve in terms of sustainability and well-being rather than what is limited today. The present system is then analysed in terms of its principal structures, pressures and barriers. Contrasting the now with the vision of a desirable future brings to light where the two differ and shows which barriers, lock-ins and enabling conditions structure this system (Quist & Vergragt 2006). The logic finally flows in the reverse direction of the vision toward the present and tracks what changes, in terms of policies, organisational structures or technologies or behaviours or governance would be needed to bring the system towards the vision. This reasoning corresponds with the transition approaches that are taught in LUT courses; the backcasting tool is seen as a mechanism linked to socio-technical transitions and systemic pathways (Härri, 2025).

The data collected to support backcasting process is mentioned in section 3.1. Several data sources were considered for data collection and analysis to make sure that the results and transition pathways are based on solid evidence rather than assumption.

3.1 Research design

This research design integrates the Backcasting approach and multi-sourced data to enable grounding of the future vision and transition pathways on empirically based servicing knowledge and actual system state. Three different types of data were used to develop a reliable evidence base.

First, a review of the literature was carried out using Finnish and EU policy documents as well as demographic and economic data (Statistics Finland, 2023; OECD, 2022) and Smart Aging project deliverables. These inputs included validated population projections, sustainability goals and design guidelines for ageing and elderly care transitions.

Work package descriptions and internal project materials of the Smart Aging Interreg BSR project were used only as background understanding. These documents are not publicly available; therefore, no internal content is cited directly in this thesis. Only publicly accessible sources have been referenced, in line with LUT University's academic requirements.

Second, two studies were conducted for the collection of user feedback such as elderly (n=7) and healthcare professionals (n=5). Respondents emphasized the importance of nature, autonomy, safety and social engagement and noted multiple tensions including time scarcity, infection control pressure, staff shortage, financial constraints search for synergies in practice project and accident-prone environment such as bathrooms. These views provided an important experiential basis to the research and served to ground Backcasting in practical requirements and expectations from users and professional experts.

Third, co-design workshops were carried out in the Kokeilimo and Peliselli Smart Aging pilot labs. These workshops facilitated the prototyping of early demonstrators and eco-budgeted solutions, focusing on inclusiveness, sensory well-being and sustainable material selection. They functioned as a co-design space that supported the survey's findings and facilitated communication of stakeholder requirements to the visioning phase.

By combining these three sources, the descriptive and contextual basis for Backcasting analysis was rich resulting in paths and recommendations that are both evidence-based and correspond to stakeholder realities.

3.2 Method used to analyse data.

Once the data was collected through methods & sources explained in research design section, the focus is shifted on how current elderly care system works, and how it could move towards an ideal state through backcasting method. The first step is to study the materials through a PESTEL lens, defining the political, economic, societal, technological, environmental and legal conditions framing the system. This approach is based on the transition-driver logic. This step contributed to explaining the context of demographic ageing, labour supply challenges, digitalisation, environmental needs and regulatory limitations, which in socio-technical transition theory are seen as macro-level landscape pressures.

Consistent with previous studies in the fields of sustainability and health-systems research, barriers stopping transition and enablers providing opportunities (Thakur, 2021; Halmosi & Aranyossy, 2024) were identified as a step. This barrier–enabler reading also reflects a systems-thinking view, where interactions between different areas and working systematically across them are treated as important analytical factors. Hence, it is interpreted how political signals, economic constraints, and social acceptance come together to drive technological change and show that drivers like these also influenced potential for the success environmental or digital solutions.

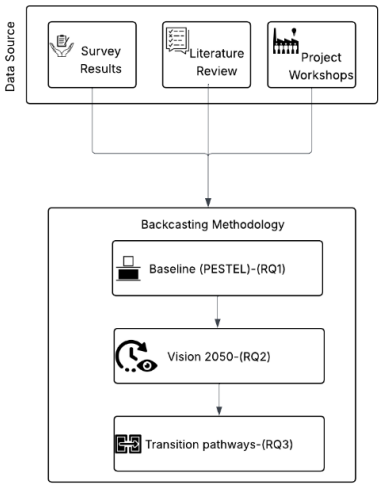

Figure 5. Thesis methodology based on the backcasting approach, showing how collected data informs the baseline analysis (PESTEL), the 2050 vision, and the creation of transition pathways.

4 Sustainability Challenges in Current Elderly Healthcare in Finland

This chapter presents the analytical findings of the study using the PESTEL framework. The descriptive baseline of the Finnish elderly healthcare system was established in Chapter 2 through published literature, national statistics, and policy documents. Here, the focus shifts to a deeper analysis of the systemic pressures shaping elderly care in Finland. The PESTEL framework is used to examine the political, economic, social, technological, environmental, and legal conditions that influence the system's sustainability.

Each subsection identifies the key drivers and constraints in its respective dimension, supported by published sources and empirical insights from the Smart Aging Survey (2025). The results capture underlying structural tensions, areas of misalignment, and the root causes of sustainability challenges. The chapter concludes with a barrier–enabler table that synthesises the findings across all PESTEL dimensions. This analytical overview forms the foundation for the transition pathways discussed later in the thesis.

In this section, the PESTEL framework was used to map the main political, economic, social, technological, environmental and legal factors that affect elderly care in Finland. It helps show how different pressures overlap and influence each other (OECD, 2023; WHO, 2019). The analysis uses national reports, research, and the Smart Aging Survey (2025). The results describe the current state of the system and highlight key pressures that form the baseline for later backcasting.

- **Political Factors**

The 2023 SOTE reform moved service responsibility from municipalities to 21 well-being services counties (Ministry of Social Affairs and Health, 2023). Fragmentation remains because counties run services, but municipalities still manage housing and the built environment (Kangas and Nikander, 2023; Ministry of Social Affairs and Health, 2022). This creates gaps in planning and slows coordination. Regions differ in budget and workforce levels, leading to uneven access to services (OECD, 2023). The staff surveyed said that tight budgets and staffing rules limit the time they can spend with older adults (Smart Aging Survey, 2025). Some units cannot meet the legal staffing ratio (Valvira, 2024).

Ageing in place is a national goal under Act 980/2012, but it requires strong cooperation between counties and municipalities (Ministry of Social Affairs and Health, 2020). Survey responses show weak cross-sector communication and delays in decision-making (smart Aging Survey, 2025). Prevention is also a political aim, yet spending still focuses on institutional care (OECD, 2023). The workforce shortage is severe, and solutions require political work in education, migration and working conditions (OECD, 2023). EU frameworks encourage digitalization and sustainable care models, but counties often lack the resources to meet these expectations (European Commission, 2020; Smart Aging Survey, 2025).

- **Economic Factors**

Finland is ageing fast while the working-age population shrinks. Health spending grows faster than GDP and many counties run deficits (OECD, 2023; Ministry of Social Affairs and Health, 2022). More older adults need long-term care and support for chronic diseases, which increases demand and costs (WHO, 2019; Strandberg et al., 2012). Survey staff reported that limited budgets reduce space, activities and staff availability (Smart Aging Survey, 2025).

Workforce shortages increase wage costs, recruitment expenses and agency fees (OECD, 2023). Staff in the survey described burnout and turnover due to high workloads (Smart Aging Survey, 2025). Many care buildings are old and need energy upgrades and accessibility improvements, but counties lack capital for renovations (Ministry of Social Affairs and Health, 2020). Staff reported safety and ergonomics problems in cramped bathrooms and narrow corridors (THL, 2023; Smart Aging Survey, 2025).

Digitalization adds extra costs for systems, licenses, training and maintenance (OECD, 2023). Survey staff said many promising digital tools remain in pilot use because counties cannot afford full-scale adoption (Smart Aging Survey, 2025). Weak finances reduce preventive and community services, leading to more demand for institutional care (WHO, 2019). Private providers add capacity but may increase long-term costs and widen regional differences (Valvira, 2024; Ministry of Social Affairs and Health, 2022). Research shows that prevention reduces long-term costs, but preventive programs are often cut first (Mehta and Myrskylä, 2017; OECD, 2023).

- **Social Factors**

Finland is one of the fastest-ageing countries in Europe (Statistics Finland, 2023). Older adults often experience chronic illness, cognitive decline and disability (WHO, 2019). Loneliness is common and harms well-being; national data show that up to one in five older adults feel lonely (THL, 2023). The elderly surveyed wanted calm spaces, meaningful activities and access to nature (Smart Aging Survey, 2025).

The older population is more diverse than before. Older migrants have different health patterns and service needs, and language can be a barrier (Kemppainen et al., 2024; WHO, 2019). Staff noted communication challenges that can interrupt care continuity (Smart Aging Survey, 2025). Some vulnerable groups are underrepresented in national surveys, so their needs may be missed (Nummela et al., 2011). Staff reported that some older adults fall through gaps when they lack social networks (Smart Aging Survey, 2025).

Built environments strongly affect social participation. Safe, accessible and homelike spaces support well-being (THL, 2023). Older adults asked for better lighting, quiet areas and outdoor access. Staff said cramped bathrooms and narrow corridors reduce chances for interaction (Smart Aging Survey, 2025). Family roles are changing due to smaller family size and higher mobility, reducing informal care and increasing pressure on formal services (OECD, 2023; WHO, 2019).

Digitalization also creates social differences. Many older adults prefer simple, familiar tools and lack digital confidence (Smart Aging Survey, 2025). Trust affects use of services. The elderly surveyed noticed differences in service quality between regions and linked this to fairness and equity concerns (WHO, 2019; Smart Aging Survey, 2025).

- **Technological Factors**

Finland has strong digital health strategies, but implementation differs widely across counties (Ministry of Social Affairs and Health, 2022; OECD, 2023). Digital exclusion remains because many older adults do not have digital skills or confidence (Vuori and Kallio, 2023; WHO, 2019). Survey participants often found smart devices difficult or unfamiliar (Smart Aging Survey, 2025).

Interoperability is incomplete. The national Kanta system supports records, but local systems vary and create extra administrative work (OECD, 2023) (Kanta Services, 2025). Staff said

switching between systems reduces direct care time (Smart Aging Survey, 2025). Training for new digital tools is limited, and many staff do not feel fully supported (OECD, 2023; Smart Aging Survey, 2025).

Counties face funding limits for licenses, hardware, training and maintenance (Ministry of Social Affairs and Health, 2022). Many digital tools stay at pilot stage due to lack of funds for full adoption (OECD, 2023; Smart Aging Survey, 2025). Older buildings do not support many assistive technologies, especially in bathrooms and corridors (THL, 2023; Smart Aging Survey, 2025).

Older adults prefer simple solutions and often fear that technology will replace human contact (Smart Aging Survey, 2025; WHO, 2019). Privacy concerns also reduce the willingness to use digital tools (Vuori and Kallio, 2023; Smart Aging Survey, 2025). Poor integration increases administrative burden, while good integration can support care coordination (OECD, 2023).

- **Environmental Factors**

Older adults spend most of their time indoors, so indoor environmental quality is important for their health and comfort (THL, 2023; WHO, 2019). Surveyed older adults wanted calm, homelike environments and access to nature (Smart Aging Survey, 2025). Air quality varies between buildings, and older facilities often lack modern ventilation (Ministry of Social Affairs and Health, 2022). Staff reported stale air, humidity problems and temperature changes that affect comfort (Smart Aging Survey, 2025).

Lighting strongly affects safety. Poor lighting increases the risk of falls and weakens orientation, especially for people with cognitive decline (WHO, 2019). Survey participants wanted warm and even lighting in corridors and bathrooms (Smart Aging Survey, 2025). Noise also affects well-being. Many facilities have hard surfaces that increase noise levels (THL, 2023; Ministry of Social Affairs and Health, 2022).

Bathrooms and corridors are the highest-risk areas because they often have cramped layouts, slippery floors and poor lighting (Smart Aging Survey, 2025; Ministry of Social Affairs and Health, 2020). Outdoor access supports mood and physical activity, but many facilities have limited or hard-to-reach outdoor spaces (WHO, 2019; THL, 2023). Staff said limited staffing makes it difficult to accompany residents outdoors (Smart Aging Survey, 2025).

Environmental sustainability also shapes care buildings. The European Green Deal promotes low-carbon and energy-efficient public buildings, but counties often lack funds for renovation (European Commission, 2020; Ministry of Social Affairs and Health, 2022). Finland's cold climate puts extra pressure on heating systems, especially in older buildings (Ministry of Social Affairs and Health, 2022). Poor environmental conditions increase staff strain and injury risk (WHO, 2019; Smart Aging Survey, 2025).

- **Legal Factors**

Elderly care is highly regulated. The Act 980/2012 defines rights to autonomy, safety and functional capacity and promotes prevention and ageing in place (Ministry of Social Affairs and Health, 2020; WHO, 2019). Minimum staffing ratios are required for 24-hour care, but many units cannot meet them due to workforce shortages (Valvira, 2024; OECD, 2023). Surveyed staff reported high workload and less time for person-centered care (Smart Aging Survey, 2025).

THL and Valvira set detailed rules for medication management, infection control, safety and documentation (Ministry of Social Affairs and Health, 2022). Staff said these duties take time away from direct care (Smart Aging Survey, 2025; WHO, 2019). Digital laws require strong data protection and cyber-security, which increases administrative tasks (Ministry of Social Affairs and Health, 2022). Older adults expressed privacy concerns, which reduce willingness to use digital tools (Vuori and Kallio, 2023; Smart Aging Survey, 2025).

Public procurement laws ensure fairness but slow down innovation. Staff reported delays in purchasing safer materials and sensor systems because processes require many approvals (Ministry of Social Affairs and Health, 2022; OECD, 2023; Smart Aging Survey, 2025). After the SOTE reform, counties handle services while municipalities manage buildings, creating uncertainty about responsibilities for accessibility and safety work (Kangas and Nikander, 2023; WHO, 2019). Law requires equal access, but regional differences remain (Ministry of Social Affairs and Health, 2020; OECD, 2023). Older adults reported unequal access to outdoor areas, rehabilitation and staff time in different counties (Smart Aging Survey, 2025).

The PESTEL results show the main pressures that shape elderly care in Finland today. These findings help identify the key barriers in the system and the conditions that can support

change. Based on the PESTEL analysis and the Smart Aging Survey (2025), the table below summarizes the system-level barriers and the enabling factors across each dimension.

Table 1. System-level barriers and enabling conditions across PESTEL dimensions

PESTEL Dimension	Barriers (Current Challenges)	Enablers (Opportunities & Positive Conditions)	Sources
Political	Fragmentation between counties (services) and municipalities (housing, built environment) creates structural misalignment).	Strong national ageing policy promoting ageing in place and integration.	(Kangas & Nikander, 2023), (Ministry of Social Affairs and Health, 2020)
	Uneven political commitment to preventive care and long-term investments.	National and EU-level strategies push toward home care, workforce reinforcement, and sustainability.	(OECD, 2023), (European Commission, 2022), (European Commission, 2020)
	Regional inequalities driven by differing county budgets, affecting fairness and access	Stable national legal framework guaranteeing universal rights to services.	(WHO, 2019), (Act 980/2012; Ministry of Social Affairs and Health, 2020).
	Limited time and administrative delays reported by professionals	Strong tradition of public health governance supports long-term policy continuity.	(Smart Aging Survey, 2025) , (Ministry of Social Affairs and Health, 2022).
Economic	Rising healthcare costs projected to exceed 12% of GDP by 2030	Investing in preventive services reduces long-term care costs.	(OECD, 2023), (Mehta & Myrskylä, 2017)
	County deficits limiting staffing, space, and renovations	Digital investments (if aligned with user needs) can improve efficiency.	(Ministry of Social Affairs and Health, 2022), (OECD, 2023)
	Workforce shortages increase wage pressures, recruitment costs, and turnover	International recruitment policies offer potential relief.	(Ministry of Social Affairs and Health, 2022), (Smart Aging Survey, 2025)

	Limited economic capacity for facility upgrades and environmental improvements	EU Green Deal encourages energy-efficient renovations and sustainable building design.	(Smart Aging Survey, 2025), (European Commission, 2020).
Social	Loneliness affects up to one in five older	Strong cultural support for autonomy, dignity, and meaningful ageing.	adults (THL, 2023), (WHO, 2019)
	Diverse elderly population with unequal health outcomes	Increasing recognition of the need for culturally sensitive care.	(WHO,2019), (Kemppainen et al., 2024)
	Underrepresentation of vulnerable groups in surveys reduces visibility in policymaking	Community-based models support participation and social connection.	(WHO, 2019), (Nummela et al., 2011).
	Older adults express unmet needs for calm environments, nature, and meaningful activities	Demand for human-centred and nature-connected care environments aligns with global age-friendly guidelines.	(Smart Aging Survey, 2025), (WHO, 2019).
Technological	Digital exclusion persists despite high national readiness	National digital infrastructures provide strong foundations.	(Vuori & Kallio, 2023), (OECD, 2023), (Kanta Services, 2025).
	Interoperability gaps between county systems	Emerging assistive technologies (fall sensors, smart materials) offer enhanced safety.	(OECD, 2023), (THL, 2023).
	Staff lack time and training for digital tools	User-centred design approaches can increase technology acceptance.	(Smart Aging Survey, 2025), (WHO, 2019).
	Older adults express mistrust and prefer simple tools	Digital solutions can support continuous monitoring and remote care when designed well.	(Smart Aging Survey, 2025), (OECD, 2023).

Environmental	Older facilities lack modern ventilation and accessibility	Finnish commitment to environmental standards supports safer building practices.	(Ministry of Social Affairs and Health, 2022), (European Commission, 2020)
	Poor lighting, acoustics, and cramped circulation areas increase risks.	Access to outdoor areas improves mobility and mental health.	(WHO, 2019)
	Bathrooms identified as the highest-risk area for falls	Environmental improvements such as natural lighting and ventilation support healthy ageing.	(Smart Aging Survey, 2025), (THL, 2023).
	Limited staff time reduces outdoor access and environmental engagement	Renovation programmes encouraged by EU climate policy can support safer indoor environments.	(Smart Aging Survey, 2025), (European Commission, 2020).
Legal	Staffing ratios legally mandated but difficult to meet due to shortages	Strong regulatory oversight protects safety and quality.	(Valvira, 2024), (THL ,2023; Ministry of Social Affairs and Health, 2022).
	Administrative and documentation requirements increase workload	Clear legal rights ensure autonomy, access, and equity.	(Smart Aging Survey, 2025), (Act 980/2012; Ministry of Social Affairs and Health, 2020).
	Procurement laws slow down innovation adoption	Legal frameworks for data protection build trust in digital tools.	(OECD, 2023), (Ministry of Social Affairs and Health, 2022).
	Fragmentation in legal responsibilities between counties and municipalities	EU strategies support alignment on accessibility, safety, and digitalisation.	(Kangas & Nikander, 2023), (European Commission, 2020).

Table 1 shows that the pressures shaping elderly care in Finland come from multiple directions. Political reforms, economic constraints, social changes, technological gaps, environmental risks, and legal requirements interact with each other and create a complex system. These factors help explain why progress toward sustainable-smart elderly care is slow and uneven. Understanding these barriers and enabling conditions is essential for designing a realistic future vision and for identifying where change is most needed.

5 Vision for Sustainable-Smart Elderly Healthcare in Finland

The vision presented in this chapter is a desirable and yet realistic future for elderly care in Finland in 2050, constructed through the backcasting pathway. It relies on conclusions from the baseline study, Smart Aging project, stakeholders' surveys and related transition theories. The aim is not to forecast the future, but rather, to paint a picture of what elderly care could look like if Finland leverages its current strengths, tackles its structural barriers and guides the system with purpose toward sustainability, equity and smart solutions.

5.1 Description of sustainable -smart elderly healthcare in the 2050 Vision

In 2050 the elderly health care in Finland is part of a unified socio-technical ecosystem where housing, care services and community life and environmental design are tightly interwoven. The traditional separation of "home", "care facility" and "healthcare service" has softened in the sense that services will be diffused, preventive and supportive rather than reactive. This immerses the process within what is recommended in the sustainability-transition literature, pointing to how systems change through multi-actor cooperation, adaptive practices and incremental reinforcement of niche innovations (Geels 2002; Loorbach 2010).

To provide a clear overview of the desired future state, the following conceptual figure summarises the core elements of sustainable-smart elderly healthcare in Finland in 2050. It visualises how preventive services, digital support, sustainable environments, and coordinated governance form an integrated system that enhances well-being, autonomy, and resource efficiency.

Figure 6. Vision of sustainable-smart elderly healthcare in Finland in 2050 (AI-visualised illustration created by the author)

Figure 6 illustrates a future neighbourhood designed for sustainable-smart ageing, featuring accessible pathways, inclusive outdoor spaces, renewable energy systems (solar panels and wind power), green roofs, active mobility options, and charging infrastructure. The scene highlights how housing, mobility, and energy systems work together to support autonomy, safety, and low-carbon living.

- **A more preventive and person-centred system**

Care is focused on the preservation of functional independence and emotional well-being. Local community centres offer integrated health, cultural and social activities that reduce loneliness and provide early help. Older adults are involved in the co-design process and make decisions on the services, spaces and technologies. These are in line with the principles of Just Transition and inclusive governance from course materials that underscore participation, equality, multi-actor involvement.

- **Supportive and sustainable built environments**

There are homes, care units and community facilities, all of which have been designed with sustainability and accessibility at their core. Buildings are constructed with low-carbon

materials, energy-saving systems and enhanced indoor environmental quality. They feature natural light, adjustable acoustics and safety-enhancing bathroom facilities, all areas that continually cropped up in the baseline as high-risk. These aspects tie in with Smart Aging's focus on indoor health, antimicrobial surfaces and ergonomic design.

- **Technology that enhances, not replaces, care**

Digital products are deeply integrated yet inspired by our physical heritage. Even where technology helps maintain autonomy and safety-as exemplified by discreet monitoring, adaptive lighting or fall prevention systems-decisions remain rooted in human judgement and ethical care. This is also in line with the tendency of Health 4.0, made up by data-driven insight and human-centred service design (Halmosi & Aranyossy, 2024). Digital inclusion programs make sure that the older people and staff know how to use tools to assist them, and they trust it is all secure.

- **Circular and resource-efficient operations**

Healthcare facilities are built and functioning based on circular economy; meaning they are designed to have durable, indoor hygiene and recyclable material content; combined water and energy systems that are partially decentralised; and long-lived, repairable, modular procurement. This is in line with sustainability frameworks discussed in lectures, which approach environmental and economic resilience together through system design.

- **Coordinated governance and seamless service pathways**

By 2050, roles of the region, well-being counties and municipalities are in better harmony. Housing and health planning is integrated to remove fragmentation and to create enabling environment when ageing in place. Information systems are inter-operable, so staff can access the data, when they require it, while data privacy policies are respected. This ties in with the SST course materials and class discussion focusing on multi-level governance and institutional coordination as a condition to both social and technological change.

- **A system that values emotional, social and ecological well-being**

Health care outcomes are assessed at a broad conceptual level, including physical health status, emotional well-being and social participation, as well as environmental influences. This is in line with the PESTEL-based sustainability literature, which considers that health

systems are influenced not only by their clinical performance, but also by social, environmental and economic circumstances (Thakur, 2021).

In this future-eutopia, Finland's elderly-care system is a circular, digital and humane ecosystem. Preventive activities ease demand on acute care; the built environment takes an engaging role in safety and well-being; technology promotes independence; and community networks support social engagement. Sustainability isn't add-on, but a principle threaded through everyday care, material choices, studio design and governance.

It is from this vision that the backcasting analysis below derives, which identifies the key transition pathways and points of leverage.

5.2 Operational Characteristics of a Sustainable–Smart Elderly Care System in 2050

To complement the conceptual vision outlined in subsection 5.1, this subsection summarises the concrete spatial, social, technological, and organisational features that characterise the envisioned future system. The focus is on Finland as a Nordic welfare state, where health and social services are organised through publicly funded wellbeing services counties. These elements are derived from annex 3, including the qualitative scenario work conducted for this thesis and represent practical interpretations of what sustainable-smart ageing would look like in everyday life. The full narrative scenarios are presented in Annex 4.

Built Environment and Housing

- Homes and care facilities are well insulated for Finnish winters and maintain stable indoor air quality, lighting, acoustics, and temperature to support older adults' sensory and physical needs.
- Universal design features, slip-resistant flooring, safe entrances during snow and ice, spacious bathrooms, rounded edges, natural materials, reduce fall risks and support independence.
- Green elements, winter gardens, and access to outdoor areas including covered walkways and nearby forest paths, promote mental well-being and safe physical activity year-round.

Digital Support and Care Coordination

- Wellbeing dashboards display essential indicators in clear, non-medical language in Finnish and Swedish, and where needed in other common languages to reduce cognitive load.
- Digital systems operate quietly in the background, supporting autonomy without overwhelming users, and connect to national e-health services such as the Kanta system.
- Interoperable information systems enable shared assessments across multidisciplinary teams working in different wellbeing services counties and municipalities.
- Digital inclusion programmes ensure older adults and staff are confident using necessary tools, including strong electronic identification methods widely used in Finland.

Community and Social Participation

- Community hubs located in local service centres, libraries or multi-use houses provide shared spaces for rehabilitation, cultural activities, physical exercise, and meaningful social interactions.
- Built environments are warm, calm, and sensory-supportive, reducing loneliness and promoting social connection in both cities and small municipalities.
- Outdoor paths, benches, and accessible micro-environments in neighbourhoods, parks and nearby nature, designed to be safe also in darker seasons, support incidental social encounters and movement.

Professional Workflows and Workforce Well-being

- Staff work in low-carbon, energy-efficient environments with ergonomic spatial layouts that follow Finnish building standards and guidelines.
- Multidisciplinary teams collaborate using shared digital platforms, reducing fragmentation and administrative workload between different provider organisations.

- Redesigned facility spaces decrease physical strain and enhance staff safety, for example when lifting and moving clients with winter clothing or assistive devices.
- Occupational well-being is supported through calmer workspaces, balanced routines, and tailored health reminder, linked to Finland's occupational health services system.

Figure 7. Future professional roles and supportive work environments in sustainable-smart elderly care. (AI-visualised illustration created by the author)

Figure 7 demonstrates healthcare professional in a modern Finnish care environment with digital dashboards and a calm, technology-friendly workspace that supports efficient and person-centred workflows.

Integrated System-Level Features

- Housing, community services, digital tools, and care workflows function as a unified ecosystem across wellbeing services counties and municipalities.
- Preventive care, person-centred design, and sustainability principles guide daily operations within Finland's tax-funded welfare model.
- System coordination reduces fragmentation and enables stable, equitable service delivery across counties between urban and rural regions.

6 Transition Pathways

This chapter illustrates how Finland could move from the current status (Baseline) studied in chapter 4, towards the vision of the future presented in Chapter 5. The transition is depicted by means of a high-level map for the 2025–2050 period and a barrier–enabler matrix that summarises the key systemic conditions driving change. The aim is not to specify determined policies but rather to sketch out the main directions and levers necessary for transformative change in the long term, consistent with both backcasting and sustainability transition principles.

6.1 Roadmap for transition (2025–2050 milestones)

- **2025–2030: Making stronger foundations and Removing System Frictions**

The first step is to address the structural issues identified in the baseline. Integrated planning between well-being counties and municipalities provides better coordination of governance to ensure that decisions in relation to housing and service provision are better aligned. This is supported by national guidelines that ask counties and municipalities to prepare joint service and housing plans. Digital interoperability is getting better due to common data standards and more user-friendly interfaces that benefit both staff and older people. National e-health platforms and shared data standards make this possible in practice. Workforce development is growing, and digital care training, ergonomics and preventative work training is regulated. Safety, accessibility and indoor air quality are beginning to be included in building guidelines. This is based on key finding from what the Smart Aging project piloting on more intelligent bathroom layouts, antimicrobial surfaces and wellness-focused designs. For example, some facilities start to test Smart Aging bathroom models and safer circulation spaces when they renovate old buildings.

At this stage, digital-governance and societal principles are established to ensure that there's always a human responsible for the use of technology and data protections and privacy are respected. National ethical guidelines for digital health and local data-governance practices enable this. These activities complement one another to mitigate fragmentation, empower staff more and encourage the early use of niche ideas. This is equivalent to the phases of

“predevelopment” and “niche building” in transition theory. It is in these stages that new principles and ideas are stabilised even while the main structure might stay the same.

- **2030-2040: Up-Scaling Niche Innovations and Aligning Regime Structures**

The second stage is when the most promising new ideas and technologies evolve into established practice. Counties standardize procurements for smart-safety solutions, sensor-supportive interiors and preventive monitoring technologies. Common national procurement criteria and funding for accessibility and energy renovations help counties to do this in a coordinated way. Multi-sector governance gets to work, and health services become integrated with housing, transport and environmental planning. Community Health Hubs are established in most communities to offer social, cultural and preventative activities that combat loneliness and enable autonomy. Many of these hubs grow from earlier pilots in libraries, service centers or multi-use buildings.

Digital inclusion initiatives become systemic, helping older adults access instruction and training to utilize supportive technologies. Municipal adult-education services and NGOs provide regular “digital support days” for older people and their care givers. The form of healthcare workforce is changing; more face to face consultation but topped off with digital tools that balance efficiency and patient-centered care. This stage also includes facets of Just Transition that guarantee those older adults in all regions and at all income levels can get access to technology and environmental upgrades, irrespective of ability or income. Targeted subsidies and grant schemes for low-income households enable these upgrades in practice.

- **2040–2050: System Reconfiguration and Stabilisation**

In the last stage, the system for long-term care of older people is restructured following the vision. Constructed developments widely adopt design principles with a low-carbon, inclusive and health focus. Circular procurement rules, low-carbon building standards and energy-efficiency targets guide new investments. Technology is both embedded and invisible, supportive yet non-displacing of human judgement and social care. Depending less on acute and institutional services: preventive and community-based models. Coordination between the national guidance and county or municipal action is well established through multi-actor governance mechanisms. National–local coordination bodies and shared monitoring indicators support this alignment.

Economic sustainability is achieved as circular procurement, long-life materials and preventive care minimize the long-term costs for well-being counties. Resource resilience is also amplified by decentralized energy systems and circular design. Local renewable-energy systems in care facilities and neighborhood-level service ecosystems are concrete examples of this resilience. At this point, both everyday routines, organizational practices and built facilities are in accordance with sustainable-smart ageing principles, referring to "acceleration" and "stabilization" stages of transition.

6.2 System-Level Challenges and Corresponding Solutions

Since the 2050 vision presented in Chapter 5 describes a coordinated and human-centred future, the next step in the backcasting process is to connect current constraints with future-oriented solutions. The following table compiles the key system-level challenges that hinder progress toward sustainable-smart elderly care in Finland and outlines potential solutions. Each challenge and solution is grounded in the findings of this thesis, including the PESTEL analysis, stakeholder insights, and transition pathway assessment.

Table 2. System-level challenges and corresponding solutions for a sustainable-smart elderly care transition

System Dimension	Challenges (Cited Constraints)	Solutions (Cited Future Directions)	Sources
Governance & Coordination	Fragmented responsibilities between counties and municipalities continue to create misalignment. Uneven implementation of national guidelines contributes to regional differences.	Integrated planning processes supported by national guidelines. Cross-sector governance structures and interoperable information systems reduce fragmentation.	(Ministry of Social Affairs and Health, 2020), (OECD, 2023), (Kangas & Nikander,2023;)
Workforce & Skills	Severe staff shortages and burnout persist. Digital competence varies widely among professionals, and training time remains limited.	National upskilling programmes and digital-competence training improve workforce capacity. Ergonomic spatial	(OECD, 2023), (Smart Aging Survey,2025), (WHO, 2019).

		redesigns reduce workload stress. Blended-care roles support flexible task allocation.	
Built Environment	Bathrooms are cramped and unsafe, and indoor air quality varies between facilities. Many buildings lack accessibility and ergonomic design	Smart Aging pilots demonstrate safe bathroom layouts, antimicrobial materials and ergonomic circulation spaces. Updated national accessibility and energy-efficient renovation policies support safer environments	(Ministry of Social Affairs and Health, 2022), (THL,2023), (Smart Aging Project, 2025), (European Commission, 2020).
Digitalisation & Inclusion	Digital exclusion remains common among older adults Staff face training gaps, and county information systems remain incompatible. Many older adults mistrust digital tools.	Digital-inclusion programmes and simplified interfaces increase accessibility Unified data standards support interoperability. Ethical digital governance frameworks protect privacy and support human oversight.	(Vuori & Kallio, 2023). (OECD, 2023), (Smart Aging Survey, 2025), (WHO, 2019), (Ministry of Social Affairs and Health, 2022).
Economic& Resource Factors	County budget deficits and short-term austerity measures limit renovation and preventive services. Investment in prevention is insufficient	Circular procurement and durable material choices reduce long term costs. Decentralised and energy-efficient systems strengthen resilience Preventive services lower long-term expenditure.	(OECD, 2023), (European Commission, 2020), (Ministry of Social Affairs and Health, 2022), (Mehta & Myrskylä, 2017).

Social& Community Factors	Loneliness remains prevalent. Design practices and community engagement vary across regions.	Community health hubs strengthen social participation. Participatory design improves relevance and equity. Neighbourhood-level service ecosystems support inclusion.	(THL, 2023), (WHO, 2019). (Smart Aging Project, 2025).
Environmental Sustainability	Older adults spend most of their time indoors, making poor indoor conditions a critical risk. Climate goals are not fully integrated into care-facility design.	Low-carbon building standards and nature-integrated design support healthy indoor conditions. Smart Aging pilot insights emphasise safe materials and improve indoor environment quality.	(THL, 2023). (Ministry of Social Affairs and Health, 2022), (European Commission, 2020), (Smart Aging Project, 2025).
Equity & Just Transition	Regional and socioeconomic disparities affect access to digital tools, safe environments, and high-quality services.	Inclusive policy design and targeted support reduce inequality. Equitable distribution of sustainable technologies ensures fairness across counties.	(OECD, 2023), (WHO, 2019), (European Commission, 2020).

The challenges shown in Table 2 highlight that the transition toward sustainable-smart elderly care is not only a technical task but a system-level process. These challenges cut across governance, workforce, digitalisation, environment, and financing. The solutions indicate that progress requires coordinated action between national policies, municipal practices, service providers, and communities. Together, these system-level insights form the foundation for building realistic transition pathways in Finland.

7 Discussion

The three research questions show that the change toward sustainable-smart elderly care in Finland is a system change. It is not only about new technology. It also affects values, culture and governance. The main idea is that sustainability and smart ageing must work together. They work best when care is human-centred, ecological and well-coordinated.

One key point is that Finland has strong equality, but the system is still fragmented and under pressure. This supports earlier research from Nordic countries (Halmosi & Aranyossy, 2024). The results also suggest that digital tools alone cannot solve the problems. Skills, organisations and culture must change at the same time. This matches work on healthcare 4.0, where systems often struggle to use new tools in full.

The vision for 2050 shows a preventive, circular and emotionally supportive care system. This means that ecological design and comfort can go together. Insights from Smart Aging projects (SAMK 2024; IKIGAIA 2025) support this idea. They show that good design in homes and services can improve safety and well-being. This is also in line with Ji et al. (2023), who show that political and social factors shape senior housing and user involvement.

The transition analysis shows that long-term thinking and fair use of technology are important. Barriers such as digital exclusion or short-term planning are not only technical issues. They also come from culture and governance. This agrees with wider sustainability-health studies that say transitions need political support and social agreement (Thakur, 2021; Vojinović & Stević, 2021).

Together, these points show that sustainable-smart ageing needs a full system shift. It cannot be one project or one policy. Environmental actions give the physical base. Digital tools help the system adapt. Participation builds trust and fairness. This idea fits sustainability transition theory, where resilience comes from learning, coordination and shared values. The Finnish case also reflects a wider European move to connect health, environment and technology.

There are clear implications for Finland. Sustainability should become part of daily governance. National programmes set goals, but stronger indicators are needed, such as

energy use, circular materials and indoor air quality. These can help decision-makers include sustainability in everyday work. This supports research that shows policy and regulation are strong drivers for system change (Thakur, 2021).

There are also economic implications. Prevention can lower long-term costs. Early support, digital monitoring and efficient buildings can help. Municipalities can support circular procurement and work with SMEs in welfare technology. This links ecological and economic goals and may also create new markets.

Social implications are important too. Older adults value autonomy, comfort and nature. This means digital systems must stay simple and inclusive. Participatory tools such as citizen panels or design sessions can help people take part in decisions. This matches the view of Komp-Leukkunen and Sarasma (2024), who highlight dignity and self-determination in ageing.

Environmental implications show that buildings matter. Care facilities use a lot of energy. Retrofitting them with renewable systems, safe materials and nature-based design can reduce emissions and improve well-being at the same time. Finland already leads in green public buildings and can extend this to elderly care.

Conceptually, this thesis suggests that smart ageing is not only technical. It is also ethical and ecological. Technology should support fairness, inclusion and dignity. This is in line with Vojinović and Stević (2021), who link health with social and ecological justice. Finland's strong trust and transparency give good conditions for fair digital care systems.

Overall, Finland can become a leader in sustainable-smart ageing. To reach this goal, welfare governance, innovation policy and environmental regulation must work together. Strong indicators, preventive investments and wider co-design can help Finland move from pilots to a national model. Sustainable-smart ageing is not only a response to demographic change. It is also a chance to renew Finnish well-being and strengthen the balance between people and nature.

7.1 Limitations of the study

This thesis presents ideas about sustainable-smart elderly healthcare in Finland, but it has its own limits. The study used qualitative methods and small surveys, so the results cannot

represent all older people or all regions in Finland. Backcasting is also normative, which means it includes values and personal judgement. The 2050 vision is only one possible future. Different values or priorities could create other future paths. Also, not all stakeholders could join the study. More input from municipalities, SMEs and policy experts could give a fuller picture. Finland's strong welfare system also makes the results more related to the Finnish context and not fully general for other countries.

There were also limits in data access. Some Smart Aging pilot information was only available in public documents, so long-term impacts could not be fully studied. Even with these limits, the study still gives an important view of how environmental, social and economic ideas can work together for sustainable-smart ageing. The limits show good directions for future research, such as comparing regions, using more methods and including more groups in the process.

7.2 Practical recommendations for healthcare providers and policymakers

To make the shift towards sustainable-smart aging, multi-level governance needs to be strengthened and coordination between municipalities, care providers, technology developers and local actors should be intensified. This alignment is critical in ensuring equity of access to elderly-care services between different areas. To underpin this, long-term sustainable funding models are required that will enable us to sustain the work on prevention, digital literacy and future-proofing infrastructure. Digital support for the elderly should also be enhanced and increased as it reduces disparities, allowing them to access tele welfare technologies and smart-care solutions.

At the same time, the sector needs to scale up controlled trial programs that can test new innovations and technologies for their effectiveness, as well as antimicrobial products and low-carbon design concepts, before widespread use. Environment-related criteria as energy, material and waste flows should be well-integrated at planning and procurement levels to keep the sustainability adopted in upcoming elderly-care environments. Co-design with seniors, caregivers and healthcare professionals would additionally (help to) ensure new solutions are practicable, human-cantered and in line with everyday aspects.

And lastly, when designing community spaces, we need to be inspired by the broad spectrum of tastes and capabilities of older adults. Just as one drug cannot be right for every patient, neither can one activity work for all seniors. As such, activity environments should provide a variety of choices for varying moods, cognitive levels, and personalities. Diverse and meaningful social, cultural, physical or creative activity has been shown to play an important role in the increase of emotional well-being as well as reinforcing interpersonal connectivity and supporting wider social sustainability of elderly care.

7.3 Future work

There are multiple paths to study sustainable-smart elderly healthcare further. This thesis was based primarily on qualitative work, and further work could use quantitative approaches such as life-cycle assessment or system-dynamics models to quantify environmental, social and economic effects.

In addition, differences between Finnish municipalities can also be investigated, since resources and capacity are not consistent. Such comparisons might reveal best practices and local barriers. Older adults, professionals and developers should be able to co-design and test new ideas together in living labs and co-design settings. For evaluating the progress status, it is possible to analyse in one to three years how the sustainability objectives are present in Finnish health and social care and reform plans procurement, financing as well as quality systems direct development. Research into ethics, data privacy and digital inclusion is also crucial to the development of trust as digital methods become more popular. Comparative studies between Nordic, European or East Asian countries could also reveal how different systems enable or inhibit this process. Lastly, the conceptual model presented in his thesis could be developed further by integrating transition theory, health-system change and design thinking and subsequently tested with empirical or simulation data.

8 Conclusion

This thesis has opened a discussion about how Finland can move towards a sustainable and smart elderly healthcare system with the intersection of sustainability and digital innovation. The results now demonstrate that Finland has already an excellent foundation, which is a stable welfare state, national strategies as support of preventive care and raising the use of the welfare technology.

However, the base line showed issues that are not going away. Yet staff shortages, regional discrepancies in service and poor digital literacy among many seniors continue to apply pressure. Environmental effects relating to use of energy, buildings and materials flows are also not being given sufficient attention in elderly care.

This backcasting vision for 2040 presented an ideal future in which care was preventive, home-based, digitally assisted, low carbon and socially inclusive. When we compared this vision to the current landscape, it became evident what was missing, namely cross-sector coordination, sustainable infrastructure and equitable access to digital tools.

It was found from PESTEL-based transition pathways that political coherence, economic investment, technology readiness, social acceptance, environmental planning and clear regulation all affect the rate of transition to different directions.

In conclusion it can be said that the results support the transition to sustainable-smart aging is feasible but not if pursued through isolated technical updates.

The study shows that the future of elderly care in Finland will be shaped by choices made today. Smart technologies can improve safety, autonomy, and well-being, but they only become meaningful when combined with social inclusion, sustainable environments, and accessible services. The transition toward sustainable-smart aging is therefore not a technological project alone. It is a societal transformation that touches values, daily routines, professional practices, and the ways communities care for elderlies. If Finland continues to integrate sustainability, digital innovation, and human-centred thinking, elderly care can become more resilient, equitable, and resource-efficient. This thesis aims to support that direction by clarifying the vision, exposing the barriers, and showing the pathways that can turn a desirable future into a realistic outcome.

References

Attendo. 2024. *Attendo – Company information*. [online]. Available at: https://www.attendo.fi [Accessed 14 November 2025].

Di Novi, C. & Santos, J. 2023. Intergenerational caregiving and gender inequalities in health and employment. *Health Economics*, 32(1), pp. 3–18.

Douglas, O., Lennon, M. & Scott, M. 2017. Green space benefits for health and well-being: a life-course approach for urban planning, design and management. *Cities*, 66, pp. 53–62.

Dreborg, K.H. 1996. Essence of backcasting. *Futures*, 28(9), pp. 813–828.

Eckelman, M.J. & Sherman, J.D. 2016. Environmental impacts of the U.S. health care system and effects on public health. *PLOS ONE*, 11(6), e0157014.

Esperi Care. 2024. *About us*. [online]. Available at: https://www.esperi.fi [Accessed 14 November 2025].

European Commission. 2020. *The European Green Deal*. COM (2019) 640 final. Brussels: European Commission.

European Commission. 2021. *EU Action Plan toward Zero Pollution for Air, Water and Soil*. COM (2021) 400 final. Brussels: European Commission.

European Commission. 2022. *European Care Strategy*. Brussels: European Commission.

Geels, F.W. 2002. Technological transitions as evolutionary reconfiguration processes. *Research Policy*, 31(8–9), pp. 1257–1274.

Gusmano, M.K. & Okma, K.G.H. 2018. Health care, aging, and inequality. *Journal of Aging & Social Policy*, 30(3–4), pp. 255–270.

Halmosi, P. & Aranyossy, M. 2024. Transformative potential of Healthcare 4.0: a systematic literature review. *Technology in Society*, 75, 102344.

Härri, T. 2025. Sustainable system transition: socio-technical change and pathways. Lecture notes, LUT University.

Herttuainen, A. 2022. *Sustainable smart ageing in Finnish municipalities: opportunities and challenges*. Master's thesis. LUT University.

IKIGAIA. 2025. *Smart Aging project materials (public overview)*. [online]. Available at: https://www.ikigaia.fi [Accessed 20 November 2025].

Interreg Baltic Sea Region. 2025. *SmartAging Project overview*. [online]. Available at: https://interreg-baltic.eu/project/smartaging/ [Accessed 20 November 2025].

Ji, T.T., Chan, E.H.W. & Chung, Y.N. 2023. Political, economic and social factors influencing the development of senior housing. *Buildings*, 13(3), 617.

Kangas, T. & Nikander, P. 2023. Ageing, inequality and social sustainability in Finland. *Finnish Journal of Social Research*, 16, pp. 45–63.

Kanta Services. 2025. *Kanta – National Digital Health Services*. [online]. Available at: https://www.kanta.fi/en [Accessed 25 November 2025].

Kemppainen, L. et al. 2024. Social sustainability in eldercare work. *BMC Geriatrics*, 24, 112.

Konttila, J. et al. 2019. Healthcare professionals' competence in digitalisation. *Journal of Clinical Nursing*, 28(5–6), pp. 745–761.

Komp-Leukkunen, K. & Sarasma, M. 2024. Social sustainability and older adults. *Journal of Aging & Social Policy*, 36(2), pp. 150–170.

Lenzen, M. et al. 2020. The environmental footprint of health care. *The Lancet Planetary Health*, 4(7), pp. e271–e279.

Loorbach, D. 2010. Transition management for sustainable development. *Governance*, 23(1), pp. 161–183.

Marino, M. et al. 2014. Access to care and health outcomes among older adults. *Journal of Aging and Health*, 26(1), pp. 21–36.

Mehta, N.K. & Myrskylä, M. 2017. Healthy lifestyle and disability-free life expectancy. *Health Affairs*, 36(11), pp. 1987–1994.

Meng, K., Xu, X., Xu, W. & Zhang, W. 2023. Fall detection in smart home environments. *Technology and Health Care*, 31(4), pp. 907–924.

Ministry of Social Affairs and Health (STM). 2020. *Quality recommendation for older persons 2020–2023*. Helsinki: STM.

Ministry of Social Affairs and Health (STM). 2021. *National Programme on Ageing 2030*. Helsinki: STM.

Ministry of Social Affairs and Health (STM). 2022. *Social welfare and healthcare reform*. Helsinki: STM.

Ministry of Social Affairs and Health (STM). 2023. *SOTE reform – changes for older people*. Helsinki: STM.

Morozova, I. & Gurova, O. 2021. Digitalisation in elderly care. *Technology in Society*, 66, 101630.

Nummela, O. et al. 2011. Self-rated health and social capital among ageing people. *Ageing & Society*, 31(7), pp. 867–883.

OECD. 2022. *Health at a Glance: Europe 2022*. Paris: OECD Publishing.

OECD. 2023. *Health at a Glance 2023: OECD Indicators*. Paris: OECD Publishing.

Pillemer, K. et al. 2010. Environmental volunteering and health outcomes. *The Gerontologist*, 50(5), pp. 594–602.

Quist, J. & Vergragt, P. 2006. Past and future of backcasting. *Futures*, 38(9), pp. 1027–1045.

Robinson, J.B. 1990. Futures under glass: a recipe for people who hate to predict. *Futures*, 22(8), pp. 820–842.

SAMK. 2024. Smart Aging project description. [online]. Available at: https://www.samk.fi [Accessed 14 November 2025].

Slaper, T.F. & Hall, T.J. 2011. The triple bottom line: What is it and how does it work? Indiana Business Review, 86(1), pp. 4–8.

Siu, J.Y.–M. & Leff, B. 2024. Aging at home in the digital era. Journal of the American Geriatrics Society, 72(4), pp. 825–833.

Statistics Finland. 2023. *Population structure*. [online]. Available at: https://www.stat.fi [Accessed 14 November 2025].

Statistics Finland 2024, 128t – Population by age and sex in population projections for different years, whole country (Population 31 Dec, projection 2024), StatFin database, Statistics Finland, Helsinki, Available at: https://pxdata.stat.fi/PxWeb/pxweb/en/StatFin/StatFin__vaenn/statfin_vaenn_pxt_128t.px/table/tableViewLayout1/ [Accessed 8 December 2025].

THL. 2023. *Older people – services and wellbeing*. [online]. Available at: https://thl.fi [Accessed 14 November 2025].

Tavakoli, A. et al. 2024. Smart ageing environments. *Journal of Aging & Environment*, 38(2), pp. 210–234.

Thakur, V. 2021. Framework for PESTEL dimensions of sustainable healthcare waste management. *Journal of Cleaner Production*, 287, 125562.

Valvira. 2024. *Supervision of services for older people*. [online]. Available at: https://www.valvira.fi [Accessed 14 November 2025].

Vojinović, N. & Stević, Ž. 2022. PESTEL analysis of the healthcare system. *TEME*, 46(2), pp. 437–455.

Vuori, O., Wik, H., Wikström, A., Jokinen, H., Hietanen, M. & Kallio, E-L. 2023. Feasibility of a novel web-based neuropsychological rehabilitation program for stroke patients. Journal of Rehabilitation Medicine, 55, pp. 1–10.

WHO. 2019. *Decade of Healthy Ageing: 2020–2030*. Geneva: World Health Organization.

WHO. 2024. *World Health Statistics 2024*. Geneva: World Health Organization.

project's dataset: Smart Aging Survey (2025). Unpublished survey conducted as part of the Smart Aging Interreg BSR project.

Appendix 1. health care professionals' survey (Finnish & English)

No.	Finnish	English
1	Mikä on roolisi?	What is your role?

2	Mikä on ammattisi tai suhteesi vanhustenhoitoon?	What is your profession or your relationship with elderly care?
3	Kuinka monta vuotta olet työskennellyt vanhusten parissa?	How many years have you worked with or supported older people?
4	Millaisessa ympäristössä työskentelet?	What kind of environment do you work in?
5	Mitkä päivittäiset toiminnot vievät eniten aikaa ikääntyneiltä?	Which daily activities do you think take up the most time for older people?
6	Missä näet suurimman tapaturmariskin (esim. kaatumiset, loukkaantumiset)?	Where do you see the greatest risk of accidents (e.g., falls, injuries)?
7	Missä pitäisi kiinnittää erityistä huomiota infektioiden ja bakteerien hallintaan?	Where should particular attention be paid to infection and bacteria control?
8	Mitkä ovat tärkeimmät opit, joita COVID-19-pandemia toi esille vanhustenhoidon ympäristöjen kehittämisessä?	What are the main lessons that the COVID-19 pandemic brought to the fore in developing care environments for older people?
9	Mikä on ikäihmisten suurin päivittäinen haaste, jonka havaitset tai koet työssäsi?	What is the biggest daily challenge for older people that you notice or experience?
10	Kuinka kuvailisit “hyvää päivää” ikääntyneelle hoivaympäristössä?	How would you describe a “good day” for an elderly person in a care setting?
11	Mitkä tekijät vaikuttavat eniten ikääntyneiden mielenterveyteen?	What factors have the biggest impact on the mental well-being of older people?
12	Mikä yksi asia parantaisi merkittävästi sinun työhyvinvointiasi?	What one thing would significantly improve your quality of life at work?
13	Missä on kiireellisin tarve parantaa hoivaympäristöjen suunnittelua?	Where is the most urgent need for design improvements?
14	Miten edellisessä kysymyksessä mainittua aluetta voisi parantaa?	How could the area you mentioned in the previous question be improved?
15	Mitä ominaisuuksia tulisi korostaa eniten tulevaisuuden suunnittelussa?	What features should be emphasized most when planning for the future?

16	Mitkä teknologiset innovaatiot ovat mielestäsi tärkeimpiä tulevaisuuden ikääntyneiden asumisessa?	Which technological innovations do you think are most important for the future of housing for older people?
17	Mitkä ovat esteitä, jotka estävät kestävät ja käyttäjälähtöiset ratkaisut alallasi tänään?	What are the barriers that prevent sustainable and user-centred solutions in your sector today?
18	Jos voisit kuvata ihanteellisen senioriasumisympäristön yhdellä lauseella, millainen se olisi?	If you could describe the ideal senior living environment in one sentence, what would it be?

Appendix 2. Seniors' Survey (Finnish & English)

No.	Finnish	English
1	Millaisessa ympäristössä asut?	What kind of environment do you live in?
2	Mitkä päivittäiset toiminnot vievät sinulta eniten aikaa?	Which daily activities take up most of your time?
3	Kuinka kuvailisit "hyvää päivää" hoivaympäristössä?	How would you describe a "good day" for you in a care setting?
4	Mikä on sinulle suurin päivittäinen haaste?	What is your biggest daily challenge?
5	Missä näet suurimman tapaturmariskin (esim. kaatumiset, loukkaantumiset)?	Where do you see the greatest risk of accidents (e.g., falls, injuries)?
6	Kuinka tyytyväinen olet nykyiseen asuinympäristöösi?	How satisfied are you with your current living environment?
7	Voitko muokata omaa asuintilaasi (esim. huonekalut, sisustus)?	Can you adapt your own living space (e.g., furniture, decoration)?
8	Mikä yksi asia parantaisi merkittävästi elämänlaatuasi?	What one thing would significantly improve your quality of life?
9	Mistä näkökulmastasi yksi parannus vaikuttaisi eniten ikäihmisten hoivaympäristöön?	From your point of view: what one improvement would make the biggest

		impact on the care environment for older people?
10	Millä alueella on kiireellisin tarve suunnittelun parantamiselle?	In which area is there the most urgent need for design improvements?
11	Kuinka edellisessä kysymyksessä mainittua aluetta voisi parantaa?	How could the area you mentioned in the previous question be improved?
12	Mitä ominaisuuksia tulisi korostaa eniten tulevaisuuden suunnittelussa?	What features should be emphasized most when planning for future?
13	Oletko valmis maksamaan enemmän palvelusta, jos se tarjoaa paremman kestävyyden, mukavuuden tai laadukkaamman suunnittelun?	Are you willing to pay more for a service if it offers better durability, comfort, or quality design?
14	Mitkä teknologiset innovaatiot ovat mielestäsi tärkeimpiä tulevaisuuden asumisessa ikäihmisille?	Which technological innovations do you think are most important for the future of housing for older people?
15	Jos voisit kuvata ihanteellisen ikäihmisten asuinympäristön yhdellä lauseella, mitä sanoisit?	If you could describe the ideal living environment for older people in one sentence, what would you say?

Appendix 3 : Smart Aging project's co-design workshops-Public documents

This annex presents the publicly published online materials related to the Smart Aging project's co-design workshops. All links are open access and publicly available through the Interreg Baltic Sea Region website.

A3.1 Smart Aging Project Overview Page

Interreg Baltic Sea Region. *SmartAging – Project Overview.*Available at: https://interreg-baltic.eu/project/smartaging/

This page provides public information about the project goals, partner organisations, and the role of co-design and piloting activities.

A3.2 Senior Needs Report

Interreg Baltic Sea Region. *Senior Needs Report: Mapping Priorities Across the Baltic Sea Region.*Available at: https://interreg-baltic.eu/project-posts/smartaging/senior-needs-report-mapping-priorities-across-the-baltic-sea-region/
This report summarises early needs-assessment findings that support the workshop activities and user-centred design approach.

A3.3 SmartAging Launch and Co-Design Introduction

Interreg Baltic Sea Region. *SmartAging launches with a collaborative start toward sustainable aging environments.*Available at: https://interreg-baltic.eu/project-posts/smartaging/smartaging-launches-with-a-collaborative-start-toward-sustainable-aging-environments/
This article describes the launch event and the first co-creation activities in the Peliselli and Kokeilimo laboratory environments.

A3.4 Blog Article on Co-Design and Collaboration

Interreg Baltic Sea Region. *Let's imagine Smart Aging as a movement to better aging!* Available at: https://interreg-baltic.eu/project-posts/smartaging/lets-imagine-smartaging-as-a-movement-to-better-aging/
This post introduces the design thinking approach and the collaborative methods used in workshops across partner countries.

Appendix 4. Narrative scenario: daily life of a senior and an expert in 2050

To better contextualize the qualitative characteristics of this future, a regular day for a senior and a healthcare expert has been imagined and describes as follow.

- **Eero, 87 years old, Retired Forest Engineer, Year 2050, Smart-Assisted Apartment, Southeast Finland**

Eero wakes up slowly as the morning light enters his room. It is soft, warm and gentle. The lighting system adjusts itself based on the time of day and Eero's usual sleep rhythm , like other elderlies. He no longer needs bright overhead lights that strain his eyes. The room feels comfortable and calm. The air is fresh because of the plant-based filtration system, which keeps humidity and temperature balanced automatically.

Eero notices that he slept well. His bed had adjusted to relieve pressure from his hips overnight. He does not think about the technology behind it. It simply works and gives him a peaceful start to the day. When he stands up, the floor feels slightly cushioned but stable. This has significantly reduced the risk of falls and protects his joints.

He starts walking towards the bathroom. Couple of steps away and he easily opens the door with a soft sliding mechanism. Inside, everything is designed for comfort and safety: a spacious shower area, rounded edges, slip-resistant tiles, warm lighting and a chair that folds out from the wall. The sink adjusts in height if he wants to sit. Handrails follow natural movement paths, not awkward angles. He always feels confident in this bathroom, unlike the cramped one he had twenty years ago.

After getting dressed, Eero walks to the kitchen. It has a large window that faces a small garden filled with evergreens. Even in winter, the garden provides colour, texture and calmness. The kitchen counter shows his morning wellbeing summary: sleep, hydration, steps and indoor air quality. The icons are simple and friendly. He understands them without stress. He sees a small note from the health hub: “Good morning, Eero. Your sleep pattern improved this week. Would you like to join the afternoon balance class? “He taps “Yes. “It feels good to be included without pressure.

Eero makes tea. The kettle shuts off automatically when the water reaches the right temperature. The handles of utensils have soft grip surfaces. Everything feels designed with care. He sits at his favourite wooden table, made from recycled birch. The surface is warm to touch and antimicrobial. He reads the news on a screen built into the window glass. He can adjust the text size by sliding his finger along the frame.

At 10:00, Eero walks toward the community hub. The path is covered, heated underneath and free of ice. The air smells of pine and fresh earth. Small resting benches are spaced along the walkway, each shaped like smooth stones. He greets a neighbour, Aila, who is also on her way to the hub. They chat briefly about the upcoming music event. Social encounters

like these give him joy. When he arrives, he steps inside a bright open lobby. The floor has natural colours and soft acoustics. He sees other older adults having coffee, chatting, working on crafts or doing morning stretching. The space feels alive but not chaotic. Volunteers and care staff greet him by name. He feels seen. He feels part of something. At 10:30, Eero meets with a digital-inclusion coach. They review his wellbeing icons and talk about the balance class he signed up for. The coach helps him schedule transportation back home later in the day. Everything is simple. He never feels rushed or judged. If he forgets something, the system gently reminds him without sounding like a machine.

Later, Eero attends a short group walk in the indoor winter garden. This space is one of his favourites. It is full of plants, natural light and small water features. The path loops in a circle, allowing people with different mobility levels to participate. A physiotherapist leads the walk, adjusting the pace to everyone's ability. Eero enjoys the smell of herbs and the soft sound of running water. The movement helps his balance and keeps his joints warm.

At noon, he eats lunch at the hub. Meals are served buffet-style with healthy, local and seasonal food. He chooses fish soup, rye bread and berries. The dining area feels like a small restaurant rather than an institution. People sit together, talk, share stories. He often comes here to avoid eating alone at home.

In the afternoon, Eero joins the balance class. The room adjusts lighting and temperature based on group needs. The floor provides gentle resistance to support muscle activation.

The class includes stretching, stepping exercises and slow movement patterns that improve coordination. The instructor gives individual guidance. Eero enjoys the gentle pace and the feeling of achievement after each session.

At 15:00, he visits the wellness commons. Some people knit. Some listen to music. Some do art.

Eero sits near a window, drinking tea and chatting with a friend from his old workplace.

He likes this room because it feels like a living room shared with neighbours. It reduces loneliness and gives him a sense of belonging.

At 16:00 , he returns home with the transport service he scheduled earlier. The vehicle is quiet, emission-free and comfortable. The seat lifts slightly to help him stand safely.

As he arrives home, the entrance light turns on softly. A calm audio cue welcomes him in. During the evening, Eero reads a book. His lamp adjusts to reduce eye strain. He feels safe, calm and supported. The system does not overwhelm him. It respects his pace, his personality and his independence.

Before bed, he looks out at the small garden. He sees the soft glow of lights under the trees.

He thinks about how different life was twenty years ago, more rushed, more fragmented, more lonely. Now, everything works together: the home, the hub, the community, the environment, and the people who support him.

In 2050, Eero lives in a system that values dignity, simplicity, autonomy and connection. A system that listens before it acts. A system where sustainability and care reinforce each other. A system where older adults live not in fear, but in comfort, safety and joy.

- **Aino , 42 years old, Senior Nurse & Community Care Coordinator , Year 2050, Southeast Finland, Community Health Hub**

Aino begins her shift at 8:00.The community health hub is bright, warm and quiet. The building uses low-carbon materials and produces most of its energy through rooftop solar and shared microgrids. Indoor air is clean and stable because of plant-based filtration systems. The space feels calm and safe. When Aino logins to her account, her dashboard loads instantly. The dashboard is user friendly and it does not overwhelm her with data. Instead, it gives a simple overview of the older adults who may need attention today. The system analyses only essential changes such as movement, hydration, sleep quality, mood indicators, and indoor air conditions. Human oversight is mandatory. Algorithms support, but never replace, professional judgement.

Her first visit is with Aino, an 82-year-old woman living in a smart-assisted apartment. The apartment has wide doors, soft rounded edges, anti-slip surfaces and warm lighting. It adjusts temperature and lighting based on Aino’s preferences. Sensors support her safety quietly in the background. Nothing feels “techy. “Nothing feels intrusive.

Aino greets Aino with coffee. They sit at a kitchen table made from recycled wood and antibacterial coatings. The digital wellbeing summary appears on a wall display with simple icons. Aino notices that Aino's nightly rest decreased slightly this week. Instead of medicalising the issue, she invites Aino to join an evening relaxation class at the hub. She also suggests a short walk in the indoor winter garden. Aino agrees. She feels heard, not managed.

Later that day , Aino joins the daily care-coordination meeting. The room is quiet and full of natural light. Professionals from different fields participate: a physiotherapist, social worker, environmental-health specialist, digital inclusion coach and part-time geriatrician. Everyone looks at the same shared dashboard. There are no duplicates and no repeated assessments. The system is finally coordinated. Decisions are made together. Healthcare experts feel supported rather than stressed and exhausted due to workload.

Before lunch, Aino teaches a digital-confidence workshop. Older adults come to practice small tasks: opening video calls, adjusting lighting, checking daily schedules, or reviewing wellbeing icons. The goal is not perfection. The goal is confidence and calmness. The system adapts to each person's abilities. No one is left behind. Digital inclusion is part of dignity.

In the afternoon, Aino visits a redesigned care facility. Bathrooms are now wide and safe. Two caregivers can work together without strain. Handrails follow natural movement paths. Floors are soft underfoot but firm for wheelchairs. Antimicrobial materials reduce cleaning time and infection risk. Every detail improves safety and reduces work stress. Residents say it feels "like a real home, not a hospital."

She checks on Matti, a 90-year-old recovering from a fall. His room faces a small indoor garden. Bird sounds are played softly. Lighting adjusts to his eyes automatically. Aino supports him through a short mobility routine. He smiles. He says the space gives him strength.

Before ending her shift, Aino stops at the "wellness commons. "It is one of the most important spaces in the hub. Older adults come to socialize, paint, cook, stretch, garden, or simply drink tea with others. This space reduces loneliness. It creates connection. It gives people purpose. Aino chats with a group preparing a small choir performance. They laugh together. It feels like community, not care.

At 16:00, Aino logs out. Her digital assistant summarises her day and recommends stretches to avoid back strain. These are small reminders that protect her long-term health. Work is not rushed. Care is not fragmented. Professionals feel valued and supported.

As she leaves, Aino looks at the hub , spreading the feeling of being alive, warm, sustainable, inclusive. She reflects on how different her work felt twenty years ago. Back then, everything was fragmented. There was little time, little coordination and too many digital barriers. Now the system works with people, not against them.