Smarter ageing in place:
Developing a stakeholder-centered framework for smart home technology implementation in clustered VPT housing

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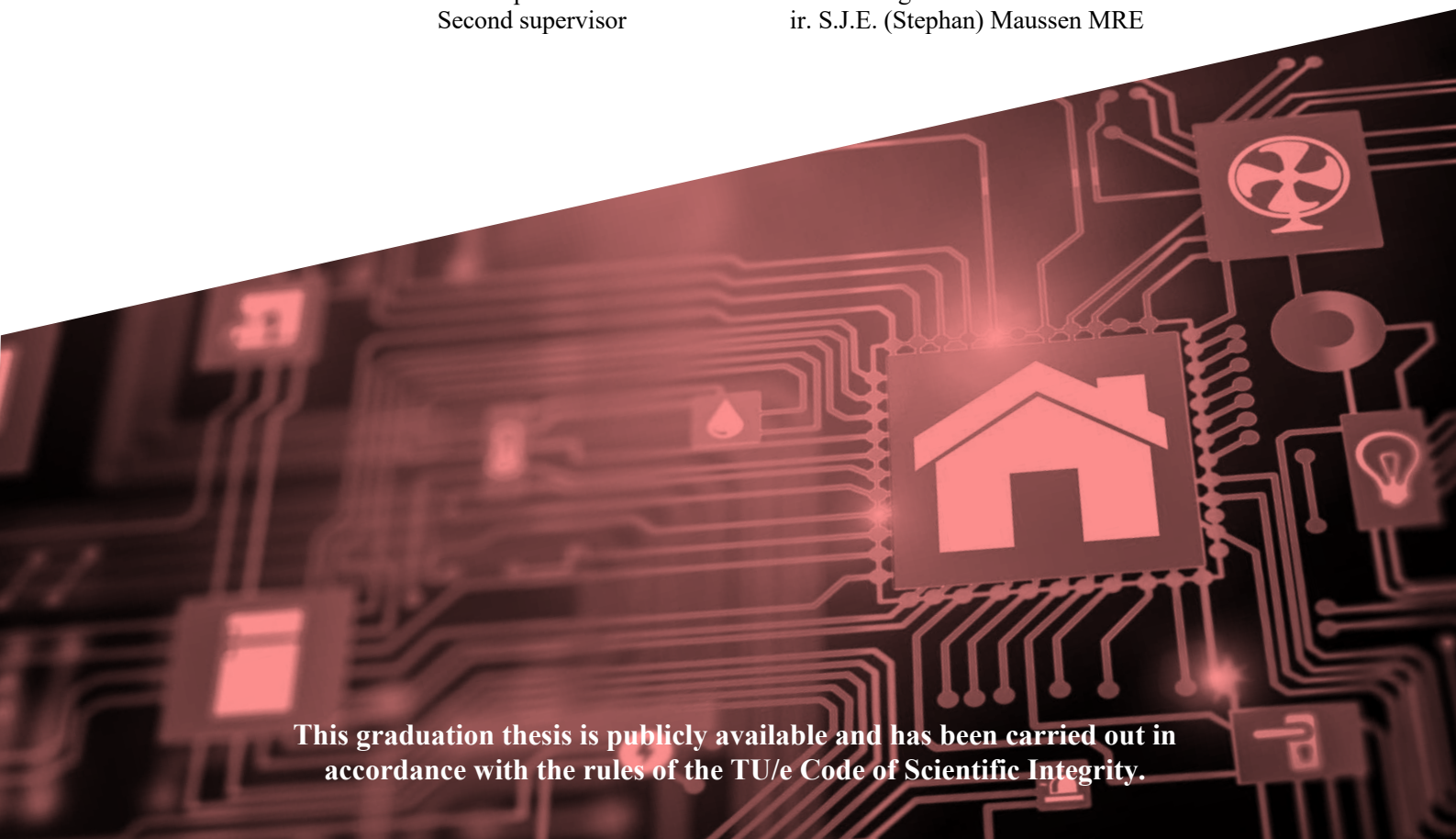

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Preface

This thesis, titled “Smarter Ageing in Place”, was written as part of the final graduation project for the master’s program in Urban Systems and Real Estate and Construction Management & Engineering at Eindhoven University of Technology. The goal of this research is to support the implementation of smart home technology in elderly care environments.
My motivation for this topic comes from a conviction that the built environment has far more to offer than just, bricks and mortar to house people. Buildings shape daily life, and when thoughtfully designed and operated, they can help tackle societal challenges, ranging from public health to sustainability and resource efficiency. In the context of elderly care, I saw the opportunity to incorporate technological possibilities as an integral component of the places where people age. This inspired me to explore how collaborative, process-oriented decision-making can bridge the gap between technical possibility and real-life implementation.
I would like to thank all the experts who generously shared their time, experiences, and perspectives. My heartfelt gratitude goes to my supervisors for their patient guidance and for keeping me motivated when I needed it most. I hope the framework presented here will serve as a stepping stone toward smarter, more efficient implementation of smart home technology easing the care burden and creating environments where people can age with dignity.

This thesis also represents the end of my studies at Eindhoven University of Technology. I would like to thank everyone who has been part of my student life in Eindhoven. Finally, I want to thank my family and friends who have supported me throughout this journey. I hope you enjoy reading this thesis and that it provides you with new insights.

Marijn Heijneman
Eindhoven, June 2025

Table of Contents

Colophon *2*

Preface *4*

Summary *7*

Samenvatting *9*

Abstract *12*

Keywords *13*

List of abbreviations *14*

List of figures *15*

List of tables *16*

Introduction *17*

1.1. Background **17**

1.2. Problem statement **19**

1.3. Research Definition **20**

1.3.1. Research objective 20

1.3.2. Main research question 20

1.3.3. Sub research questions 20

1.4. Research design **20**

1.5. Academic and Societal Relevance **21**

1.5.1. Academic relevance 21

1.5.2. Societal relevance 21

1.6. Reading guide **22**

2. Literature review ***23***

2.1. Introduction **23**

2.2. Care situation in the Netherlands **23**

2.2.1. Challenges in senior care 23

2.2.2. Policy responds 26

2.3. Smart home technology **28**

2.4. Decision-making in healthcare and the built environment **32**

2.4.1. Decision-making process in SHT implementation 33

2.4.2. Barriers and challenges 34

2.5. Stakeholders and interests **35**

2.5.1. Care receivers / seniors 37

2.5.2. Support providers 38

2.5.3. Care workers 39

2.5.4. Care providers 41

2.5.5. Technology providers 41

2.5.6. Building owners / developers 42

2.6. Information management and process modelling **43**

2.6.1. Project life cycle 43

2.6.2. BIM and information management 45

2.6.3. Building smart ... 46
2.6.4. Basic structure of IDM ... 46
2.7. Conclusion ... 48
3. Methodology ... 50
3.1. Introduction ... 50
3.2. Problem investigation ... 51
3.2.1. Expert interviews ... 51
3.2.2. Policy documents ... 54
3.2.3. Data analysis ... 54
3.3. Treatment design ... 55
4. Results ... 58
4.1. Introduction ... 58
4.2. Expert interviews ... 58
4.2.1. Expert overview ... 58
4.2.2. Coding structure ... 59
4.2.3. Current processes ... 60
4.2.4. Barriers ... 66
4.2.5. Solutions to barriers ... 68
4.2.6. Comparison interviews and literature review ... 71
4.2.7. Conclusion ... 72
4.3. Treatment design / model development ... 72
4.3.1. Process phases ... 72
4.3.2. Process mapping ... 73
4.3.3. Flowchart ... 80
4.3.4. Improvements in the current process ... 81
4.4. Conclusion ... 84
5. Conclusion, discussion, limitation, and recommendations ... 86
5.1. Conclusion ... 86
5.2. Academic relevance ... 88
5.3. Societal relevance ... 88
5.4. Discussion and limitations ... 88
5.5. Future recommendations ... 89
References ... 91
Appendix A: Guidebook expert interviews (NL) ... 96
Appendix B: Guidebook expert interviews (EN) ... 99

Summary

The Netherlands is undergoing a significant demographic change, that is marked by a rapidly ageing population. It is expected that by 2040, nearly 40% of the population to be over the age of 65, and the number of individuals aged over 80 will double. Simultaneously, there will be an increase in chronic illness among the elderly. These trends place a large strain on the Dutch Healthcare system, with projections showing a 76% rise in required healthcare staff and a near doubling of care-related expenditures if no structural changes are made. At the same, time there is a growing shortage in the labour market, creating an urgent need for more efficient and sustainable models for care delivery.

In response, the Dutch government has adopted a policy focusing on "ageing in place". This concept allows older adults to continue living in their own homes or communities, even when they have a high care demand. Key to supporting this policy is the Volledig pakket thuis (VPT), which allows individuals with long-term care indication to receive 24-hour care at home instead of being placed in institutional facilities. This VPT care can be delivered in clustered housing arrangements, these are residential complexes where multiple seniors live independently while they share care services. This model emerged as a promising model. It reduces the time care staff spends on travel between clients, improving operational efficiency.

An additional support to the ageing in place, and the VPT model is Smart Home Technology (SHT). SHT consists of a range of interconnected digital solutions embedded in the home environment such as fall detection sensors, access control, lifestyle monitoring and smart lighting. These technologies can improve the safety, autonomy, and quality of life while reducing the workload for caregivers. Despite the potential benefits SHT offers, the adoption of clustered VPT housing is inconsistent and faces several barriers. These include unclear division of responsibilities among different stakeholders, lack of structured decision-making processes, technological fragmentation, and misaligned financial incentives.

This thesis aims to develop a stakeholder-centred process framework to improve the implementation of SHT in clustered VPT housing. The research follows two phases, the problem investigation phase and the treatment design phase. The objective is to provide stakeholders including care providers, real estate developers, technology suppliers, and support providers a transparent, structured process map to guide the planning and implementation of SHT in clustered VPT housing developments.

The first phase of the research involved a comprehensive literature review, covering the current situation in the healthcare market in the Netherlands, by looking further into the demographic trends and challenges for the senior care market. Secondly, the current state of SHT was reviewed by its potential benefits and challenges. The current decision-making practices in health care regarding SHT implementation include stakeholders, roles, responsibilities interests and barriers.

The review revealed that while SHT is widely promoted in policy and practice, it is rarely embedded within a structured implementation path. Common barriers include knowledge gaps among decision-makers, a lack of interoperability among technologies, unclear funding responsibilities, and insufficient stakeholder engagement in the early project stages.

To validate, and deepen these insights, the second phase of the research consisted of expert interviews, which were analyzed using thematic analysis. Experts were selected from various

sectors, including care organizations, real estate developers, technology providers and support providers. The interviews confirmed that the current implementation process of SHT is fragmented, with unclear responsibilities regarding the process of decision-making.

Many experts acknowledged the potential benefits of SHT but expressed hesitation to invest, reasons for this are the high costs and lack of sufficient funding. Additionally, the experts emphasized the need for a structured decision-making tool to align the stakeholder expectations and clarify roles throughout the implementation process.

Beyond the barrier identification, the interviews also formed the foundation for the development of the process model. The experts indicated that the SHT implementation process could be divided into five key phases: Development of a program of requirements, technology (supplier) selection, installation, operation and maintenance and cost allocation phase. The interviewees clarified which stakeholders are involved at each stage and what their responsibilities entail. Frequently mentioned actors included care organizations, developers, technology suppliers, care staff and support providers.

In addition to mapping the existing process and its stakeholders, the interviewees proposed several improvements. These included increased subsidies, early involvement of all relevant stakeholders, and early-stage financial planning and discussion to determine the financial impact and responsibilities.

Based on these interview results, A BPMN-process map was developed to address the identified issues. The process map is divided into the same 5 phases and defines key decision points, required deliverables, and expected stakeholder contribution in each phase. It is intended as a tool that stakeholders can adapt to specific contexts while benefitting from a consistent structure. By clarifying who is responsible for which actions and when, the process map should facilitate better coordination throughout the SHT implementation process.

This thesis makes both academic and societal contributions. Academically, it fills a gap in the literature by integrating collaboration, healthcare technology and stakeholder management into a framework. Where most existing studies focus on the technology acceptance or technical feasibilities of SHT.

On a societal level, the framework proposes to help accelerate the implementation of SHT in clustered VPT housing, contributing to a more resilient and sustainable care system. By facilitating a more efficient implementation process, reducing the burden on care workers, and improving the quality of life for older adults.

Future work could focus on testing the framework in real-world development projects to assess its impact on project outcomes, refine its usability, and explore opportunities for integration with national health policy instruments or digital care platforms.

Samenvatting

Nederland ondergaat een demografische verandering, met een sterk vergrijzende bevolking, naar verwachting zal tegen 2040 bij 40% van de bevolking ouder zijn dan 65 jaar, en het aantal mensen ouder dan 80 zal ook verdubbelen. Tegelijkertijd zal het aantal ouderen met een chronische aandoening ook toenemen. Deze ontwikkelingen leggen een grote druk op het Nederlandse zorgsysteem. Prognoses geven aan dat er een stijging van 76% in het benodigde zorgpersoneel zal zijn en dat de zorguitgaven bijna zullen verdubbelen als er geen structurele veranderingen worden doorgevoerd. Tegelijktijdig is er sprake van een groeiend tekort op de arbeidsmarkt, wat een dringende behoefte creëert aan efficiëntere en duurzamere zorgmodellen.

Als reactie op deze ontwikkelingen heeft de Nederlandse overheid een beleid ontwikkeld dat zich richt op “langer zelfstandig thuis wonen”. Dit stelt ouderen in staat om in hun eigen huis of buurt te blijven wonen, zelfs wanneer zij een hoge zorgbehoefte hebben. Een belangrijk instrument ter ondersteuning van dit beleid is het Volledig Pakket Thuis (VPT), waarmee mensen met een indicatie voor langdurige zorg 24-uurszorg aan huis kunnen ontvangen in plaats van in een intramurale instelling te worden opgenomen. Deze VPT-zorg kan ook worden geleverd in geclusterde woonvormen: wooncomplexen waar meerdere ouderen zelfstandig wonen, terwijl ze gedeelde zorgdiensten ontvangen. Dit model is veelbelovend gebleken, omdat het de reistijd van zorgpersoneel tussen cliënten vermindert en de operationele efficiëntie verbetert.

Als aanvulling op het langer zelfstandig thuis wonen en het VPT-model is er slimme woningtechnologie (Smart Home Technology, SHT). SHT bestaat uit een reeks digitale oplossingen die zijn geïntegreerd in de woonomgeving, zoals valdetectiesensoren, toegangscontrole, leefstijlmonitoring en slimme verlichting. Deze technologieën kunnen de veiligheid, autonomie en kwaliteit van leven verbeteren, terwijl ze tegelijkertijd de werkdruk voor zorgverleners verlagen. Ondanks de potentiële voordelen is de toepassing van geclusterde VPT-woningen met SHT inconsistent en stuit op diverse obstakels. Deze omvatten een onduidelijke verdeling van verantwoordelijkheden tussen de verschillende betrokkenen, een gebrek aan gestructureerde besluitvormingsprocessen, technologie die niet op elkaar is afgestemd en niet op elkaar afgestemde financiële prikkels.

Dit onderzoek heeft als doel een stakeholder-gericht proceskader te ontwikkelen om de implementatie van SHT in geclusterde VPT-woningen te verbeteren. Het onderzoek bestaat uit twee fasen: de probleem analysefase en de oplossingsontwerpfase. Het doel is om stakeholders, waaronder zorgaanbieders, projectontwikkelaars, technologieaanbieders en mantel zorgers , een transparant en gestructureerd stappenplan te bieden dat hen begeleidt bij de planning en uitvoering van SHT in geclusterde VPT-projecten.

In de eerste fase van het onderzoek is een uitgebreide literatuurstudie uitgevoerd naar de huidige situatie op de zorgmarkt in Nederland, met aandacht voor demografische trends en uitdagingen binnen de ouderenzorg. Vervolgens is de huidige stand van zaken van SHT geanalyseerd, inclusief de potentiële voordelen en belemmeringen. Ook is gekeken naar bestaande besluitvormingen rond de implementatie van SHT in de zorg, met aandacht voor betrokken stakeholders, hun rollen, verantwoordelijkheden, belangen en obstakels.

De literatuurstudie liet zien dat hoewel SHT veel wordt gepromoot in beleid en praktijk, het zelden wordt toegepast in een gestructureerde implementatie. Veelvoorkomende

belemmeringen is het gebrek aan kennis bij besluitvormers, een gebrek aan interoperabiliteit tussen technologieën, onduidelijkheid over financieringsverantwoordelijkheden en onvoldoende betrokkenheid van stakeholders in de vroege projectfasen.

Om verder te gaan met deze inzichten en deze te valideren, is in de tweede fase van het onderzoek een reeks expertinterviews gehouden en geanalyseerd via thematische analyse. De experts kwamen uit verschillende sectoren, waaronder zorgorganisaties, projectontwikkelaars, technologieaanbieders en ondersteuningsorganisaties. Uit de interviews bleek dat het huidige implementatieproces van SHT gefragmenteerd is, met onduidelijkheden over verantwoordelijkheden in het besluitvormingsproces.

Veel experts erkenden de potentiële voordelen van SHT, maar gaven aan terughoudend te zijn met investeringen vanwege de hoge kosten en het ontbreken van voldoende financiering. Ook benadrukten zij de behoefte aan een gestructureerd besluitvormingsinstrument om verwachtingen van stakeholders op elkaar af te stemmen en rollen tijdens het implementatie proces te verduidelijken.

Naast het in kaart brengen van knelpunten, vormden de interviews de basis voor de ontwikkeling van het procesmodel. De experts gaven aan dat het implementatieproces van SHT verdeeld kan worden in vijf hoofdfasen: het opstellen van een Programma van Eisen, selectie van technologie en leveranciers, installatie, gebruik en onderhoud, en kostenverdeling. De geïnterviewden lichtten toe welke stakeholders in elke fase betrokken zijn en welke verantwoordelijkheden zij dragen. Veelgenoemde actoren waren zorgorganisaties, project ontwikkelaars, technologie aanbieders, zorg medewerkers en mantel zorgers.

Naast het in kaart brengen van het bestaande proces en de betrokken partijen, deden de geïnterviewden ook suggesties voor verbeteringen. Deze omvatten het verhogen van subsidies, vroege betrokkenheid van alle relevante stakeholders, en financiële planning in een vroeg stadium om de financiële impact en verantwoordelijkheden vast te stellen.

Op basis van de interviewresultaten is een BPMN-process map ontwikkeld om de gesignaleerde knelpunten aan te pakken. Deze proceskaart is opgedeeld in dezelfde vijf fasen en beschrijft belangrijke beslismomenten, benodigde output en verwachte bijdragen van stakeholders per fase. De kaart is bedoeld als hulpmiddel dat aanpasbaar is aan specifieke contexten, maar tegelijkertijd structuur biedt. Door te verduidelijken wie waarvoor verantwoordelijk is en wanneer, moet de proceskaart bijdragen aan betere coördinatie tijdens de implementatie van SHT.

Dit onderzoek levert zowel een academische als maatschappelijke bijdrage. Academisch vult het een leegte in de literatuur door samenwerking, zorgtechnologie en stakeholdermanagement te integreren in één kader. Waar bestaande studies zich vaak richten op technologische acceptatie of technische haalbaarheid, biedt dit onderzoek een procesmatige en organisatorische benadering.

Op maatschappelijk niveau draagt het kader bij aan het versnellen van de implementatie van SHT in geclusterde VPT-woningen, en daarmee aan een veerkrachtiger en duurzamer zorgsysteem. Het biedt handvatten voor een efficiënter implementatieproces, vermindert de druk op zorgverleners en verhoogt de kwaliteit van leven voor ouderen.

Toekomstig onderzoek kan zich richten op het testen van het kader in praktijkprojecten, het evalueren van de impact op projectresultaten, het verfijnen van de bruikbaarheid en het onderzoeken van integratiemogelijkheden met nationaal zorgbeleid of digitale zorgplatforms.

Abstract

The Netherlands is facing growing pressure on its healthcare system due to an ageing population. In response, the national policy emphasizes “ageing in place” allowing older adults to receive care at home through arrangements like Volledig Pakket (VPT). Clustered VPT housing is where seniors live in dedicated residential complexes with access to shared care services, offering an efficient alternative to institutional care or care at home. Smart Home Technology (SHT) can enhance this by improving autonomy, safety and care efficiency. Despite the availability and benefits of technology, SHT adoption in clustered VPT settings remains limited. Previous research largely focused on technological feasibility and user acceptance, leaving a gap in understanding the organizational barriers to implementation.

This study investigates how stakeholder roles, decision-making criteria, and process-related challenges influence SHT implementation in clustered VPT housing, with the aim of developing a practical process framework. For this research, a literature review was combined with interviews with experts from the care, housing, and technology sectors. Findings indicate that implementation is often fragmented and hindered by unclear responsibilities, misaligned incentives, and a lack of planning.

To address these barriers, a five-phase process framework was developed using the Business process model notation (BPMN) based on the input from the expert interviews and literature study. The phases include the development of the program of requirements, technology (supplier) selection, design and installation, operation and maintenance, and cost allocation. Each phase specifies stakeholder roles, decision points and deliverables, offering a structured and transparent approach to what is often an unorganized process.

The framework contributes academically by shifting the focus from technical solutions to the process dynamics of stakeholder collaboration, thereby addressing a gap in the literature. It also offers practical value by enabling stakeholder to align their roles, reduce risks, and improve the implementation process. However, the model has not yet been validated in a real-world setting, limiting its current applicability. Future research should focus on empirical testing through pilot projects, allowing for practical validation. This would be essential for transforming the theoretical framework into a practical framework for the successful implementation of SHT in clustered VPT housing.

Keywords

Smart Home Technology, Collaboration, Stakeholders, Clustered VPT, Process Mapping

List of abbreviations

SHT	–	Smart home technogy
VPT	–	Volledig pakket thuis
BPMN	–	Business process modelling notation
WLZ	–	Wet langdurige zorg.
ZvW	–	Zorgverzekerings wet
WmO	–	Wet Maatschappelijke ondersteuning
OMG	–	Object management group
CAK	–	Centraal administratie kantoor
ROI	–	Return on investment

List of figures

Figure 1 Organization of VPT Care (NzA, 2023).....18
Figure 2 Categories of smart home technology(Chabot et al., 2019).....18
Figure 3 Cost allocation VPT (KPMG, 2022).....19
Figure 4 Design cycle (Wieringa, 2014).....21
Figure 5 Population composition on age and gender 1970 and 2020 (Gopal et al., 2022).....24
Figure 6 Population development age groups 2020-2050 (Gopal et al., 2022).....24
Figure 7 % care cost related to GDP (IBO, 2023).....25
Figure 8 Own contribution(IBO, 2023).....25
Figure 9 Organization of the healthcare laws in the netherlands.....27
Figure 10 Organization of VPT care (CZ zorgkantoor, 2023).....28
Figure 11 Overview smart home technology(Chabot et al., 2019).....29
Figure 12 Smart home modification process (Ma et al., 2022).....33
Figure 13Project life cycle.....43
Figure 14 Macleamy curve (Johnson et al., 2004).....44
Figure 15 Informationloss by disruptions in the information flow(Borrmann et al., 2018).....45
Figure 16 Little BIM and big BIM (Volk et al., 2014).....45
Figure 17 IDM components(Wix & Karlshøj, 2010).....46
Figure 18 Design cycle by Wieringa.....50
Figure 19 Power-interest diagram (source).....53
Figure 20 Simplified implementation process.....73
Figure 21 Development of POR.....74
Figure 22 Tender Bidding.....75
Figure 23 Supplier selection.....77
Figure 24 Design and installation phase.....78
Figure 25 Process operation / maintenance phase.....79
Figure 26 Cost allocation model.....80
Figure 27 Improved phase 1 Development of program of requirements.....82
Figure 28 Improved cost allocation.....84
Figure 29 Schematic overview implementation process.....86

List of tables

Table 1 Cost of long-term senior care in the Netherlands (RIVM, 2022) 25
Table 2 Increase care demand (Gopal et al, 2022) 26
Table 3 Technologies and their costs and benefits (Drost et al., 2021) 30
Table 4 Roles and responsibilities (KPMG, 2022) 35
Table 5 Actors and activities (Sponselee, 2008) 35
Table 6 Actors and activities (Guo et al, 2021) 36
Table 7 roles, actors and activities Value network (Ehrenhard et al., 2014) 36
Table 8 Stakeholder summary 37
Table 9 Senior overview 38
Table 10 Support provider overview 39
Table 11 Care workers overview 40
Table 12 Care providers overview 41
Table 13 Technology providers overview 42
Table 14 Common business process modelling methods (TUE, 2020) 47
Table 15 Stakeholders 52
Table 16 Criteria 53
Table 17 Interviewee information 58
Table 18 Frequency analysis of themes 59
Table 19 Summary Phase 1 61
Table 20 Summary sub-process 2 62
Table 21 Summary sub-process 3 63
Table 22 Summary cost allocation 64
Table 23 Summary operation / maintenance 65
Table 24 Barriers in current process 66
Table 25 Solutions to the barriers 68
Table 26Summary Barriers and solutions 70
Table 27 Overview improvements current process 81

Introduction

The Netherlands is undergoing a demographic transition, characterized by a rapidly ageing population. Projections indicate that by 2040, approximately 40% of the population will be aged 65 years and older, while the number of individuals aged above 80 will double over the same period (CBS, 2020). Besides that, the incidence of chronic diseases among the elderly is expected to rise significantly (Menting et al., 2019). If the current healthcare policies remain unchanged, the demand for care staff in senior care will increase by 76% from 2020 to 2040(Gopal et al., 2022), accompanied by a doubling of senior care-related expenditures. (RIVM, 2022). The addition of these stats presents urgent challenges for the Dutch senior care market, especially in financial sustainability and labour shortages.
(RIVM, 2022)

1.1. Background

Recent reports have shown the large challenges that society faces due to elderly care. Research of TNO has predicted that without any policy changes, the demand for institutional nursing spaces will double by 2040 (Hinkema et al., 2019). Multiple reports and research's highlight that the current organization of care is unsustainable, and policies must change (Centraal Planbureau, Ministerie van Volksgezondheid & Financiën., 2020).

The expenses to long term care and support in the Netherlands are relatively high compared internationally, the difference with other countries will only increase in the coming years, since the Netherlands is at the start of the ageing wave, compared to other countries. The care in the Netherlands is also relatively expensive, since housing, meals, and support activities in the intramural care(Kruse et al., 2021).
To address some of the challenges related to the ageing population and shortages on the labor market, the Dutch government has shifted its policy focus towards ageing in place. Ageing in place is defined as allowing older adults to remain in their own homes and communities for as long as possible, even if they become vulnerable (Gobbens et al., 2018). This approach not only realizes a cost reduction for institutional care, but it is also the preferred option for a large share of the elderly individuals (De Witte. et al., 2012)
Ageing in place is not as simple, as elderly just living in their own home, but various arrangements, can be used for this. Such as seniors living independently in their homes, or seniors moving to senior-specific housing, or seniors receiving 24-hour care at home through clustered living concepts. The policy shift towards ageing in place is supported by the introduction of the Long-term care act in the Netherlands (Wlz) introduced in 2015, which provides funding options for receiving care at home, and thus prompting the growth of private care homes in the Netherlands.

Part of the Wlz law is Volledig Pakket thuis (VPT), this aims to separate care from housing and increase the diversity of living situations for care dependent elderly. This policy is in line with the goal of ageing in place, allowing care providers to deliver the same 24-hour care at home that normally only was available in institutional settings, there are multiple models in which VPT can be implemented:

1. **Unclustered VPT:** Care is provided to clients living in different buildings across various streets.
2. **VPT Linked to Nursing Home**: Care is provided in or near a nursing home, such as in sheltered housing or a neighboring complex.
3. **VPT in Residential Complex**: Care is provided in a residential complex housing both care recipients and non-recipients.

4. **Clustered VPT:** Care is exclusively provided in a residential complex dedicated to VPT

(Actiz, 2023) A schematic overview of these VPT models is shown in Figure 1.

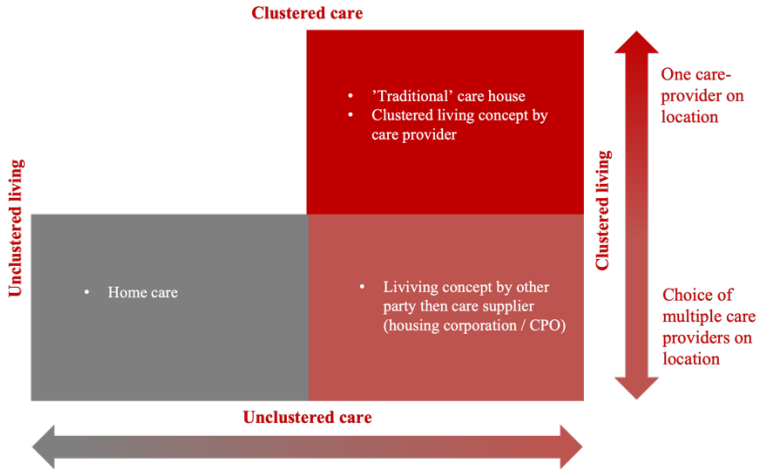


Figure 1 Organization of VPT Care (NzA, 2023)

Research from VU Amsterdam indicated that elderly with a Wlz indication receiving VPT care tend to live longer, at lower daily care costs compared to those who receive institutional care (Portrait & Koolman, 2021)

Home nurses spend around 25% of their working time travelling between clients, time that could be better utilized in direct care if clients were clustered in one location. Clustering senior housing can significantly save FTEs for care organizations, allowing nurses to focus on medical tasks. Doubling the share of clustered senior housing by 2031 could reduce staff shortages by approximately 9,000 FTE(KPMG, 2022)

To support the elderly to live more independently in their own place, the rise of smart technology offers promising solutions. These smart home technologies can be divided into four categories: sensor systems, wearable technology, information, and communication technologies and SHT (Chabot et al., 2019)

1. Wearable technology: these include devices such as hearing aids and smartwatches that monitor vital signs and body movements to prevent functional decline.
2. Information and communication technologies: devices like iPads can reduce social isolation among seniors, although this falls outside the scope of the built environment
3. Technologies like smart thermostats, locks and lighting can enhance the independence of seniors and reduce the workload on care staff.
4. Sensor technology: these are systems that monitor daily routines and detect emergencies, this can minimize costly hospitalization and provide crucial data to caregivers and family members.

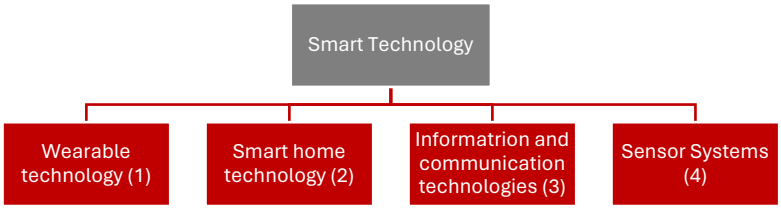


Figure 2 Categories of smart home technology(Chabot et al., 2019)

With optimal use of potential 15.5 million hours of health care for seniors can be saved over the next decade (Ponds et al., 2022) the Dutch research institute Vilans has researched the cost and benefits of SHT in care organizations, highlighting the hard and soft benefits of these systems (Majumder et al., 2017)

Despite the many benefits of SHT for senior care have been proven there are significant challenges in its implementation. Especially in VPT settings. It is often unclear who is responsible for the implementation, care providers, real estate investors, or clients. Since benefits are spread across these stakeholders, this creates a principal-agent problem. This makes the funding complex, and there is also no systematic decision-making. Currently, implementation is often done by rules and guidelines rather than evidence-based decision-making, with many unknowns about actual costs and benefits.(van der Kuil et al., 2021)

Research of KPMG identified the stakeholders involved in the development of clustered VPT housing, these stakeholders include investors, care provides, municipalities, care offices, VWS, BZK and the care recipients themselves. Effective collaboration and clear division of responsibilities among these stakeholders is essential for successful implementation for clustered VPT Housing concepts (KPMG, 2022), as can be seen in the figure below, there are multiple options what party is responsible for the financial payments of the housing.

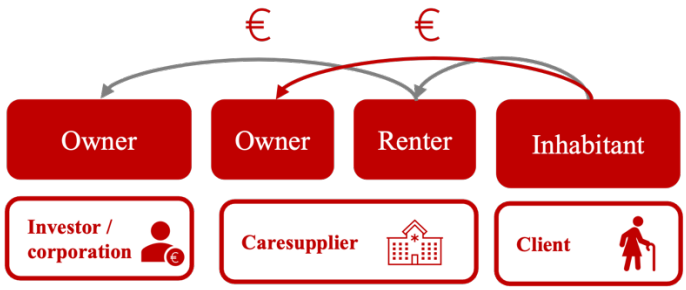


Figure 3 Cost allocation VPT (KPMG, 2022)

The increasing demand for care housing due to population ageing presents opportunities for investors. The healthcare real estate market offers a stable Return on investment (ROI), and a resilience investment that goes against economic fluctuations. However new developments are often halted due to staffing shortages, this situation highlights the need for innovative housing solutions that support seniors' independence and reduce the workload on care staff. Investors can play a crucial role by developing clustered housing concepts with integrated SHT (Bouwinvest, 2023).

1.2. Problem statement

As discussed in the research background, the problem is that with the current pace of ageing, the current care system will reach its limits with not only the budget being a limiting factor. But also, with shortages in staffing. This is not just a problem for the seniors and the care sector, it is a societal challenge that needs to be tackled.

With ageing in place and the VPT a big step in relieving pressure on the intramural care is made. But there is still room for improvement. Despite the proven benefits on smart home technology for senior care, and this is especially the case for VPT care, the implementation of

such technology is lacking whereas institutional care experience less problems with the implementation of technology. (NZA, 2022). Where it is unclear, which party is responsible for the implementation, the care supplier, the real estate investor, or the client. Since the benefits can be spread across the different users. Another Struggle in the implementation process is the different fundings for the government, that makes it unclear, which party pays for what and how. Overall, the process of implementing SHT is unorganized, and stakeholders do not know how to follow up steps.

1.3. Research Definition

1.3.1. Research objective

The main objective of this research is to improve the implementation process regarding smart home technology in clustered VPT housing in the Netherlands. This improvement will be achieved by getting a better understanding of the current process and its challenges. The goal is to map out the current process.

1.3.2. Main research question

Research has shown that in most cases there is no systematic decision-making process for implementing smart home technology for care housing. The implementation is often not supported by evidence but decided on rules and guidelines, with a lot of unknowns about, the real costs of purchase, maintenance, timesaving, or the real benefits of the technology. To address this problem and promote the implementation of SHT in clustered VPT housing, and to develop a process framework. The following research question is formulated:

"How can a process map be developed to support stakeholders in understanding and improving the implementation process of smart home technologies in clustered VPT senior care housing?"

1.3.3. Sub research questions

The goal of this process map is to provide a universally applicable approach to the implementation of SHT for clustered VPT housing. This is done by developing a modelled process. The input for this will consist of an extensive literature study on the current decision process, the stakeholders and their interests, and the current state of technology. Combined with expert input to see if the literature covers all the relevant aspects. Based on these the following research questions are formulated.

1. What Smart home technology is available?
2. How are decisions currently made in SHT implementation? Which stakeholders are involved and what are the barriers and interests?
3. How can stakeholders, criteria, roles, be translated into a practical process map framework to overcome the barriers?

1.4. Research design

This research aims both at identifying what the problems are in the current implementation processes and providing a useful tool that can help decision-makers solve these problems. The research method that will be used is the design science methodology (Wieringa, 2014). This approach aims to develop and evaluate innovative solutions to real-world problems. It is a problem-solving approach. That involves creating and evaluating artefacts (tools) to address the problem at hand. The Design cycle consists of the problem investigation phase, treatment design, and treatment validation. As can be seen in Figure 4 below.

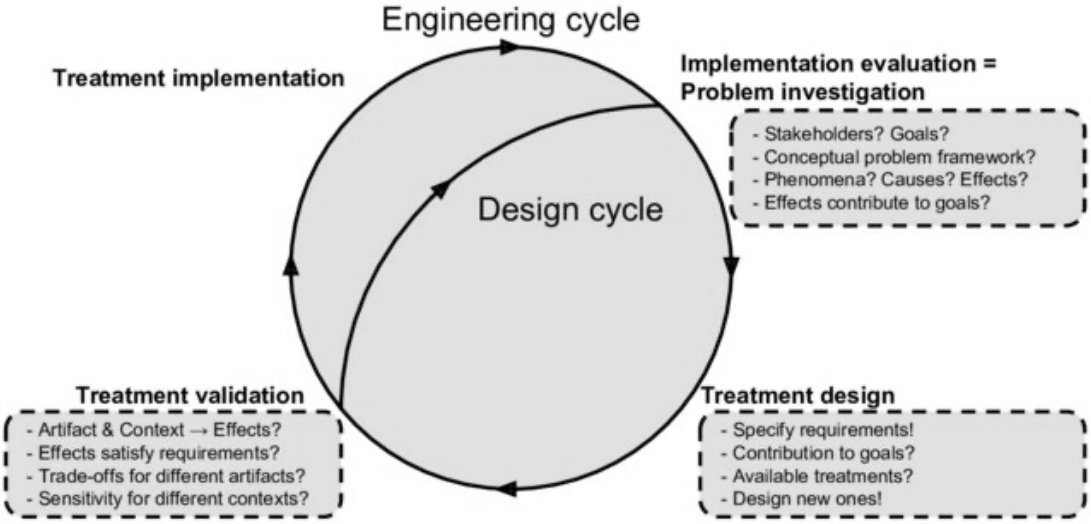


Figure 4 Design cycle (Wieringa, 2014)

So this research is divided into three parts that are visualized in the conceptual model in Figure 4, the First phase is the problem investigation, here a literature review is combined with expert interviews to complement if in the found literature nothing was missed, this will result in a clear insight of the current decision process, and the barriers found along the way. Also, the stakeholders and their main interests will be identified. Based on the findings in this problem investigation, the specific requirements for the tool are defined. With these requirements, the tool will be developed. To round up the research a conclusion, discussion and recommendation for further research will be given.

1.5. Academic and Societal Relevance

1.5.1. Academic relevance

The topic of SHT in senior care has been researched from multiple perspectives, such as the technology acceptability of the elderly (McCreadie & Tinker, 2005), the labour-saving effects of SHT (Voor & Deel, 2021) and the benefits for elderly users (Tian et al., 2024) However, a topic that remains underexposed in research is how the different stakeholders collaboratively make decisions in health care real estate. By researching how these stakeholders can collaborate. A step can be made to improve the quality of life of seniors, and the quality of work for the caring staff.

1.5.2. Societal relevance

The ageing population in the Netherlands has a large societal impact, with the elderly population increasing, so does the demand for health care services and long-term care. By helping decision-makers implement SHT impact can be made on several societal challenges:

Most importantly the quality of life for the elderly, by enabling older adults to age in place. Seniors prefer to stay in familiar surroundings, which contributes to their emotional and physical well-being. Developing effective strategies to support this with technology will improve overall life satisfaction among seniors.

Secondly, there is a large financial impact of increasing care needs, By 2040 the expenses of senior care are expected to double, which is unsustainable to carry by the working population.

Finding cost-effective solutions by integrating smart technologies can help to manage these rising costs and ensure that the health care system remains affordable.

The anticipated 76% increase in demand for care staff (Gopal et al., 2022) cannot be carried by the shortage in the labour market, so there is a need for innovative solutions. Addressing this challenge is vital to prevent a crisis with staffing shortages.

1.6. Reading guide

This chapter (Chapter 1) introduced the research context, problem statement and research questions regarding the development of a process map framework regarding the implementation of SHT in clustered VPT housing. Chapter 2 presents the literature review in 5 parts, first diving deeper into the context of the current senior care situation in the Netherlands and secondly investigating the current state of the art of smart home technology, the third section describes how decision-making is currently done regarding the SHT, with the involved stakeholders, and what barriers arise. Lastly, some common decision-making methods and tools, that are used in the built environment are reviewed. After the literature review, the methodology is described. In this section, it is explained how the interviews are conducted and analysed, and how the results are transformed into a process map. In Chapter 4 this process map development is done systematically and lastly, chapter 5 concludes the research, by providing a critical reflection and recommendation for future research.

2. Literature review

2.1. Introduction

To develop a tool that stakeholders can use for the implementation of smart home technology in clustered VPT housing, the research begins with creating a broader understanding of the context in which the framework will be applied. This requires a review of several key topics, that influence the current decision-making process for technology implementation in the senior care housing.

The first section of this literature review explores the current state of the senior care market in the Netherlands, with a focus on demographic trends, shortages in the workforce, and the current government policies regarding senior care. This provides the necessary background to get a better understanding of the challenges and pressure that this sector faces. The second section focuses on Smart home technologies themselves, offering an overview of the types that are currently available on the market, as well as their reported benefits and barriers related to their implementation in the senior care setting. The third section investigates the decision-making processes involved in the implementation of such technologies. This includes an analysis of the key stakeholders, influential factors, and challenges.

Finally, the literature review addresses broader decision-making processes in the built environment, offering insights into how complex multidisciplinary decisions are made. Together, these sections provide a comprehensive foundation for the development of a contextually informed and practical relevant tool.

2.2. Care situation in the Netherlands

Understanding the current situation of the senior care market in the Netherlands is essential for the relevance and role of SHT within this sector. As the amount of elderly keeps growing and the demand for long-term care increases, the existing care is under a large strain. This section provides an overview of the key challenges shaping this care landscape, including demographic trends, structural features of the care system, staffing shortages and governmental policies. By outlining these conditions, this section creates a better understanding of the urgency and opportunity for innovation.

2.2.1. Challenges in senior care

Ageing population and demographic shift

An important factor behind the increasing demand for elderly care and housing is the demographic composition of the Dutch population. Figure 5 shows this composition in 1970 and 2020. In both parts of the figure, the age groups of 1946-1970 are marked. People born between 1946 and 1955 are generally referred to as baby boomers and are part of the Western European baby boom following the end of World War II. The birth rate in the Netherlands also remained relatively high during the period from 1955 to 1970. Due to the introduction of the pill and the increased labour participation of women, the yearly number of births has sharply decreased since then. These developments not only impact the age structure of the population but will continue to do so in the coming years(Gopal et al., 2022).

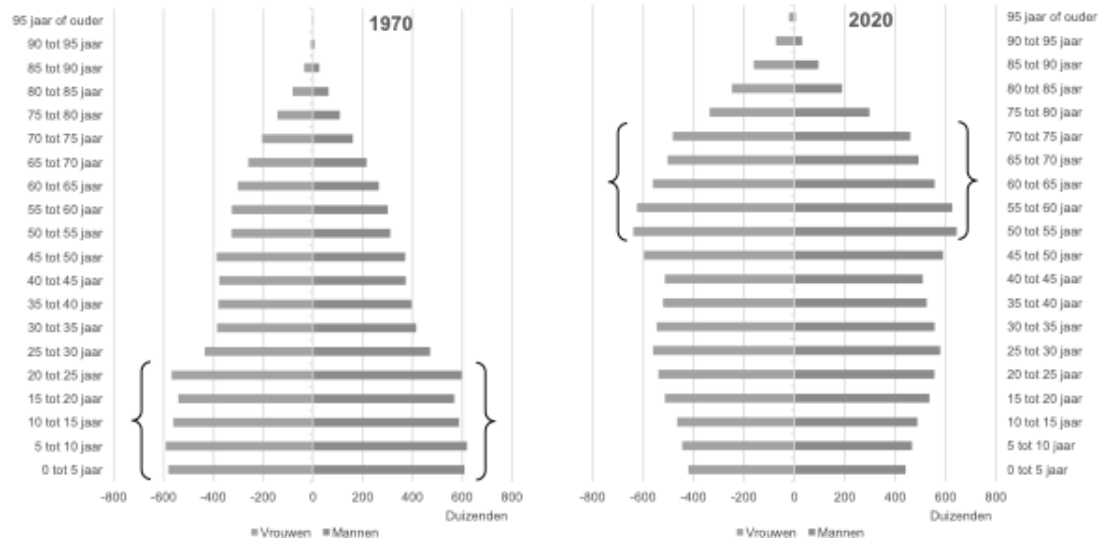


Figure 5 Population composition on age and gender 1970 and 2020 (Gopal et al., 2022)

In 1970 the birth cohort 1946-1970 belongs to the age group 0 – 25 years and forms the bottom of the so-called population pyramid. This cohort concerns on that moment 45% of the total Dutch population. In 2020 the pyramid shape changed into an egg shape, the cohort now belongs to the age group 50-76 and still makes up for the largest part of the population. The percentage of 65+ has changed between 1970 to 2020 from 10% to 19% of the total population. At the same time, in the last 50 years, the natural birth has reduced as well.
In the demographic Primos prognosis, an increase in the national population between 2020 and 2050 of 1,26 million persons is assumed. It is expected that this growth in the coming 30 years is 85% due to a positive migration saldo, and only 15% will be due to natural birth. For comparison the last 30 years, the population increased by 2.5 million of which 58% was from natural birth.

The prediction population growth will not be equal for all age groups. The biggest growth is expected in the group of 75 +, the two oldest groups from Figure 6, which will almost double from 1,45 to 2,97 million persons (Gopal et al., 2022).

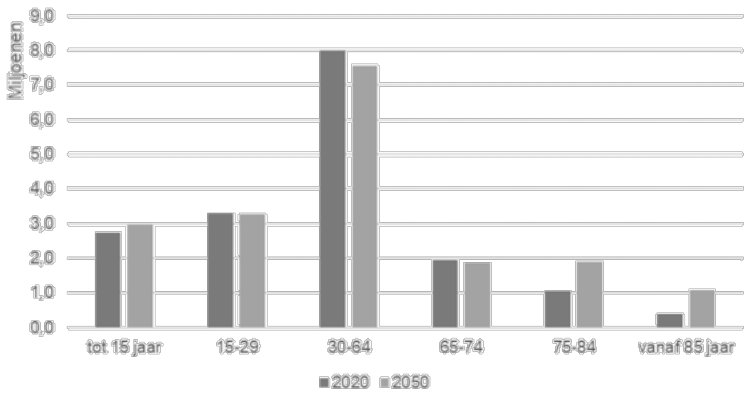


Figure 6 Population development age groups 2020-2050 (Gopal et al., 2022)

Financial sustainability care

This demographic development also has an impact on the care demand, since with people getting older, the demand for care also increases. It is predicted that by 2040, the number of people with chronic diseases will double This increase of people needing care also has an impact on the financial sustainability of senior care.

The Ministry of Volksgezondheid predicted what the care costs would do over the coming years. By unchanged policy, the care costs increase from 2.3% of the GDP in 2021 to 3,6 % of the GDP in 20240. 80 % of this increase is due to the demographic change. Table x shows how to cost will rise in the coming years in numbers (RIVM, 2022).

Table 1 Cost of long-term senior care in the Netherlands (RIVM, 2022)

Cost of senior care total	
Year	***Cost senior care (mld €)***
2021	*19.994*
2030	*28.135*
2040	*39.334*

The spending on long-term care in the Netherlands is relatively high even when compared to other countries, see Figure 7 in addition to this the contribution out of own pockets is relatively low see Figure 8. This difference in long-term care and expenditures is only set to increase further in the coming years, as the Netherlands is only at the beginning of the ageing wave, compared to other countries. One explanation for these high costs is partly the high number of institutional care beds. This is relatively expensive because of the housing, meals, and various support activities (IBO, 2023) .

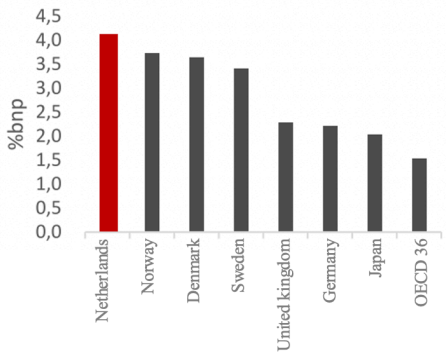


Figure 7 % care cost related to GDP (IBO, 2023)

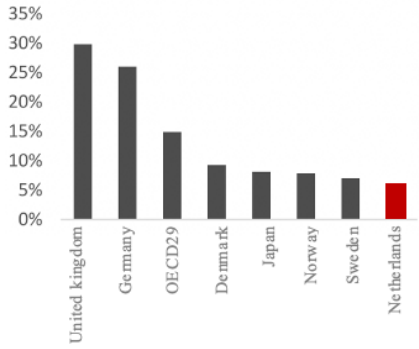


Figure 8 Own contribution(IBO, 2023)

Staff shortages and workforce pressure

With an unchanged policy of the Dutch government, the demand for labour and care for seniors will increase. For labour demand will increase from 482.000 in 2020 to 849.000 in 2040. While the working population does not change that much at all over the same period. The share of elderly care in the working population will increase from 4,14 % to 7,27 % (IBO, 2023) The biggest growth of clients with care will be in ZZP 4, ZZP 5 and ZZP 4.

Table 2 Increase care demand (Gopal et al, 2022)

Care demand for senior care		
% Increase compared to 2021	***2030***	***2040***
Labor demand (in persons)	*40%*	*76%*
Working population	*2%*	*-2%*
Care demand in amount of clients	*36%*	*70%*
- *Amount of client's home care*	*28%*	*56%*
- *Amount of domestic help*	*30%*	*57%*
- *Amount of client VV*	*44%*	*97%*
Care expenses senior care	*41%*	*96%*

2.2.2. Policy responds

Ageing in place

To cope with the challenges of an increasingly ageing population, increasing care demand, rising care costs and shortages in the labour market for care staff. The Dutch government changed their policy on care for seniors. Motivating older people to Age in place. This is defined as remaining living in their own home and environment as long as possible even if they are vulnerable (Gobbens & Van Assen, 2018).

Ageing in place not only avoids costly intramural care, but it is also the more favoured option the older people themselves (De Witte. et al., 2012). Ageing in place is not easily definable as one sort of living situation. There can be different options for ageing in place, for example, people getting old in their own home, or living independently in senior-specific housing, or there are more intensive options that are still considered as ageing in place, by people who need 24 – hours of care and they receive it in their own home or clustered living concepts.

Current care policy in the Netherlands

In the Netherlands, there are currently three different laws delivering senior care, De wet langdurige zorg (WlZ), de zorgverzekeringswet (ZvW) and Wet Maatschappelijke ondersteuning, (WmO), The ZvW focuses on cure people, and the WmO is to support people in living in their place, but at a certain intensity this support will be financed through the WlZ. This is the case for people with dementia etc.

De wet langdurige zorg (Wlz)

People in the Netherlands who need permanent surveillance or 24-hour care in proximity can make use of the Wlz. The Wlz applies to a select group of vulnerable people, such as the elderly with advanced dementia, and people with severe mental or physical limitations. And people with long-term psychiatric disorders.

Care from the Wlz

The care that civilians can get from the Wlz is described in several functions, with a broad definition. This provides lots of freedom to organize the care together with the care supplier. The most common functions are:

- Stay in a healthcare institution.
- Personal care, like washing, dressing, eating and drinking.

- Guidance on self-reliance
- Nursing
- Wlz treatment
- Transport from and to the “dagbesteding” or treatments

Forms of WLZ

Insured individuals with an indication for Wlz care can choose institutional care (ZZP) or under certain conditions opt to receive the care at home. For home care, the client can choose from:

1. Volledig pakket thuis (VPT), receiving the institutional care at home.
2. Modulair pakket thuis (MPT), indicating that some parts of the full care package are received at home.
3. Persoonsgebonden budget (PGB), means that a client organizes their care with a given budget.

A schematic overview of the different care packages in the Netherlands is given in Figure 1 below.

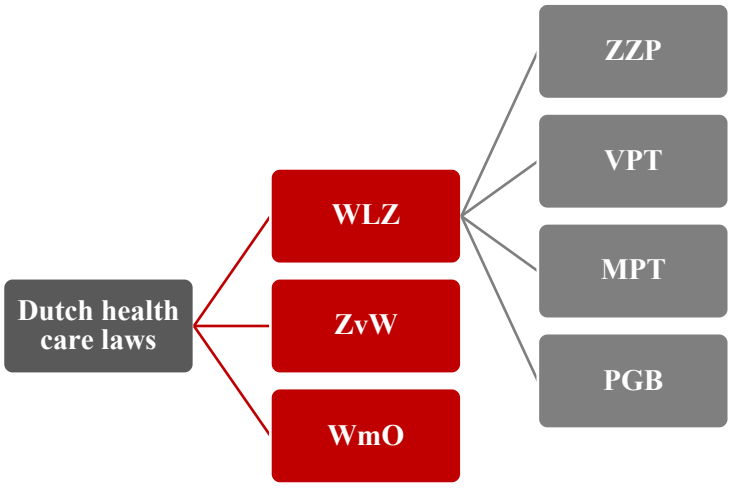


Figure 9 Organization of the healthcare laws in the netherlands

Volledig pakket thuis (VPT)

The VPT was introduced in 2015 to separate the care from the housing and increase the diversity in living arrangements. This matched with the goal of ageing in place, where care providers can focus on supplying care. The care within the VPT is the same 24-hour care that is delivered in institutional care units. Only the housing component is split. To keep the care cost sustainable, the Dutch government has made a policy that no more intramural care places can be realized therefore, the care for the higher ZZP groups has to be compensated by the VPT or other methods.

Based on the location the VPT can be distinguished into four different models:

1. *Unclustered VPT*: the VPT is delivered in the area, with clients living in different buildings on different streets.
2. *VPT linked to a nursing home*: The VPT is delivered in or in the proximity of a nursing home, this could be sheltered housing or a neighbouring complex.
3. *VPT spread in residential complex:* The VPT is delivered in a residential complex where not only people with a WLZ indication live but also people who do not receive care or different care. In this case, there is no connection with a nursing home.

4. *Clustered VPT:* The VPT is delivered in a residential complex where only VPT is delivered.

(Actiz, 2023)

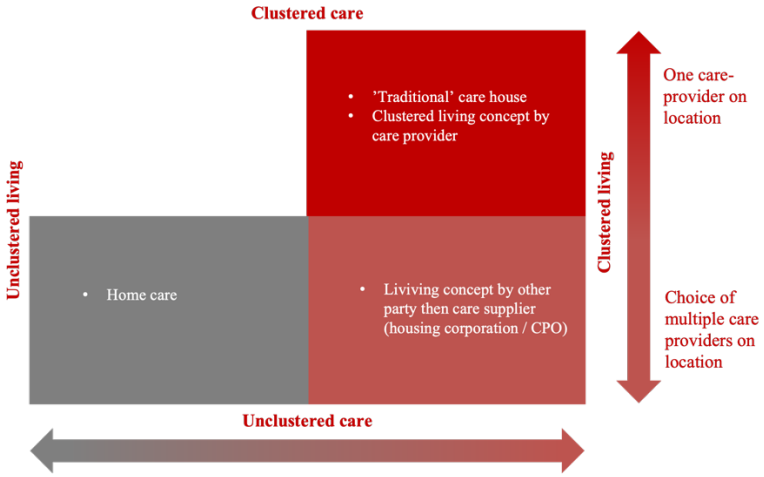


Figure 10 Organization of VPT care (CZ zorgkantoor, 2023)

Research of the Vrije Universiteit van Amsterdam has shown that under elderly with a Wlz indication the ones receiving VPT care live a year longer than someone in an institution (1288 days against 922 days). Next to that the costs of long-term care, are 58 euros lower than with institutional care on a daily base. Other benefits are a lower burden on healthcare workers (Portrait & Koolman, 2021)

Clustering

Home nurses spend on average 25% of their working time travelling between the different clients. This time can be spent on the clients if the clients are clustered in one location. So, in the case of labour-saving clustering senior houses can save a significant amount of FTE's for care organizations. With nurses being able to focus on medical tasks instead of travelling. Research has shown that a doubling in the share of clustered senior housing in 2031 can reduce staff shortages with 9.000 FTEs (Dantuma, 2022).

Need for innovation

The growing shortages in the labour market, the rising costs of the healthcare system, and the increasing demand for healthcare workers due to an ageing population may serve as an additional incentive for care providers to adopt labour-saving technologies to meet the rising demand for care. However individual care providers are not responsible for delivering care to all individuals in need, they are only accountable for their existing clients, this results in waiting lists for seniors to receive care. To reduce these waiting lists and ensure the sustainability of senior care, the government promotes care providers the use of labour-saving technologies. The implementation of SHT is increasingly seen as a potential addition to the traditional care model. The following section will review these technologies and the implementation process in greater detail.

2.3. Smart home technology

Smart home technology (SHT) plays a growing role in supporting ageing in place, by enhancing independence, safety, and the quality of living. This section explores the scope, types, benefits, and challenges regarding implementation in the context of VPT housing. The literature makes a distinction between four different categories of smart technology that made an impact on the daily lives of elderly, or care staff. These categories include sensor systems,

wearable technology, information and communication technologies and smart homes (Chabot et al., 2019), see figure below for an overview of these types.

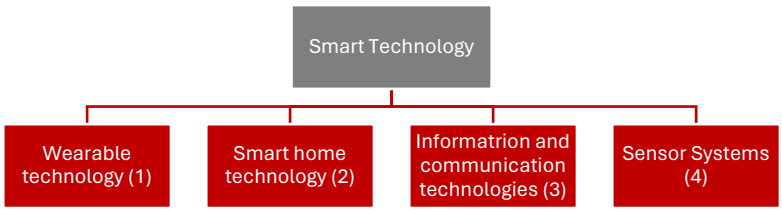


Figure 11 Overview smart home technology(Chabot et al., 2019)

Definition SHT

Smart home technology refers to a network of interconnected devices and systems within a residential setting that utilizes sensors, actuators, communication technologies, and artificial intelligence to enable automation, remote monitoring, and control of home functions(Balta-Ozkan et al., 2014). These systems aim to enhance energy efficiency, security, comfort, and convenience by adapting to user behaviors and preferences through data analysis and machine learning Core components often include smart thermostats, lighting systems, security cameras, and appliances, all coordinated via a central hub or cloud-based platform (Chen et al., 2023).

Types of technology

Wearable technology

Wearable technology is sensors that contribute to support living in place, instead of being integrated into the building or environment, these sensors are worn on the body(Blackman et al., 2016; Kim et al., 2017). Popular examples are hearing aids, tracking watches, and smart incontinence materials. These technologies can track vital signs, and body movements to detect and prevent functional decline(Lewis & Neider, 2017; Li et al., 2019). Even though these wearable technology shows promising results to support ageing in place and reduce the workload on care staff. It falls outside the scope of this research since the focus is on the built environment.

Information and communication technologies

As adults live longer, they can experience a feeling of social isolation, which can lead to loneliness and depression resulting in a health decline (Delello & McWhorter, 2017). Research shows that devices like an iPad can overcome this and have a positive impact on seniors (Chabot et al., 2019a). However, just like the wearable technology this is not building-specific, so it falls outside the scope of this research.

Smart home technology

Smart home technology is a home or residence that is equipped with technology that is integrated into the infrastructure of the building(Liu et al., 2016). Often used technologies have functions for detecting emergencies and falls, and providing visual assistance (Chabot et al., 2019a). More practical examples are technologies such as smart thermostats and smart locks, smart lighting. These technologies do not have to be care-specific, but research has shown that these technologies can help with the independence of seniors and therefore reduce the pressure on care workers (Peek et al., 2016).

Sensor technology

Diseases like dementia can result in functional decline that can lead to hospitalization for interventions, this is costly, however with early detection this cost can be minimized(Liu et al., 2016)Sensor systems can collect information about the daily routines of persons, and see if the

daily tasks are executed, without becoming noticeable, unlike the wearable devices.(Peek et al., 2016) Examples of these technologies are lifestyle monitoring and fall detection. For these sensor systems to be useful, a connection with the data needs to be made for family and healthcare workers. (Rantz et al., 2015)

Benefits of smart home technology

Technology does not only increase the comfort of occupants but has also the potential to reduce care costs as a whole, and contribute to reducing staff shortages in the care industry(Drost et al., 2021). It is estimated that the optimal use of technology can lead to 15.5 million potential additional hours available for health care, over the next 10 years in the Netherlands(Ponds et al., 2022).

The Dutch research institute Vilans did research at several large care organizations that already implemented smart technologies, on behalf of the Ministry of Healthcare an overview of the costs and benefits (hard and soft) are shown in the table below(Drost et al., 2021).

Table 3 Technologies and their costs and benefits (Drost et al., 2021)

Technology	*Type of technology*	*Clients*	*Benefits*	*Costs*
Domotics	Smart home technology	x	1) Peace of mind for clients 2) Increased sense of safety 3) Peace of mind for relatives 4) More customization **5) More capacity to help other clients.** **6) Staff can arrive more quickly.**	○ Less physical contact moments ○ Required behavioral change is large ○ App notifications can be annoying. ○ **Introduction costs organization (training, installation, maintenance)** ○ **Cost for phones, internet connection etc.** ○ **In case of disruptions more work** ○ **Cost hardware/software (long payback period)** ○ **Cost support of supplier** ○ **Specific installation costs (wiring etc.)**
Access management	Smart home technology	13.000 Intra and extramural	○ Increased sense of safety for client ○ Increased sense of privacy for client ○ Quicker deployment care staff ○ More insight voor care / relatives ○ **Less travel time**	○ Involvement and consent of involved stake holders ○ Redesigng the care process ○ Learn to work with technology

			○ **Quicker access to home**	○ Explanation to clients and informal care workers ○ **Introduction to the organization (training, installation and maintenance)** ○ **Smartfphones / internet connection** ○ **In case of disruptions more work** ○ **Cost hardware/software** ○ **Set up costs bij professional** ○ **Subscription costs (multiple of regular key locker.**	
Lifestyle monitoring	Sensor system	5500 extramural	○ **Less care moments** ○ **Less travel time** ○ **Prevention of care** ○ **Postpone admission** ○ Less stress on client ○ More insight for relatives ○ Less stress for relatives ○ More customization	○ **Cost for introduction in organization** ○ **Installation costs** ○ **Cost for items such as smartphones and internet connection** ○ **In case of error extra workload** ○ **Costs of care central** ○ **Dialing in** ○ **Costs of subscription** ○ **Possible damage to interior** ○ Less physical contact moments for client ○ Acceptation of technology ○ Behavioral change is necessary. ○ Clear coordination with relatives	

*The Bold benefits and costs are hard the normal ones are soft.

Implementation challenges of SHT

Despite the proven benefits, SHT implementation has for the senior health care. The implementation in practice is lacking. The IBO report (2022) presented these challenges, and an overview will be given below(IBO, 2023).

Non-committal

Despite the government promoting the use of the SHT, the trade association has set some goals regarding the implementation of technology. With the current rules, it is still non-committal that care organizations need to use technology. There are no goals they should reach.

Financing

The use of SHT requires an initial investment, from the care provider. Regarding the purchase of the technology, time investment to train the staff, for the connection with a digital environment and to transition from old to new situation. These costs come before the benefits which result in care providers not directly receiving benefits from their investments. On top of that the current financing and subsidies are not adequate for successful implementation of the technology.

Knowledge gap

The knowledge regarding implementation and care technology is not centralized, and lots of care providers need to reinvent the wheel. There is limited access to quantitative information about the effectiveness of the technology, since there is also limited data available, because of limited monitoring of effectiveness, or that care organizations keep the data for themselves. There are also no quality marks for reliability or preconditions on which technology suppliers need to comply. This combined makes it difficult for care suppliers to make funded choices in the technology(source).

Education care staffing

SHT does not always align with the wishes, needs and skills of care workers. To address this, it is important to integrate these technologies into healthcare education so that new employees can use and apply the SHTs in the workplace. For current employees it is often seen that they are redundant to SHT because they are not known with the benefits of SHT, and how it can enlighten their work.

No standardization

Another challenge to the effective implementation of SHT is the lack of standardization and interoperability across systems and technologies. Many solutions are not designed with the end-user in mind, resulting in different signals and platforms. Additionally, information exchange between healthcare providers is not standardized and systems cannot communicate with each other. This increases the administrative burden and the risks of errors. This lack of interoperability also hinders the broader application of the technologies to rely on patient data. The healthcare sector and government have called for stronger measures in coordinating and regulating this, however, that is not yet the case currently.

SHT offers promising solutions to relieve pressure on the care sector, with enhanced independence and improved care. The implementation of it into senior care housing, especially in the setting of clustered VPT housing has a lot of challenges. The success of it depends on a complex collaboration in the decision-making made by multiple stakeholders, funding, and organizational processes. The next section will explore how these decisions are made, what actors are involved, and what factors influence the effective implementation of SHT.

2.4. Decision-making in healthcare and the built environment

While Smart home technology presents promising solutions to the challenges that are faced by the senior care industry, the successful implementation of it is not as straightforward. The implementation process is shaped by a variety of stakeholders, with diverse decision criteria

and different interests, that influence if and how such technologies are integrated into the clustered VPT care environments. To develop a useful decision support framework, it is firstly necessary to understand how these decisions are made, who is involved and what considerations guide this process. These next sections will explore the decision-making process, identify the key stakeholders, outline influential factors, and highlight the challenges that arise in practice.

2.4.1. Decision-making process in SHT implementation

The modification/implementation process for SHT for seniors consists of 4 phases: home assessment, technology selection, design strategy and user evaluation. These are in line with the framework proposed for designing smart home environments in general (Ma et al., 2022).

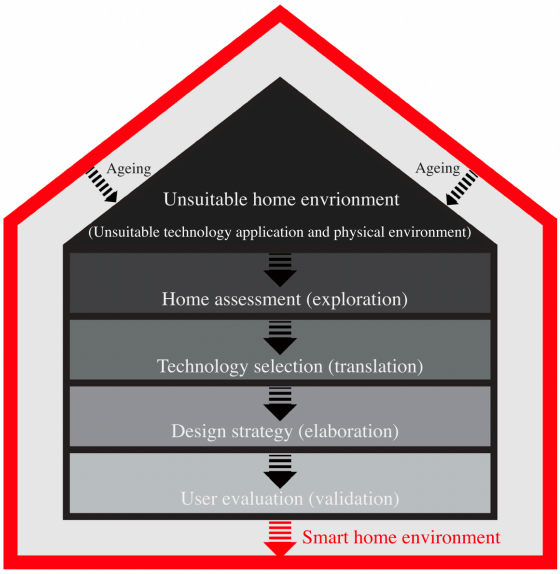


Figure 12 Smart home modification process (Ma et al., 2022)

Home assessment phase

The home assessment phase is an essential step in the SHT implementation, multiple studies underline this importance for supporting older people living independently. This phase can help by identifying potential hazards in the housing environment and contributing. Home assessment tools vary from traditional checklists to high-tech technologies such as BIM, the checklist is the simplest method to detect hidden dangers in homes The contents of checklists vary according to different objectives (Ma et al., 2022).

Technology selection phase

As a total group, older people have various and changing living habits, limitations, requirements, and preferences. These differences should always be considered in the technology selection phase, which aims to match users' characteristics (Jännes et al., 2015). As McCreadie and Tinker (2005) summarized, the acceptability of smart technologies requires matching both older people's individuals and housing conditions, and it is also affected by the attributes of the technology itself(Mccreadie & Tinker, 2015). Therefore, it is crucial to explore compensation requirements in older people's daily lives and translate them as selection criteria to match suitable technologies. The features of smart technologies with higher acceptance are identified as being less intrusive, having lower costs, being user-friendly control, having a user-friendly interface, and having fewer design features(Chabot et al., 2019a; Golant, 2017).

Another research advocated for the benefits of using universal design for developing standardized devices and systems to make sure they are uniformly accessible or usable by persons of varying abilities(Agree, 2014). However, the main barrier to promoting smart technologies in the market is the missing common standards in the interoperability and compatibility of these products(Jännes et al., 2015; Mohammadi, 2010; Phan & Kim, 2020). Challenges remain for older people to constantly adapt to non-universal smart systems until these barriers are eliminated in future phases.

Design strategy

Multiple studies have explored to integrate innovative technologies into home environments to support ageing in place. However, the understanding of seniors' lives is often limited by other age groups and younger designers. Therefore, it is suggested that designers negotiate with seniors, to get a better understanding of their personal needs and preferences in the design phase instead of coming up with general recommendations(Iwarsson, 2014).

User Evaluation

This is a critical phase in assessing SHT modifications for ageing in place. While SHT can enhance independence, it cannot replace the role of a supportive physical environment (Carnemolla, 2018). Effective adaptations to the home environment require both architectural and technological interventions. However, most evaluation rely on subjective methods, such as interviews and self-reports, lacking objective, performance-based scores (Cho et al., 2016), making it difficult to compare findings or guide future improvements.

To address this gap, several models and frameworks have been developed. Carnemolla's (2018) HAST model assesses home's across four different domains: Human capacity, acitivity, space and technology. Despite progress being made, most studies used unsmart technologies and small sample sizes, These findings stress the need for comprehensive empirical evaluation methods and greater inclusion of older adults in the design and feedback process. (Ma et al., 2022).

2.4.2. Barriers and challenges

With ageing in place and the VPT, a big step in relieving pressure on intramural care is made. But there is still room for improvement.

Despite the proven benefits of smart home technology for senior care, this is especially the case for VPT care, whereas institutional care experiences fewer problems with the implementation of technology. (NZA, 2022). Where it is unclear, which party is responsible for the implementation, the care supplier, the real estate investor, or the client. Since the benefits can be spread across the different users. Another Struggle in the implementation process is the different funding for the government, which makes it unclear, which party pays for what and how.

Research has also shown that in most cases there is no systematic decision-making with implementing smart technology for care housing. The implementation is often not supported by evidence but decided on rules and guidelines, with a lot of unknowns about, the real costs of purchase, maintenance and time, or the real benefits of the technology. To address this problem and promote the implementation of SHT in clustered VPT housing, and to develop a decision-making tool. (Bezboruah et al., 2014):

The effectiveness of each phase in the SHT implementation process, whether it is the technology selection or the home assessment, depends on the input of the actors involved and their roles, responsibilities, and interests. In practice, decisions are made by a complex system

of stakeholders with each having different priorities resources and levels of influence. The next section therefore explores the actors involved in SHT implementation within the clustered VPT housing, to understand how their interactions and interests affect the decision-making process.

2.5. Stakeholders and interests

To ensure a successful implementation of SHT in clustered VPT housing, all relevant stakeholders must be aligned throughout the various implementation phases. This section will identify key stakeholders, analyze their interests, roles, and influence, and select the most relevant actors for this research.

Definition

Stakeholders can be persons, neighborhoods, institutions, groups, society, or the environment. However, the exact definition is often not agreed upon in literature and must be described in general terms to avoid inconsistency. The term stakeholder comes from a management theory, and a widely used definition for stakeholders is, any group or individual who can affect or be affected by an organization's objectives, policies, and subsequent actions (Sousa, 2011). A simplified definition is, where a stakeholder is an entity with a stake in the subject activity(McGrath & Whitty, 2017). For this research, the general definition will be actors or entities with a stake in the implementation of smart home technology in clustered VPT housing.

General stakeholders

There is no specific list of stakeholders for this research problem, therefor three studies with a similar problem are taken to map out the involved stakeholders in the decision process.

In the publication of KPMG (2022), they've mapped out the involved parties of the clustered housing arrangement in the Netherlands, with a focus on the additional costs of such arrangements and how these costs can be mitigated. In Table 4 below the roles and activities of the mentioned stakeholders are listed(KPMG, 2022)

Table 4 Roles and responsibilities (KPMG, 2022)

Role	*Responsibility*
VWS	- *Stimulate ageing in place.*
BZK	
Investors	- *Subsidy*
	- *Realisation of construction and exploitation of the housing*
Care providers	
Municipalities	- *providing WLZ care*
	- *Spatial planning and facilitating the construction of clustered care housing*
Care offices	
	- *VPT compensation*

The publication of KPMG (2022), focused on the development of clustered housing concepts, the study of Sponselee et al, (2008). Focus on the SHT perceptions of multidisciplinary stakeholders in the extramural care setting (Sponselee et al., 2008). A list of the mentioned stakeholders and their activity is mentioned in the table below.

Table 5 Actors and activities (Sponselee, 2008)

Actor	*Activity*
Designer	*Focus on functionality of the technology*
Care receivers	*Receive care*
Care institutions	*Organize the care*
Service providers	

Housing corporations *Insurance companies* *government*	*Provide living*

In the study of Guo et al (2021) a stakeholder mechanism for Elderly community retrofit projects in China is developed. This research classified relevant stakeholders into three groups, core stakeholders, latent stakeholders, and marginal stakeholders. In the table below the stakeholders from this research are mentioned (Guo et al., 2021)

Table 6 Actors and activities (Guo et al, 2021)

Actor	***Activity***
Senior family	*Focus on functionality of the technology*
ECRP companies	*Retrofit and construction*
Government organisations	*Determine policy , regulate and subsidy*
Financial institutions	*Investments*
Investors	*Funding*
Residents	*End users*
Property service companies	*Maintenance and operation*

The study from Ehrenhard, et al(2014), mapped a value network, for the implementation of SHT in Dutch senior care, this gives a relatively complete list of all the actors involved in the implementation process. This result in an extensive list of stakeholders, the identified actors and their activities are shown in Table 7 below. Not all the stakeholders will be relevant for every technology implementation, however it can be expected that in general several stakeholders will reoccur. With each of these stakeholders having their specific interests (Ehrenhard et al., 2014).

Table 7 roles, actors and activities Value network (Ehrenhard et al., 2014)

Role	***Actor***	***Activity***
End user / patient	*Elderly people with care needs*	*Receiving care and treatment*
Support providers	*Informal carers*	*Giving additional support*
Care workers	*Doctors/nursers/etc.*	*Care and treatment*
Care provider	*Care organization*	*Link between demand and supply*
Additional care service provider	*External partners*	*Offering extra services*
Building owner		
Insurance provider	*Investor / housing corporation*	*Offers smart building / housing.*
Home builder /designer	*Insurance companies*	*Offers health insurance.*
Software supplier	*Construction company / architects*	*Offers Smart services.*
Hardware supplier	-	*Offers software.*
System integrator	-	*Offers hardware.*
Network provider	-	*Integrates hardware and software.*
	-	*Offers connectivity*

The mentioned stakeholders by the 4 different researches can be combined in a list of 10 different stakeholders that are involved in the development of clustered VPT housing. Table 8 shows a summary in which article each stakeholder is mentioned.

Table 8 Stakeholder summary

	Role	KPMG	Sponselee	Guo	Ehrenhart
S1	Government	x	x	x	
S2	Care recievers / seniors		x	x	x
S3	Support providers		x	x	x
S4	Care workers		x		x
S5	Care providers	x	x		x
S6	Technology providers		x	x	x
S7	Investors / building owners /developpers	x	x	x	x
S8	Insurance companies	x	x		x
S9	System integrator				x
S10	Network provider				x

For this research, not all the previously identified stakeholders are directly involved in the SHT decision-making process. To maintain a relevant scope, the selection has been narrowed down to six key stakeholder groups care receivers / seniors (S2), support providers (S3), care workers (S4), Care providers (S5), Technology providers (S6) and Investors / building owners / developers (S7). Other stakeholders, such as insurance companies (S8) and network providers (S10) could be relevant, however these are excluded because their role in the SHT implementation process is indirect or context dependent. Besides that, these groups could have added extra complexity without a significant contribution to this study. The next section explores the main stakeholders in more detail.

2.5.1. Care receivers / seniors

The first group of stakeholders are the seniors, this is a primary stakeholder since this party is living in the accommodation and receiving the care. For this research the focus is on seniors receiving care in the VPT.

Ageing comes with several problems for seniors, especially when they become care dependent. Seniors will have a functional decline (O'Brien et al., 2020), resulting in several mobility issues and a decrease in independence. For example, they cannot wash themselves anymore, they have memory loss, and they forget to turn off the stove. Furthermore, elderly people can suffer from loneliness when they live on their own (Latikka et al., 2021).

This group can directly benefit from the implementation of SHT. With an enhanced quality of life using technology, SHT can automate daily tasks such as adjusting lighting, controlling temperature, or managing appliances, this can increase the comfort and convenience for elderly users. For elderly patients, SHT can also include health monitoring systems that track vital signs, send reminders for medication, allowing timely interventions in case an issue happens. Independency is also a benefit that is mentioned in research's of Agree (Agree, 2014b), with technologies such as fall detection, emergency alerts and remote monitoring. Users can live independent with the technology keeping an eye out. This reduces the need for seniors, to relocate to intramural living concepts. The number of visits of cares can also be reduced, which means that the seniors are not interrupted as much.

Other benefits that are mentioned are cost savings, by preventing accidents and early detection of functional decline, SHT can reduce the need for expensive health care interventions or emergency care. Smart home systems can also optimize energy use, such as cooling and heating leading to lower energy bills.

Furthermore, increased social interaction is mentioned as benefit, Some SHT include communication tools that help users to stay connected with relatives, resulting in a decreased feeling of isolation, and improving the mental well-being of the seniors (Lee & Kim, 2020). There are not only benefits to the seniors there are also challenges and negative effects for the implementation of SHT. Elderly users are not familiar with modern technology, that makes it difficult for that generation to learn how to use it effectively. The complexity of SHT systems can be overwhelming and lead to resistance of improper use (Lee & Kim, 2020). On top of that seniors could have a fear of new technologies, particularly if users doubt their ability to use it. Seniors may also have privacy concerns, about their personal information and the security of their data being collected by SHT devices or care organizations, it also fears them that the SHT, often can be controlled by others, leading into a discomfort or mistrust of the technology (Courtney et al., 2008).

The costs of purchasing, installing, and maintaining SHT, also makes seniors hesitant for implementing SHT, despite their proven benefits (Sánchez et al., 2019). A final concern mentioned by (Tian et al., 2024) is reliability, users may be concerned about the reliability of SHT, especially if they have important functions such as health monitoring.

Regarding the implementation of SHT there significant barriers and challenges for the seniors, especially with technology acceptance, privacy, and cost. That must be measured against the benefits in terms added safety, independence, and quality of live.

Table 9 Senior overview

Stakeholder	Activity	Benefits	Challenges
Seniors (care-recievers)	*Primary stakeholder living in the accommodation and receiving care*	- *Improved quality of living* - *Improved independcy* - *Cost savings* - *Enhances social ineteraction*	- *Difficult learning new technologies* - *Privacy and security concerns* - *Fear of technology* - *High cost of purchasing / maintining SHT* - *Reliability concerns for health monitoring*

2.5.2. Support providers

Support providers are informal care workers, who provide unpaid care to people with whom they have a social relationship (e.g., family, friends, neighbors etc.) for an extended period. This care may take the form of physical, domestic, or social assistance. Most of the informal caregiving is carried out by persons who have not had any formal training in caregiving.(Mitseva et al., 2012)

Problems that support providers may encounter by providing informal care are that they may receive stress from their senior living in their place, and not having the security of an institutional care organization, to check up on the health and safety. Besides that, support providers often have other daily activities then full-time care for the elderly, therefore they cannot always visit or have contact with the elderly(Anderson & Wiener, 2015).

By implementing SHT, it is expected that support providers can receive multiple benefits. One of the main benefits for family members and friends is the ability to monitor the person they are caring for. This gives the support providers peace of mind and will help to better support the end users (Tian et al., 2024). The increased independence of the elderly is also a benefit to the support provider since the use of SHT can make them less reliant on their children (Anderson & Wiener, 2015; Korchut et al., 2017).

Technologies that support social contacts such as iPad can also increase the ease of social contact from the support provider to the end user, making it easier to check up on the loved ones.
The lack of trust in technology is also there for support providers since they may struggle with the technology, especially if the SHT is unreliable or difficult to use(Tian et al., 2024). This reliability concern could affect the willingness to fully depend on the technology what makes it defeat its purpose.

Regarding the financial burden of SHT, support providers are less sensitive to this compared to the seniors. (Draper & Sorell, 2017; Mitseva et al., 2012). Where end users fear loss of relationship this is not a problem mentioned by support providers, as they do not believe that the technology would weaken their contact with the older person(Rantanen et al., 2017).
So, for support providers there are less barriers and benefits to the use of SHT, and mainly benefits if the technology acceptance is overcome.

Table 10 Support provider overview

Stakeholder	Activity	Benefits	Challenges
Support providers	*Informal caregivers (e.g., family friends, neighbors) who provide unpaid care and assistance*	- *Ability to remotely monitor care recipients for peace of mind* - *Increased independence for elderly reduces reliance on caregivers.* - *Easier communication through SHT* - *Less financial sensitivity than seniors*	- *Trust issues with technology* - *Technology complexity may hinder adoption* -

2.5.3. Care workers

Care workers, refer to those who are paid to help seniors receive medical treatment or perform tasks in their home. For example, nurses, doctors, and housekeepers. For care workers, there are also multiple challenges, the first one being the increasing shortage of care staff (Drost et

al., 2021). Due to this shortage, the workload on the existing care workers increases, resulting in higher stress for the workers (IBO, 2023), physical strain due to demanding tasks, or emotional detachment due to limited time with patients. This can all result in a lower quality of work and make the profession of care workers even less popular, what will increase the shortages.

The enhanced monitoring that is an often-mentioned benefit of SHT, is also mentioned beneficial for the care workers (Husebo et al., 2020), by providing the ability of remote monitoring the number of visits of professional care workers can be reduced, what reduced the time spent per person, meaning that a care professional can help more patients at the same time. Also the nightly visits can be reduced, resulting in less care staff needed at those times (Obayashi et al., 2020).

Another benefit for the care workers is that they can make a more informed decision, with the collection of real time data a better decision can be made improving the overall quality of care(Lussier et al., 2020).

Other benefits of the increased independence of seniors, means that the care workers have more time to focus on the actual care instead of all the side tasks that they perform (Tian et al., 2024). There are not only benefits for care workers but also challenges and barriers regarding the implementation of SHT. Even though most care givers are younger than the care receivers, a common thing care givers are known for is their technophobia. This reluctance towards technology can partly be explained by the nature of the characters, that is caring. People who choose for care delivery or nursing as profession, often prefer to work with people who need them. And by giving away tasks to technological interventions, can raise an aversion to technology as a fear of losing constant with the clients. Care givers can also see a reduction in time spent with clients as a direct decrease in quality of care (Sponselee et al., 2008).

Not only is there a potential decrease in workload but also a possible increase in workload is mentioned as concern, by care workers requiring training and time before being able to work with the SHT (Melkas et al., 2020; Wright, 2018) Also have research shown that when a SHT does not work properly the workload is likely to increase so the usage of SHT, does not always have to result in a decrease of workload (Tian et al., 2024).
Overall, care workers workload can be reduced with the implementation of SHT, however the ease of use and reliability are important factors for it to save time.

Table 11 Care workers overview

Stakeholder	Activity	Benefits	Challenges
Care workers	*Paid professions (e.g., nurses, doctors etc.)*	- *Reduced time spent per person through remote monitoring.* - *Improved decision making* - *More focus on essential care tasks*	- *Fear of using technology* - *Extra workload*

2.5.4. Care providers

Care providers are the organizations responsible for delivering the care, they act as intermediaries between the technology providers, care workers, and building owners, managing the care delivered, the housing and the technology being used.

Care providers, also face several problems, with the ageing population, and the promise to deliver care. With rising costs, the budgets of care organizations are tighter than ever, what makes it difficult to deliver all the promised care(Thilo et al., 2021). Furthermore, the shortage of care workers also reflects to the care providers, by having difficulties finding enough qualified staff do actual care for the elderly(Hinkema et al., 2019) Also governmental policies change over time where it is often not sure if implementation is part of the care providers responsibility or that of the building owner. SHT can also allow care providers to offer more comprehensive care service, with a smaller number of resources (Drost et al., 2021)

Management of care organization play a vital role in the integration of SHT. One of their primary concerns is conducting a cost-benefit analysis to ensure that the financial investments in technology are justified by the benefits they bring. This calculation not only includes the initial costs of purchasing the technology, but also the long-term savings and efficiencies it may generate (Bezboruah et al., 2014).

Policy and organizational changes are often deemed necessary, to implement new technologies, managers must advocate for and support these changes, ensuring that the organizational infrastructure of the care organization can support the technology. This may involve policy changes, procedures, and workflows, for an effective incorporation of the technology (Alders & Schut, 2019)

Table 12 Care providers overview

Stakeholder	*Activity*	*Benefits*	*Challenges*
Care providers	*Organizations managing care delivery, housing and technology integration*	- *More comprehensive services with fewer resources* - *Potential cost savings from improved care efficiency* - *Ability to offer innovative care solutions*	- *Need for organizational and policy changes* - *Challenges with incorporating technology into existing procedures and workflows* - *Financial investments*

2.5.5. Technology providers

Technology providers are companies that develop and manufacture the hardware and software components of SHT. They are responsible for creating the devices and platforms that make a smart home a smart home.
Problems that technology providers may face are lack of alignment with user needs (Procter et al., 2018), providers may focus more on innovative features rather than addressing the actual needs of the end users and care professionals (Sponselee et al., 2008), this can make it hard to work with the SHT or unnecessary for the day to day works . Other problems that technology providers have are interoperability issues with different providers. This also creates difficulties for the end user, as they may need more devices or services to work seamlessly (Majumder et

al., 2017). This lack of standardization can lead to frustration and decreased adoption of the technology resulting in lower sales Technology resistance of care organization can also be challenging for providers especially if the return of investment is not clear directly .

The incentive of technology providers is different than that of the careers, end users and care organizations, since their business is to sell, technology so. Delivering a reliable, and user-friendly product, can build a strong customer trust and brand loyalty, which can lead to repeat business. By partnering with other stakeholders such as care organization, technology providers can enhance their offerings.

Table 13 Technology providers overview

Stakeholder	Activity	Benefits	Challenges
Technology providers	*Companies that develop and manufacture SHT hardware and software*	- *Pottential business growth* - *Opportunity to build custuomer trust through reliable products* - *Ability to partner with other stakeholders*	- *Pressure to deliver user-friendly and reliable technology* - *Balancing innovation with ease of use* - *Competition from other providers*

2.5.6. Building owners / developers

The last stakeholder group is the building owner / developers, this stakeholder group consists of two types. The first type is parties such as institutional real estate investors, housing association, care organizations who own a building where care is develivered. Or real estate developers who are responsible for developing the building for these building owners. Both play a crucial role in providing and maintaining housing accommodations for the elderly. They are responsible for ensuring that the building, meets the needs of the ageing population, and the organizations and persons providing care (KPMG, 2022). One aspect that attracts investors to the care market is the resilience of economic turbulence, in combination with attractive yields(Bouwinvest, 2023).

Problems that they might encounter include, balancing maximum financial results and social responsibility, and still complying with the complex regulations. And managing the risks accusation with changes in care policies and other sustainability goals for technological upgrades(NZA, 2022).

By offering SHT, building owners can enhance the appeal of their properties, by increasing safety and convencience and energy efficiency for the end users. Offering more than other building can offer SHT can also improve tenants' satisfaction, and reduce their operational costs over time, this can create opportunities for sale and leaseback transactions with health care providers (Bouwinvest, 2023).

However, there are also challenges of implementing SHT including high investments costs that are required for the installation of SHT (Tian et al., 2024) ensuring interoperability of different

SHT's. The need to maintain these technologies and to meet the security and privacy standards. Finally, it is also challenging to align the SHT capabilities with the specific requirements of the end users (IBO, 2023).

Stakeholder	*Activity*	*Benefits*	*Challenges*
Building owners/ developpers	*Develop and own and manage the property*	- *Increased property appeal* - *Improved tenant satisfaction* - *Operational cost reduction* - *Energy efficiency* -	- *High investment costs* - *Interoperability issues* - *Maintenance costs* - *Technological complexity* - *Alignment with other stakeholders/*

To conclude, the successful implementation of SHT relies heavily on the collaborative efforts and aligned interest of a diverse group of stakeholders, from receivers and informal care workers to professional care workers, care organization and building owners. Each party plays a different role in the implementation process, and has unique motivations and concerns ranging from technical usability and care quality to financial feasibility, this must be carefully balanced to ensure effective implementation and integration of SHT. In the next chapter, general decision making in the built environment will be covered, to see how it relates to the context of this research.

2.6. Information management and process modelling

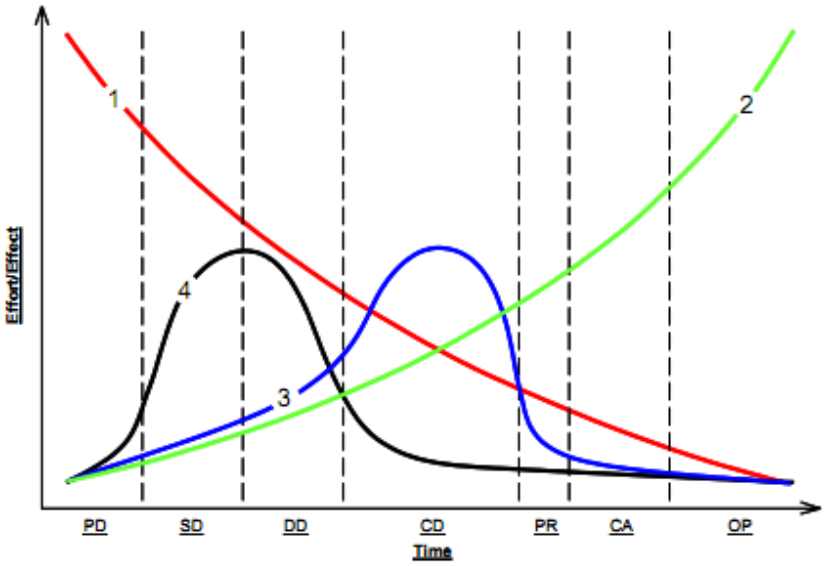
The previous section, explored, what the challenges and opportunities are of implementing SHT in the clustered VPT housing setting in the Netherlands, by emphasizing on the crucial role of the stakeholders and their collaboration. This section builds on the previous discussion of these challenges and opportunities. It continues by exploring the decision-making process in the built environment, introducing key concepts such as the project lifecycle, design management, Building information modelling (BIM), and process modelling. This section highlights the importance of structured, early-stage decision-making throughout the lifecycle of a building. Tools like BIM and IDM are shown to be essential for enabling collaboration and efficient information exchange, providing a clear and coordinated structure for successful project delivery.

2.6.1. Project life cycle

This section of the literature elaborates on the entire project lifecycle of a construction project, and the impact decision makers can have during the different phases. There are multiple ways to represent the building project lifecycle. For this thesis the structure of the Macleamy curve is used (Johnson et al., 2004) . In this cycle the project, goes through multiple design stages, a procurement phase, construction phase and finally the operation phase. A schematic representation of this traditional design and construction cycle is shown in Figure 13.

Figure 13Project life cycle

Owners driving full collaboration through information sharing early in the project process are most likely to achieve the desired outcomes: faster, more efficient, and cost bound. This collaboration shifts the design, and decision making earlier in the design process, by maximizing good decisions with early collaboration, this concept is shown in the figure below(Johnson et al., 2004).



1. Ability to impact cost and functional capabilitie
2. Cost of design changes
3. Traditional design process
4. Preferred design process

PD: Pre-design
SD: Schematic design
DD: Design development
CD: Construction documentation
PR: procurement
CA: Construction administration

Figure 14 Macleamy curve (Johnson et al., 2004)

The diagram above, illustrates four different concepts related to the design effort / costs and the traditional phases of design and construction, with each described by a different line.
Red line (1): represent the decreasing ability to alter project variables such as cost, schedule, and functional capability as the project progresses.
Green line (2): Indicates that the costs of making changes increases as the project progresses.
Blue line (3). Shows the distribution of effort in a traditional building project when design information is developed mostly in the construction document phase.
Black line (4): is the desired distribution of design effort under full collaboration. Where information is collected and integrated and documented earlier in the design process due to the input and collaboration of all the stakeholders. By maximizing the ability to effective changes and minimize the potential costs and risks of design changes (Johnson et al., 2004).

Design management

The AEC industry is facing the issue that projects are not yet managed well during design in some cases (Knotten et al., 2015) This mismanagement can lead to document deficiency and more rework. Furthermore, it can result in a lower building quality. Knotten et al (2015) states that this is the result of the fact that it is a complex task to manage the design process because of the many information flows of information. That design management is essential for controlling the flow of information and stakeholders in the design process. Therefore, it is important that all the stakeholders know their role in the process, and how and what action they should take, this emphasizes the need for process models (Emmitt & Ruikar, 2013)

2.6.2. BIM and information management

Information management plays a very important role in the AEC industry because several stakeholders are involved, and information loss needs to be prevented. Therefore, it is suggested to work with Building information modeling (BIM).

BIM is often referred to as building information model or building information modeling. The BIM model refers to the digital representation of the building with embedded information, while BIM modeling on the other hand refers not only to the process of modelling, but also the process of maintaining, using and exchange it through the lifecycle (Borrmann et al., 2018) One of the benefits of the modelling over a traditional design process is reducing the information loss, this is schematically represented in the figure below.

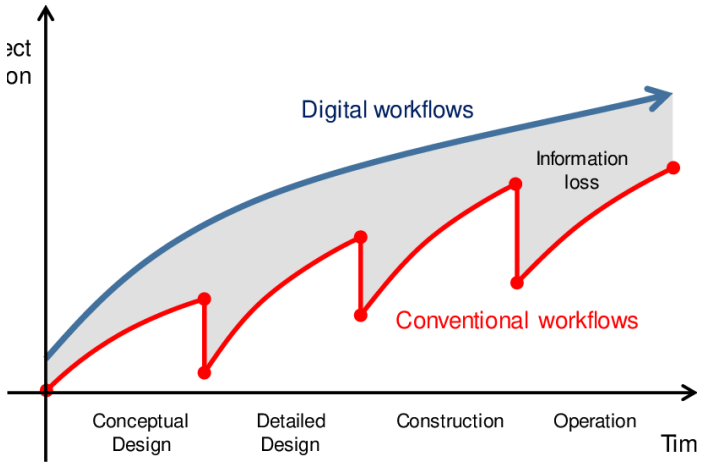


Figure 15 Informationloss by disruptions in the information flow(Borrmann et al., 2018)

BIM has multiple levels, starting with 2D drawings all the way to models with cost included. When all the 2D and 3D drawings are combined with 4D (time), and 5D (costs), the model comes alive for the involved stakeholders (smith, 2014.) BIM can be interpreted in a little BIM and a big BIM way see Figure 16. where the little BIM is only considering the 3d model, big BIM considers functional, informational, and organizational issues as well(Volk et al., 2014).

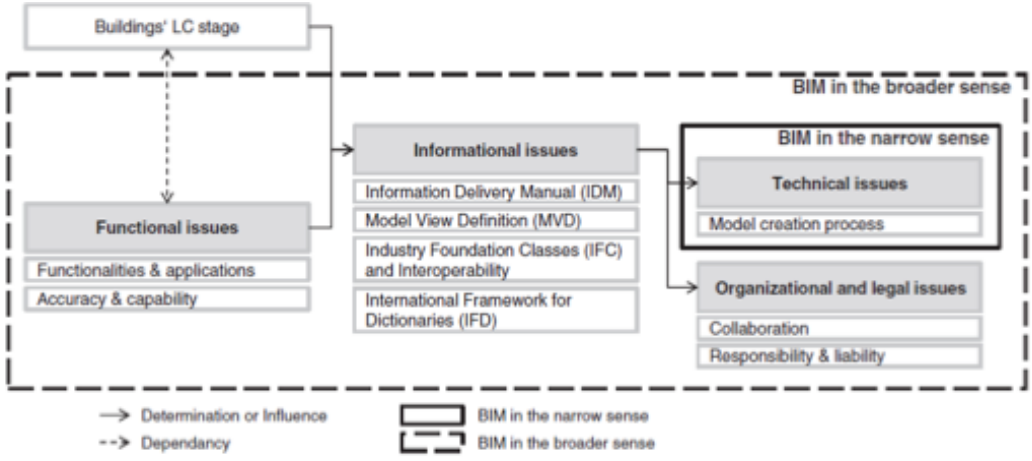


Figure 16 Little BIM and big BIM (Volk et al., 2014)

The main advantages of BIM come from efficiency improvements. Through the support of collaboration and information exchange, it can reduce costs, improve project results, and plan more efficiently. However, it must be implemented properly to benefit, and an information delivery manual IDM can help with this.

IDM is a standard for describing the process of a project, in construction collaboration takes place among a variety of stakeholders who insert, extract, update or modify information, at different lifecycle phases(Sacks et al., 2018). An IDM specifies how and when these activities take place and who is involved. Further, it indicates which information is created, utilized, and exchanged at what point in the process and what software is used. In this way it captures the processes whist providing specification of the information to the actors. Given the above, an IDM supports a structured exchange of information amongst actors, ensures information quality and supports reliable decision making.

2.6.3. Building smart

Building Smart (Wix & Karlshøj, 2010) developed this IDM approach as an international organization that enables standards within the construction industry. The organization focuses on facilitating digital workflows with open international standards based on BIM. Their goal is to generate productive and efficient processes and share these openly with the global community.

2.6.4. Basic structure of IDM

An information delivery manual (IDM) is a way to control information expanse with the construction industry and consists of three main components see Figure 17

1. Process map helps to understand the operational flow and how the tasks should be performed and by whom.
2. Exchange requirements are components that connect process and data. It consists of the information exhanchanged during the process.
3. Functional parts consist of the actions that the right stakeholders should undertake that is needed to carry out the process. This action consists of information that the stakeholders develop further and contains a specification of information they exchange.

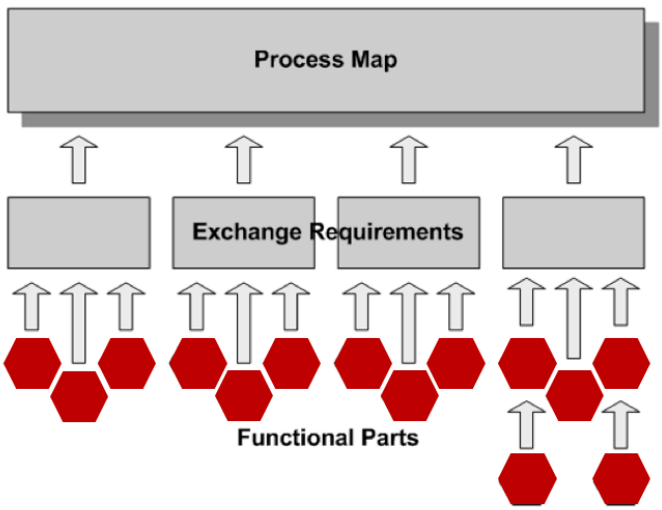


Figure 17 IDM components(Wix & Karlshøj, 2010)

Since the scope of this research is on the operational flow, and assigning the responsibilities, only the process mapping will be elaborated.

Process map

The process map is a central part of the IDM since all other components are somehow connected to the process map. The purpose of the process map is to provide an overview of the work that is undertaken to achieve a well-defined objective. As such, it describes the flow or sequence of activities undertaken by actors in a particular business process. It supports the understanding of the configuration of activities that make the process work, the actors that are involved and the information that is required, produced, and exchanged amongst them. Furthermore, a process map identifies the start and end events in the process as well as events where information is exchanged, and decisions are made (Sacks et al., 2018).

Process modeling

A business process is about a predefined sequence of activities and/or procedures targeted to collectively achieve a business objective(Sacks et al., 2018).Often this concerns a process in the organizational context, defined by functional roles and relations of the involved actors. An example could be the efforts of multiple stakeholders to implement smart home technology in senior care housing. To manage and streamline such a process and ultimately increase efficiency and output quality requires overview. This is what the goal is of business process modeling, business modeling concerns the activity of constructing and streamlining the model which represents the process. In a way that it offers insight in the relevant activities' actors and interactions.

Important things to consider when creating a process model. Firstly, it is important to keep its purpose and target audience in mind, this determines what should be included in the model, and which representation is most suitable. The model should be clear and understandable, and the terminology should be familiar to the target audience (TUE, 2020). Furthermore, the model should be accurate. That is precisely encodes the actual situation a biased view. However, it must be noted that these requirements do not sum up to one single correct model. There are still multiple ways to properly model a particular process.

One way where models can vary in is the notation method. This notation method refers to structure and rules that are used for constructing the diagram. Table 14 provides an overview of commonly used notation across industries (TUE, 2020).

Table 14 Common business process modelling methods (TUE, 2020)

Notation	*Full name*	*Purpose*
BPMN	Business process modelling	Modelling language for specifying business processes
IDEF0	Integrated DEFinitions method	Modelling language for the analysis development, reengineerin, and integration of information system
EPC	Event driven process chain	Flow chart for business process modelling
UML	Unified modeling language	Visual, object-oriented, and multipurpose modelling language
Petri-net	Place / transition ne	Mathematical modelling language for the description of distributed systems

With the use of IDM, the most common process notation is the BPMN, it is preferred to use BPMN because it is supported as emerging standard by the object management group (OMG), it is increasingly used in major projects with business processes and there are several only tools freely available(Wix & Karlshøj, 2010).

BPMN is a further development of notations like the UML, IDEF, etc. BPMN is a general comprehendible, often used notation filling the gap between process design and implementation. BPMN adds some structure and approaches to the IDM approach. The following rules are indicated as necessary for BPMN in the IDM approach.

Purpose of process map

A process map should align the exchange requirements with the underlying business process. It integrates key details of the developed workflow, supporting both the process improvement and the effective information sharing (wix & karlshoj, 2010). Besides that, the pupose of a process map is to help in understanding how work is undertaking in achieving a well-defined objective.

A process map:

1. Has a goal
2. Has specific inputs
3. Has specific outputs
4. Uses resources.
5. Has a number of activities that are performed in some order
6. May affect more than one organizational unit.
7. Creates value of some kind f
8. or the customer.

(Wix & Karlshøj, 2010)
Within IDM the roles of the process map are to:

- Set boundary for the extent of the information contained within the process.
- Establish the activities within the process and their logical sequence.
- Identify the exchange requirements that support the activities within the process.
- Enable reference processes to be determined.

This section has shown the importance of structured, early-stage decision making across the project life cycle in the built environment, particularly for clustered senior housing. The emphasis was placed on early stakeholder involvement and standardized processes, which help to streamline the design, reduce cost and improve the construction. With tools like BIM and IDM being shown essential in facilitating collaboration an information exchange. Offering a clear structure.

Overall, integrating decision making early and systematically helps to adapt easier, for projects involving smart home technology where multiple stakeholders are involved and have different interests. These methods mark a shift towards a more collaborative and digital driven construction industry.

2.7. Conclusion

The literature review in this chapter, revealed that, while smart home technologies offer proven benefits and opportunities to reduce the pressure on the senior care sector. Especially in the clustered VPT setting, the implementation remains fragmented, inconsistent, and based on ad-hoc decision making rather than well-informed decision-making frameworks. Resulting in a low implementation of SHT in the clustered VPT setting. Challenges that arise with the implementation are complex stakeholder dynamics, unclear responsibilities and lacking

financial structures. These institutional and organizational challenges hinder the full potential of SHT in clustered VPT care.

To advance the implementation of SHT in clustered VPT housing, a shift is required from the current approach towards a more integrated, stakeholder centered approach. A insight from this literature review is that the current gap is not purely technological or the lack of funding, but rather the absence of a shared clear implementation process. Addressing this procedural gap requires rethinking of the responsibilities and the decisions made in the implementation process, and how this integrates with the perspectives of the stakeholders.

The next chapters build on these insights by investigating how these challenges are perceived by experts and how they relate to the real-world implementation process. Based on this a practical process map framework is developed to support the systematic decision making.

3. Methodology

3.1. Introduction

This chapter outlines the methodology that is used to address the main research objective: to develop a process map framework that can assist stakeholders with the implementation of smart home technologies withing clustered VPT housing. Given the multi-disciplinary approach by combining healthcare, real estate development and technology, an approach was needed that could combine theory and practical implementation for this reason the Design cycle methodology developed by Wieinga (2014) had been used.

The Design cycle methodology highlights the importance of matching the research with the stakeholder goals and validate the solution in an analytical and empirical way before the implementation phase (Wieringa, 2014). This structured approach results in a artifact or framework, that is both practical in addressing the identified problem and theoretical sound. The Design cycle generally consists of three iterative phases namely: the problem investigation, treatment design and treatment validation. In Figure 18 a schematic representation of the design cycle related to the engineering cycle is shown.

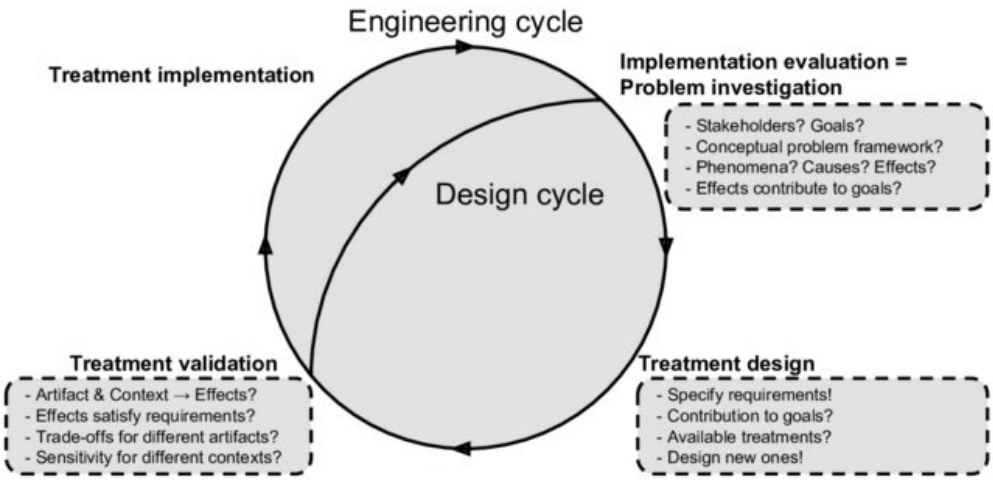


Figure 18 Design cycle by Wieringa

The first step of the design cycle is to analyse the current situation and define the problem definitions. This includes mapping the stakeholders and their objectives and goals, find best practices.
The findings of the problem investigation phase form the basis of the treatment design phase. The goal of this phase is to develop a decision support framework based on the information found in the problem investigation, and therefor aligns with the goals and objectives of the stakeholders. The goal is to develop a process map framework, that helps with the implementation process of smart home technology in clustered VPT housing in the Netherlands. This is done by presenting the current implementation process with the BPMN notation, which is an industry independent understood process model notation. This provides a systematic approach for mapping the process.
The last step of the design cycle is the framework validation. The goal of validation in research is to develop a design theory, that allows us to predict what would happen in the artifact would be used in its intended problem context and if it would have the desired effects (Wieringa, 2014). The following research steps are followed to develop the framework, this structured approach allows for a systematic development of a tool, that is supported by theory and experts

of the industry. The remainder of this chapter is organized as follows: section 3.2 presents the problem investigation phase, including the literature review and the expert interview. Section3.3 details the design of the proposed process map framework.

3.2. Problem investigation

The problem investigation phase serves as the foundation for understanding the current challenges and inefficiencies in the implementation of smart home technology (SHT) within clustered VPT housing. This phase aims to identify key decision-making bottlenecks, stakeholder roles, and implementation barriers, which will inform the requirements for the decision-support tool developed later in the study. A dual-method approach is used to conduct this. Namely a literature review and expert interviews, the literature review is described in chapter 2, and the next section describes the expert interviews.

3.2.1. Expert interviews

The purpose of the expert interviews is to validate the stakeholders, decision criteria and the decision-making processes involved in the implementation of SHT in clustered VPT housing. It will also gather challenges and barriers for the current process and input on how these barriers and challenges can be overcome. Therefor experts are needed to share their experiences, ultimately for each of the defined stakeholder groups 2 experts are needed. Semi structured interviews help to combine the scientifical world with the practical working field.

Semi-structured interviews are conducted because they offer a systematic approach while still being flexible in gathering detailed information from the participants. This semi-structured method allows for exploration of specific topics. While it gives the interviewees space to explain in greater detail about certain topics that are relevant for them A structured interview would have been too like a questionnaire and would not give in depth answers of an expert, and information could be missed. Whereas on the other hand an unstructured interview, would give too much room to the expert, and would not give enough direction.

Existing studies mainly focus on the effects of single stakeholder groups, to overcome this, multiple experts from different disciplines were interviewed. The experts were contacted with the help of the company and personal network.

Each interview was organized around 5 key themes namely, personal background, decision making process, stakeholders, criteria, and decision support tool. The interviews were conducted live and via Microsoft teams. All, the interviews are transcribed with Microsoft teams, and only the sound was recorded. The next sections will explain the questions, and why they were asked. It is important to acknowledge that the automatic transcription from teams is not always correct and can make some mistakes, therefor, the transcriptions are manually controlled, with the help of the recorded sound of the interviews.

Personal background

The first part of the interview is an introductory part consisting of general questions asked to the interviewee, about their personal roles, work experiences and experiences with implementation of SHT. The aim here is to validate their role as an expert on this topic and gather information for questions later in the interview.
Questions that were asked are:

- *Can you describe your role and how long you have been in this position?*
- *What smart home technology are you familiar with, and what have you used / implemented?*

Decision making process.

The second part of the interview is about mapping the current decision process, since this was lacking in the literature. The goal of this is to map out the current decision process. To see the sequence of events, who are involved in the decision-making process, and if there are any conflicts of any. At this stage none of the prelisted stakeholders, or criteria are given, so that the answer of the interviewees, is based on their own experience.
The following questions were asked:

- Could you describe the decision-making process for implementing SHT?
    - What is the sequence of events?
    - Who is involved in each phase of decision-making?
- Who has the final say in the decision to implement SHT?
    - What are critical stages when decisions are made?
- How do stakeholders collaborate or negotiate in this process?
- Are there any common conflicts or competing interests between stakeholders?

Stakeholders

In this section of the interview, the interviewee, is shown a list of stakeholders, with a short description of their role. The interviewee must describe if he or she recognizes the stakeholders as such, and to validate their role in the process. The list with found stakeholders is found in Table 15. Furthermore, it is asked what the power and influence of different stakeholders was in the implementation process, for this the interviewees, should fill in the Table 18, and lastly this section is to validate that there are no stakeholders overlooked.

Table 15 Stakeholders

Stakeholder	***Role***
Care receiver	The end-users / residents living in the housing complex and receiving the care.
Support provider	*Informal caregivers, e.g., family and friends of the care receivers, who provide unpaid care.*
Care workers	*Paid professionals such as nurses. Doctors etc.*
Care providers	*Organizations managing care delivery and housing etc.*
Technology providers	*Developers / providers of the smart home technology*
Building developer / investor	*They develop the building, and own the building, note that this still can be two different parties.*

With the following questions, the interviews are asked about their experiences with the listed stakeholders, and if it matches with the described decision process part of the interview.

1. Do you recognize this list of stakeholders as key players in the implementation of SHT in senior housing?
    - can you describe their role in the decision-making process?
2. How would you describe the importance or power of each stakeholder in the decision-making process? (fill in the figure below, using the numbers of the stakeholder table above)
    - Who are the most influential stakeholders in deciding which technologies are implemented?

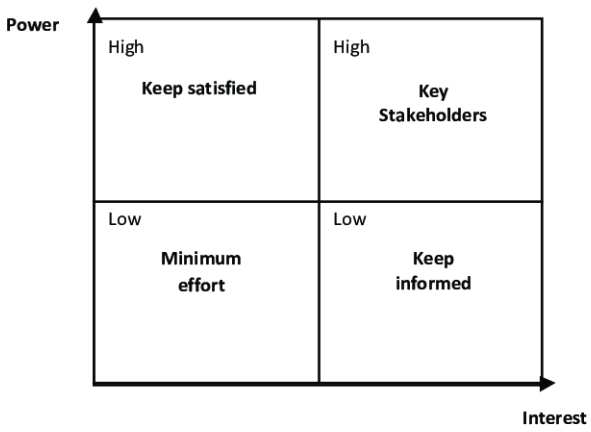


Figure 19 Power-interest diagram (source)

3. Do you think any stakeholders have been overlooked? If so, who are they, and what are their primary concerns or interests in the implementation process?

Criteria

Similar to the stakeholder section, this criterion, starts by showing the interviewees, a list with the found criteria in the decision-making process, the list can be found in Table 16 the interviewees should give their opinion about these and mention if any is missing.

Table 16 Criteria

Criterion	*Sub-criterion*
Independency	- Support basic activities - Reduce reliance on (informal) care givers
Useability	- Easy to use - Not disruptive in environment - Accurate - Stable - Integratable
Financial	- Investment costs - Monthly costs - Labor saving
Social acceptance	- Added value
Monitoring	- Alarm functions - Provide info - Available for informal carers - Detect functional decline
Social interaction	- Promotes interaction
Security	- Privacy / data

The question that are asked here are:

- Looking at the criteria / sub criteria, do you agree that these are the key factors in making decisions regarding SHT?
  - Why or why not?
- Do you believe there are other important criteria / sub criteria that should be added?
  - If so, what are they, and why are they important?
- Do stakeholders in your organization use these criteria in their decision process?
  - How are these criteria weighted in decision-making?

- What kind of data, can you link to these criteria: (e.g., costs, monthly costs, labor savings, etc.)
    - Is this data being used in the decision-making process?

Requirements for the tool

Since the goal of the research is to develop a tool that can help in this process, the interviewees are asked about what they find important in a tool, and what wants them to use it. To get this knowledge the following questions were asked.

1. In your opinion, what are the most important requirements for a decision support tool that would assist in the implementation of SHT?
    - What type of information should the tool provide?
    - What outputs would be most useful for you and other stakeholders?
2. What is the most important decision the tool should help with?
    - What should the final output of the tool be (e.g., a recommendation, a ranking of options)?
3. What is the ideal timeline for decision-making in the implementation of SHT?
    - How could a tool assist at different stages of this timeline?
4. Who do you think should use the tool, and at what stage of the process?

3.2.2. Policy documents

During the interviews, multiple interviewees, shared policy documents that they use for the current implementation process. These policy documents are used as input for the process modelling, However, due to confidentiality agreements and data protection regulations, the direct sharing of these documents is not permitted.

Despite these restrictions, the BPMN development process extracts relevant insight from the policy documents without disclosing their contents. The model produced is based on generalized information. Additionally, anonymization and abstraction, are applied to prevent unauthorized sharing of sensitive information. The policy documents are scanned through, and the important information that could be used is implemented in the process maps in chapter 4.

3.2.3. Data analysis

This section presents the methodical framework, for the analysis of the qualitative data collected from the seven experts in different disciplines through the expert interviews. The transcriptions of the interviews are analysed by thematic analysis, with the use of the tageutte online software. The section explains the steps taken to conduct this thematic analysis.

Type of analysis

For the analysis of the interviews, the method of thematic analysis is executed. This analysis method enables to do qualitative research by textual analysis. Furthermore, this method can be performed to identify and distinguish different themes. The aim of the interviews is to find the stakeholders challenges and processes, for implementing smart home technology in clustered VPT housing. which can generate a new approach to speed up the process. The thematic analysis is based on the structure of Jodi (1994).

1. *Familiarization*
   The first step is to conduct all the interviews and organize these. To familiarize with the data all interviews are transcribed, relistened and double checked. By doing this the first familiarization occurs. As mentioned in the expert interview section, the interviews

were automatically transcribed with the Microsoft teams software, these transcriptions were anonymized and manually checked to compare it with the sound recordings.

2. *Coding process, highlighting*
   The second step is the coding process, the first phase of the coding is conducted. Per questions the answers are coded. The coding highlights the essential words, sentences or parts of sentences which structures the first information per question.
3. *Generate themes*
   Based on the created codes, themes can be created to combine the codes. The codes are combined in overall code groups. These themes groups are primarily based on the next research step.
   1. BPMN related Codes
   2. Barrier and challenge codes
   3. Solution codes
   4. Research problem codes
   5. Independent codes
4. *Review themes*

This method helps to analyze the interviews in a structured manner. Furthermore, by indicating themes between codes, a more conceptual view can be generated. This conceptual view indicates the main objective necessary for the development of the framework.

Taguette

For the coding and analysis of the interviews the Taguette software is used. This is an open-source software that enables to work in a structured way for analyzing the transcripts. Since it is an open-source software it is freely available on the internet. You can run taguette, on their server or on your own server.

Coding example

Below an example is shown to indicate how the coding process is applied. The interview results are in Dutch therefor this English text below is not in the exact words from the interview, but should be seen as an example of how the coding process took place

Question: Do you recognize this list of stakeholders as the key players in the implementation of SHT in elderly care homes?

Answer: Look, if you say so, but your healthcare provider… You have the hands at the bedside, which has narrowed down, let's say, to just the hands at the bedside. But as I just described, for example, if there are malfunctions, who is responsible then? Often, it turns out that you have the ICT department of the healthcare organization backing it up. And that's that. Well, we now also have discussions with the care facility—it has been a whole lot of hassle with that home automation. At a certain point, they also ask at our ICT department: "We are spending so many hours on this, who is going to pay for it?"

Stakeholder-code
Communication-code
Financial-code
Responsisibility code

3.3. Treatment design

Following the problem investigation phase, the next phase is the treatment design phase, this phase focuses on translating the identified challenges, stakeholder requirements and process

inefficacies into a structured framework. The goal of this phase is to develop a clear process map framework that supports systematic implementation of SHT in clustered VPT housing.

To achieve this, a process-oriented approach is adopted, by developing structured models based on the Business process model notation (BPMN) this method enables the visualization of the roles, and decision points for the related actors across the process, it will be described in the section below.

Process map development

The development of a process map is about mapping the tasks, and actors and decision points of a process, to come to such a process map Building smart defined three different development routes:

- Process discovery and mining
- Business rule localization
- Reverse engineering

discovery and data mining

The chosen development route for this research is the process discovery and data mining, this is the most conventical process used in process map development, this method assumes that there is no initial presence of software of exchange requirements. The development approach can be seen as a linear sequence, however in practice, feedback between development stages and cyclic developments can be expected.

Discover process.

This phase involves working with the industry specialists to determine the business processes within the scope that need to be satisfied. This discover process is done with the literature review and expert interviews that method can be found in section 3.2, and the results of this can be found in section 4.2.

Constructing the process map

The first step of the chosen development route is to construct the process map, as discussed in the literature review, the BPMN notation developed by OMG, is most common and logic to use. To build a BPMN process map several steps, are undertaken. First, the basic structure of swimming pools and swimming lanes is be created. After that the start and end events are be identified and located in the map. Next the activities and gateways that connect the star and end events are placed on the map and should be connected to form a closed sequence. Finally, the exchanges within and among lanes is specified. This is done in the information model lane. In the next part each section and steps to undertake are explained.

Swimming pools and swim lanes

An important characteristic of the BPMN notation, is that it can capture the roles of multiple stakeholders that are involved within the process. This is due to the swim lane in the map, that is assigned to each actor. All these swimming lanes combined make up a swimming pool. This method with swimming lanes and pools, provide a structure to the map and clarifies which activities and coordination points relate to which actor. Different stakeholders such as the developer and care organization have their own swimming lane, in which their activities are presented. Furthermore, there is always one swim lane that is dedicated to the information model. This lane contains the exchange requirements among actors.

Events

Events concern the points in the process map, were something happens that is relevant to the process at stake. That is, they influence the flow of the process. Often the events cause and impact.

According to their place in the process events can be categorized in three different groups: Start events, these events indicate the start of the process, at the other end of the map are end eventst that indicate the end of a process, between the start and end there are intermediate events, these events can both catch and throw signals.

Activities

Activities in a process map describe work tasks. It is a general name given to any work done by an actor that may appear in a process map. In a process map an acidity is visualized as a rectangle, with rounded corner.

Gateways

Gateways represent decisive points in the process map where sequence flows split or join. How the process continues past a gateway, which flows are activated, depends on the outcomes of the activities that take place before it, this is also influenced by the type of gateways.

A gateway is presented as a diamond shaped element. Activities that are connected by it through arrows provide the basis for decisions.

Artefacts

An artefact is presented by a document icon and represents the input and or output of an activity. Including these objects in the process map gives insights in which activities produce or require certain data.

This artefact is then linked to an exchange requirement, including the information that is essential to be exchanged, at a particular stage in the process. These ER are shown in the information model swim lane at the bottom of the process map.

Improvements current process

Mapping out the current process is only one part of the research, the interviewees also opted other improvements to get a smoother implementation process, these improvements are explained, translated into applicable actions, and what impacts they have on the process and what phased they have an influence on.

4. Results

4.1. Introduction

This chapter presents the results from the research methodology outlined in chapter 3, it follows the phases of the design cycle with the Problem investigation phase, describing the results from the literature and the results of the expert interviews. This identifys the core functionalities required for the tool development, and that it matches the stakeholder needs.
Based on the findings from the problem investigation phase, the process map is developed, using the data that was collected with the literature review and interviews. The results include a structured process map, on this process map the challenges and barriers of the current implementation process are highlighted, and a new and improved process map will be proposed.

4.2. Expert interviews

This section presents the findings from the interview analysis conducted with 7 experts on the topic of senior care housing and technology implementation. The analysis followed a structured approach as explained in the methodology, performing a thematic analysis, with the focus on the current implementation process of smart home technology in the clustered VPT housing, and highlighting challenges/ barriers and possible solutions to these barriers and challenges.
The interviews were conducted live and via teams, and lasted between 45 – 60 minutes, the interviews were automatically transcribed by teams, however this does not work perfect, therefor the transcriptions were manually checked by comparing these with the recorded audio files of the interviews. First an overview of the interviewed experts will be given, after that the coding structure will be explained. Followed by the results of the thematic analysis, describing the current process, challenges and barriers, solutions to these barriers. To be finished with a comparison to the literature review and a conclusion

4.2.1. Expert overview

In total, 7 experts were found to provide the necessary information and input on the stakeholders, and the decision-making process. These interviewees worked in different fields, at care organizations, real estate developers, technology suppliers and representatives for informal care workers. This amount was considered sufficient for this research since the results of the interviews aligned.

The first part of the interviews focused on the personal information; this made it clear if the expert was experienced enough to continue the interview and answer the questions of the other sections. For each respondent, their role and background are provided into the table below.

Table 17 Interviewee information

	Stakeholder group	Role	Company
E1	Technology supplier	Marketing and communication manager	Specialized in care technology and fire safety solutions, enhancing safety and well-being in healthcare environments with innovative systems.
E2	Developer, investor	Head development department	A Developer / investor / builder of societal real estate with the focus on care housing, in intramural setting and for VPT setting or housing that can be adjusted to care housing. With projects around the Netherlands, with

			projects for own investments and other projects for larger investors.
E3	Developer, investor	Project manager	A Developer / investor / builder of societal real estate with the focus on care housing, in intramural setting and for VPT setting or housing that can be adjusted to care housing. With projects around the Netherlands, with projects for own investments and other projects for larger investors.
E4	Care organization	Real estate manager	a Dutch organization that provides housing, care, and related services with a focus on elderly individuals, particularly those aligned with its Reformed Christian identity. The organization offers a variety of services, including residential care, nursing, home care, and community-oriented activities, tailored to support both physical and spiritual well-being.
E5	Informal carers	Real estate manager	A organization that stands up for the interests of informal carers. They represent the group in national politics and they support the informal carers
E6	Care organization	Project advisory technology	A Dutch care organization that provides housing, care and related services with the focus on elderly individuals, recent merger from three separate care organizations
E7	Care organization	Real estate manager	A Dutch care organization that provides housing, care, and related services with the focus on elderly individuals, recent merger from three separate care organizations

4.2.2. Coding structure

In Table 18, the coding structure that is used for the coding of the expert interviews is given. The goal of the coding is to indicate the current process with the essential steps, stakeholders, and decision moments. The challenges and barriers of the current process and the possible solutions that can help to overcome these, with the coding it is reviewed what concepts are mentioned the most among the different experts.

Table 18 Frequency analysis of themes

Theme	Count	
1.Current process	216	
1.1Stakeholders		135
1.2. Events / activities / decision point		62
1.3Exchange requirements / Artefacts		14
2.Barriers and challenges	100	
3.Solutions to barriers	77	

4. Context related	27
5.Independent quotes	9

Current process

The interviews provided information to develop the initial process models, with experts highlighting what actors are involved and in what way, with quotes like “Did we (care organization) developed a program of requirements” or “a developers says, I provide the bricks you provide the care”. Also, information was on events supported by quotes like “three technology providers presented their solutions” and “we invited people from multiple disciplines to watch and rate the presentations”.

Barriers and challenges

The interviews revealed that there were lots of similarities in the barriers that the stakeholders ran into, most of them were about, uncertainty of what stakeholder must take responsibility for what step in the process, or financial related barriers supported with quotes like: “Every investment we make in the building, we have to bill the end user in that case the solution will be too expensive”.

Solution to barriers

The interviewees also opted solutions to improve the implementation process and overcome some of the barriers this is emphasised with quotes like “If you just sit down together from the beginning, and you lay your cards open on the table” and “The process could be made easier if the government simply made sufficient subsidies available”. Most solution focus, on the financial part, and on collaboration.

Context related.

It was not directly asked in one of the sections, however during the interviews, the experts made it clear that the defined research problem, with the context related problems on the care market are confirmed. With mentioned problems, such as staff shortages, the need for technical solutions. As well the struggles with the current implementation process. With mentions of the high costs, the uncertainty in responsibility. However, these sections are also covered in the barriers and challenges.

In the interviews it also became clear that defined research problem was acknowledged by the experts, while they all mentioned similar problems in the care market. With problems like increasing work pressure, staff shortages, show the need for technical solutions. As well the struggles with the current process, mentioning the high costs, and the uncertainty in which party should take responsibility for what, however this is also covered in the barriers and challenges.

Independent quotes

The last themes are independent quotes, these include the role and experiences from the interviewees, and the organizations they work for, and other interesting quotes that cannot be directly related to the other topics mentioned above.

4.2.3. Current processes

The implementation of SHT in clustered VPT housing involves multiple phases, from the initial selection and design stages to the maintenance and operation phase. Through the expert interviews, it became evident that this process could be divided into 5 different phases, Collecting requirements, technology supplier selection, Design and installation phase, cost allocation and the operation and maintenance phase.

This next section will show the interview results on each part of the process as described by the interviewees, presenting insights, and summarizing the goals, actors, responsibility's' interactions and information exchanges for each phase, and in what phase of the project lifecycle each step needs to take place.

1. Collection of requirements

The first phases that is indicated by most interviewee's is the development of the program of requirements (POR), which includes both technical and functional aspects related to the SHT. This phase is crucial as it is the guideline for each project. As E4 emphasizes, "What we do for each project, is that we create a spatial and functional program of requirement, before the construction". This ensures that all necessary elements and requirements are accounted for from the start, what will reduce the risks of major adjustments later in the process.

The importance of developing the POR early in the project lifecycle is reinforces by E3, who states, "Usually this should be known in the DO (definitief ontwerp) phase, since all the connections need to be prepared and construction prizes will be determined on what needs to be included."

The stakeholder responsibly for initiating in the POR development lies with the care organization, E3 as developer said, "We don't take any decisions on that, that is something a care organization do in their POR". Both interviewed care organizations mentioned that they work with work groups to develop the POR, these workgroups consist of workers, from different disciplines of the organization. For example, technical staff, care staff and organizational staff. These disciplines are included since these will be the users of the technology in the operation phase. E7 mentioned: "After we formed the work group, we tried to answer questions like, what are the minimum functionalities on a room that we need, what new technologies are available". To indicate what such a meeting should answer.

Table 19 Summary Phase 1

Sub-process 1 : Development of POR		
Goal	Develop a program of requirement	
Project phase	Pre-design	
Stakeholder	**Description**	**Responsibility**
Care organization	The organization that is responsible for delivering the care, the organizational part that is not directly at the bed.	- Initiate the development of the POR - Create work group - Guide collaboration - End responsibility for the POR
Work group	Care workers, and technical staff of the organization	- Provide input for the POR
Information exchange	Functional and technical program of requirements	

2. Technology (supplier) selection

After the development of the program of requirements a technology supplier needs to be selected. Currently the technology in a care facility is often the responsibility of one party,

there for the care organizations choose this in a similar way as in the traditional care housing. By making a tender, in this tender multiple technology suppliers are contacted to get a fair competition between them. E7 mentioned: this POR is submitted to 4 different parties if they could present their products and services". This presentation should include financial and technical and informational documents, so that the different suppliers can be compared to each other. E6 provided a detailed document on the tender process of their organization, that will be used as guideline for the next step of the research but not added to the appendix, due to confidentially.

Before the bid must be delivered, the technology suppliers have the change to ask questions about the bid, if there are any unclarity's in the tender request. These questions will then be publicly answered by the care organization, so that the technology suppliers can deliver their bids in time for the deadline.

After all invited technology suppliers delivered their bids, the care organization collects these and will assess these. E6 mentioned that for this assessment they make use of the same work group who helped with the development of the POR. The bids will be assessed by an assessment form by same group that was used for the development of the POR. In this assessment the bids will be scored, on topics like costs, functionality usability etc. The care organization will collect this assessment from the work groups, and calculate the scores, based on the highest score the winning bid will be contracted to be responsible for the technology in the care facility.

Table 20 Summary sub-process 2

Sub-process 2: Technology supplier selection		
Goal	Choose party responsible for the technology	
Project phase	Pre-design	
Actors	**Description**	**Responsibility**
Care organization	The organization that is responsible for delivering the care, the organizational part that is not directly at the bed.	- Sets out the tender - Invites the technology providers - Delivers the POR - Answers questions - Collect the results -Collect assessment result
Technology supplier	Organization that will deliver the technology for the care facility	- Ask questions if needed - Deliver bid
Work group	Care workers, and technical staff of the organization	- Assess the bids
Information exchange	Tender request, POR, Questions, Answers, BID, Assessment forms, contract	

3. Design and installation

During the design and the installation phase, the key interaction occurs between the technology supplier and the building developer, and other designers. At this stage the building must be

prepared for the integration of the SHT. Several experts (E1, E5 and E7) noted that the process has become more manageable with the rise of wireless solutions. However, these wireless solutions do not mean that a building does not need any preparation at all. In fact, the rise of wireless solutions means that there is an increasing importance of stable networks throughout the buildings, and sufficient access points As E3 explained," the technology supplier indicates on drawings, how many data points are needed and how many wifi points there should be around the building". Additionally, E2 mentioned that technology suppliers or care organizations may request the addition of empty conduits or pipes in the building. This allows for future upgrades or the addition of new technology without requiring major remodelling.

Once the building design is complete and construction is finished, the Technology supplier installs the smart home technology. At this point, the care organization takes responsibility for maintaining a stable network environment. Since the seniors could not be held responsible for providing a stable network.

Table 21 Summary sub-process 3

Sub-process 3: Design and installation		
Goal	Incorporate technology in the building	
Project phase	design – building	
Actors	**Description**	**Responsibility**
Technology supplier	The organization that is responsible for delivering the care, the organizational part that is not directly at the bed.	- Delivers their POR - Delivers their design - Install technology
Building developer / owner	Owner of the building, or party that is developing the building	- Collect the designs - Collaborate with other designers - Prepare building
Care organization	The organization that is responsible for delivering the care, the organizational part that is not directly at the bed.	- Provide stable network
Information exchange	POR, BIM model, construction plans, clash reports etc.	

4. Cost allocation

The cost allocation is different to the other described phases, as is does not align with a specific point in the building process. This is because there are various options on how the costs are passed on. For example, E1 mentioned, that they as technology provider with a price upfront, and a service fee, to keep the systems running, or just a monthly fee that will also cover the initial costs. E3, mentioned something similar over the possibility of subscription fee to cover the whole costs. E4 described the process of how the financing in the VPT care works, with that the care is paid for through WLZ and an own contribution, and the housing is paid for by

the senior itself. In addition to this policy documents were used, to get a better understanding of the cost allocation in the VPT care.

In the general cost allocation of VPT care there are several stakeholders that are not mentioned before, the central administration office (CAK) is responsible for the financial compensation for VPT entitled seniors, and the health care office determines gets a VPT indication and is responsible for the financial compensation to the health care organization.

Table 22 Summary cost allocation

Sub-process 4: Cost allocation		
Goal	Clear overview of who pays for what	
Project phase	Construction / operation	
Actors	**Description**	**Responsibility**
Care organization	The organization that is responsible for delivering the care, the organizational part that is not directly at the bed.	- Pay for the SHT - Bill it to end user - Subsidy request - Claim insurance
Seniors	One who needs the care	- Pay for housing - Pay own contribution
Tech supplier	One who delivers the tech	- Delivers tech - Gets payed - supply contract
Health care office	Public organization responsible for long term care in the Netherlands, divided over geographic region	- Determine care indication - Pay the care organization
CAK	Public organization responsible for the administration related to care	- Receive own contribution
Real estate owner	The owner of the building complex	- Receive rent - Receive compensation care organization
Information exchange	Invoices, Care information,	

5. Operation / maintenance

The final phase in the implementation of SHT in clustered VPT housing is the operation and maintenance phase. This phase involves the daily functioning and upkeep of the technology when the seniors are moved in and the care facility is up and running, with the technology integrated in the care process. Based on the interviews, this phase can be divided into two main processes: the handling of care related notifications, and the handling of malfunctions or technical failures of the SHT.

E6 and E3, mentioned that an important stakeholder in this phase is a report room (meld kamer), where all the incoming signals of the SHT are received and assessed. These notifications can come from different locations, application, or users. And can include anything from fall detection to system errors.

In case of a care notification, the Report room should assess the level of emergency, and then create a task for the care worker, to check the client, or in case of emergency, call the emergency services. In less serious cases informal workers could be asked for help, despite E2, and E6 mention that this does not happen frequently in practice.

For technical notifications, there are multiple options, E4 and E7 mention that their care organization have a technical department, that is responsible for the day to day working of the technology. However, E6 and E1 also mention that technology suppliers work with maintenance schemes. Were service of the technology is included.

Table 23 Summary operation / maintenance

Sub-process 5: operation / maintenance		
Goal	Day to day operation of SHT	
Project phase	Operation / maintenance	
Actors	**Description**	**Responsibility**
Care organization	The organization that is responsible for delivering the care, the organizational part that is not directly at the bed.	- Not a direct role - Maintain stable network
Tech supplier	Party that delivers the technology	- Fix technical errors - Maintain system -
Care workers	The staff that is responsible of the elderly care	- Perform care
Tech support	The staff that is responsible that the technology keeps working	- Fix technical errors - Solve day to day technical errors - Coordinate with tech supplier -
Elderly	The group that is receiving care	- Trigger care alerts
Informal workers	Family of the seniors who help with the care.	- Help in non critical tasks -
Report room		- Receive notifications - Assess notifications - Forward notifications
Information exchange	Fault message, Care notification, Tasks, Response status	

4.2.4. Barriers

While chapter 4.2.3 presents a structured overview of the current implementation processes for SHT in clustered VPT housing, The practical execution of these is not without challenges and barriers. The following section explores the barriers that the stakeholders encounter throughout these stages, or in general regarding SHT. The analysis is aimed on identifying and understanding the nature of these barriers, this reveals several patterns in the obstacles. Below an overview is given of the mentioned barriers, furthermore the table shows the count by how many times it is mentioned by the interviewee's and to what phase of the process the barriers belong. Not all barriers relate directly to a part of the process but can also be more generalized on the whole topic of SHT integration.

Table 24 Barriers in current process

Barrier	Count	Phase
Financial	54	1,2,3,4,5
Not taking responsibility	7	1,2,4,5
Benefit misalignment	6	1,4,5
Privacy	6	1,5
Small group for VPT	4	4, 5
Subsidy not covering.	4	4,5
Different views	1	1
Knowledge barrier	3	1,2,4,5
Change of care organization	3	5
Technical life	2	4,5
Competion	2	5
Pass on costs	2	4,5
Dependency	1	5
Stress increase	1	5

Financial

By far the most reoccurring barrier in the interviews, were the financial barriers related to the implementation of smart home technology. These barriers range from, party's not receiving financial benefits for their investments, to high initial investment costs, that cannot be passed to the end users. E4 mentioned "building owners don't want to invest to much in the building" and "the care organization cannot make a return on investments with the current care rates", Another financial barrier mentioned by several interviewees, is that delay in the design process could also make the whole operation more expensive, since it is more time consuming and more intensive to make changes later in the design process. The financial barriers impact over the whole process, with delays in the beginning could result in higher costs, and unclarity who is paying for what in other phases, in combination with tight budgets and margins for both the investors and care organization, makes it a difficult puzzle to solve.

Related project phase (1,2,3,4,5)

Not taking responsibility

The second most mentioned barrier after the financial barriers, is emphasized by multiple stakeholders, there is lacking a party taking responsibility in the implementation process, and that currently it is a lot of fingers pointing to each other, who must pay for it, who should operate it who should maintain it. This makes it unclear who is responsible for what. Where E3 mentions from the perspective of the developer, it should be the care organization who is

responsible because they use the technology, E4,6,7 point the finger to the developer saying it is your building, and for us to deliver care it should be equipped with SHT.

Related project phase (1,2,4,5)

Benefit misalignment

The reason, why real estate developers are hesitant to invest in SHT, is that the benefits of the technology are for the care organization, in the form of more efficient care. E3 says on this:" the investments are for their care efficiency, so they should get a return of investment out of it" This is also the case for the elderly, why should they invest in technology as the benefits are for the care organization.

Related project phase (1,4,5)

Privacy

Another reoccurring barrier is related to privacy concerns, particularly regarding the miniating and data collection association with SHT. Since many systems are are capable of detecting movement, falls and behaviour. The privacy of the seniors is a issue that needs to be carefully monitored with the implementation of SHT.

E4 and E6 both emphasized that technology is only implemented if there is permission of the elderly or informal carers, and most data is not stored and only used for direct monitoring. However, this can be hard to belief by seniors or their informal carers.

Related project phase (1,5)

Small group of VPT

Care organizations mentioned that another barrier for the clustered VPT housing is, that people often come to live there when they are still to fit to need all the technological solutions, and it is difficult to fill a complete clustered complex with people with the same care demand. Emphasized by E4 "The people who come to live in these VPT complexes are to vital, to make full use of implemented technology"

Related project phase (4, 5)

Subsidy not covering.

Despite the presents of subsidy's 6 out of 7 of the interviewees mentioned that they current subsidies are not covering the cost for implementing SHT. Besides the lack of subsidy some interviewees also mentioned that in this case insurance companies are not willing to step up and reimburse technologies.

Related project phase (4,5)

Knowledge barrier

The knowledge barrier is also mentioned by several interviewees, what it means, this mostly relates to the seniors, who often do not know what technology available, and what possible benefits is are to use that technology, therefor it is difficult to take them along with investments in such kinds of technology implementations. E5 mentioned that technological solutions are

not checked verry well with informal workers, so that technology's that seem to relief pressure on this group can increase the pressure.

Related project phase (1,2,4,5)

Technical life
Both E2 and E4 mention that due to rapid technologic developments, the depreciation rate of SHT can be fast, this means that the investment should be earned back in a shorter period, therefor the whole process starts again, and this short technical life can also be related to the financial barriers.

Related project phase (4,5)

4.2.5. Solutions to barriers

Having identified the main barriers that complicate the implementation of SHT, this section aims to provide possible solutions to these barriers as suggested by the interviewed experts. These solutions are not only intended to specifically address the mentioned barriers, but also improve the overall feasibility of the SHT implementation.

The solutions offer combinations of process improvements, policy changes, and technology factors. Table 25 presents the range and frequency of the proposed solutions. These solutions will be described and mapped to the corresponding barriers, showing where the solutions could have the biggest impact in the process.

Table 25 Solutions to the barriers

Solutions	Count
Collaboration	17
Integration	13
Flexibility	7
Subsidy	6
Early planning	5
Retirement home 2.0	4
Education	4

Collaboration
In the current process steps, the actors collaborate to little, with more collaboration they implementation could be better, as examples were called, open finance were party's show each other their margins to see who has more room for financial investments, also involvement of personal and informal care workers is mentioned. E5 as a representative for informal workers mentioned that if the informal workers are involved early in the decision making, that it could decrease their stress, and maximized the use of technology.

E6 proposed in taking the investor / developer along in the development of requirements, so that they can have input on that from a building perspective.

Also in the operation phase more collaboration could take place E1,E5,E6 and E4 mentioned that it can be useful to involve informal care workers, with the alarms, so that they can help with care of the seniors. However, E5 mentioned, that this has to be in good consideration since it can also put too much pressure on the informal carers.

Linked barriers

- Benefits misalignment (Phase 1,4,5)
- Not taking responsibility (Phase 1,2,4,5)
- Knowledge barriers (Phase 1,2,4,5)
- Competition (Phase 5)

Integration

Integration refers to the development of a technology systems that are interoperable across so that it can be adjusted to organizational Experts emphasized that currently each care organizations work with their own systems, and that makes it difficult to change from care providers. E1 mentioned that they offer a solution, that is independent of the brand of technology, and care organizations are not limited to certain technology providers.

Linked barriers

- Change of care organization (Phase 5)
- Competition between providers (Phase 5)
- Short technical life (Phase 4 and 5)

Flexibility

Plug and play solutions are also mentioned in the interviews as a possible solution, E4 said " if there comes a new senior, who only needs an alarm, than we can remove the sensors or add some if the care situation changes." By providing flexible solutions care organizations can taylored the technology needs to the end user, and there would be no wase of resources for technology that is not used.

Linked barriers

- *Technical life (Phase 4, 5)*
- *Pass-on costs to users (Phase 4, 5)*
- *Small group for VPT (Phase 4,5)*

Subsidy

Multiple experts mentioned that despite the presence of various subsidies available, they are not enough to cover the expenses, let alone invest in new technology, therefor the opper to increase the subsidies or the insurance compensation.

Linked barriers

- Financial barrier (Phase 1-5)
- Subsidy not covering (General)
- Responsibility (Phase 1,2,4,5)

Early planning

Several experts mentioned, that if the plans are early discussed with building owners, the building could be prepared for the instalment of technology, this could reduce the risk of later changes that could be expensive to do in an existing building. Preferably in the do phase, link to the BIM graph, that changes cost more later in the process.

Linked barriers

- *Financial (Phase 1-3)*
- *Responsibility (Phase 1-3)*

Retirement home 2.0
Some experts mentioned, to create new living concepts, to make it more feasible, with the focus on people with a specific VPP level or creating smaller but more technical rooms. E4 stated: the trandional care home does not exists anymore, only for people with an intramural indication, for that group below we should build some sort of care homes, only for people with a VPT indication" E6 and E7 mentioned a similar solution as representatives of care organizations, to make the concept of clustered VPT housing feasible.

Linked barriers
- *Small VPT target groups (Phase 4 and 5)*
- *Financial (General)*
- Benefits misalignment (Phase 4)

Education
Educate the people who must work with it, so they are more open to it. Educate the seniors and their family, to show the benefits of using technology and why it might be a good idea to pay extra for it …….

Linked barriers
- *Knowledge barriers (Phase 1,2,4,5)*
- *Privacy concerns (Phase 1, 5)*
- *Stress increase (Phase 5)*
- *Pass-on costs (Phase 4,5)*

Furthermore in Table 26 shows a overview of the mentioned barriers, with the solution that are proposed by the interviewees. Besides that the table indicates for each barrier and solution which phase is impacted by it. Please note that not all barriers and solutions are included since not all of them could be directly linked to each other.

Table 26Summary Barriers and solutions

Barriers	Solutions	Related phase
Financial	Subsidy Education Retirement 2.0 Early planning	1,2,3,4,5
Knowledge barrier	Collaboration Education	1,2,4,5
Small group for VPT	Retirement 2.0	4,5
Technical life	Flexibility Integration	4,5
Benefit misalignment	Collaboration	1,4,5
Privacy	Education	1,5
Competion	Collaboration Integration	5,1
Change of care organization	Flexibility Integration	5
Stress increase	Education Collaboration	1,5
Pass on costs	Education, Flexibility	4,5
Not taking responsibility	Collaboration Early planning	1,2,4,5
Subsidy not covering.	Subsidy	4,5
Different views	Education	1,2,4,5

4.2.6. Comparison interviews and literature review

This comparison extents the results of the literature study in comparison with the conducted expert interviews, on the implementation of SHT in clustered VPT housing. This section covers the same sections as the literature review, with the current care situation in the Netherlands, Smart home technology, Stakeholders and Decision making, and process.

Care situation in the Netherlands

The literature review showed that, there is an increasing shortage in care staffing and an increasing amount of elderly, with associated high costs and deficits in healthcare organization budgets. That the current situation is untenable, is confirmed by E3, E4,E6,E7. With all the interviews, mentioning that the amount of work stress is increasing, it is becoming more difficult to get enough care workers. It is remarkable that these concerns mainly arise, with the people who must deal with it on a daily base, this indicates that Technology suppliers and developers experience the stress on the care market less.

Besides the stress on the market the literature review also explained the current care policy in the Netherlands. This was not detailly discussed in the interviews since the focus was on the clustered VPT setting. However, the care organizations interviewed, that even though this policy is already in place since 2015, they did not have a lot of experience with working with this setting. Because of the mentioned barriers that do not only apply on SHT but on the whole concept of clustered VPT care.

Smart home technology

The Smart home technology section discussed what SHT technology is, what types of it exists and what benefits could be. Since the interviews were more about the process then the actual technology the interviewees did not explicitly mention, what technology they have experience, however some mentioned, the use of lifestyle monitoring, alarm sensors, bed sensors, and smart diapers, as technology that is often used in their organization.

Stakeholders

Regarding the stakeholders, the interviews aligned the stakeholders found in literature, only it became clear, that the in the current situation, the elderly and informal workers, have little to no influence in the current decision making, whereas that is something specifically mentioned as preferred situation by the representative of the informal care workers. Besides that, new stakeholders were mentioned, E3, E6 and E7 mentioned that the Care central (zorgcentrale) should be included as a stakeholder, since this party is responsible for translating the notifications to tasks or alarms. Also, the insurance company's / government were mentioned as stakeholders in the process.

Decision making process.

In the literature study, one of the identified gaps, was the decision-making process, since the organization structure for clustered VPT differs from other care settings, that leaves a lot of challenges in the decision-making process. Such as the lack of responsibility, in the process. This is a barrier that is mentioned by all the interviewees. However, the interviews also showed that the situation of clustered VPT, is not completely different to other care situations, and that the lots of processes are like the old care situation, with the technology selection phase and the development of program of requirements. Also, the phases, are like normal building cycles and information drops occur between different users. But the interviewees, emphasize, that they struggle to link the different phases and associated responsibilities.

4.2.7. Conclusion

The analysis of the interviews with 7 experts in the domain of senior care housing and technology provides an insight into the current SHT implementation process for clustered VPT housing, with its barriers and challenges. In line with this the interviewees also came up with possible solutions on how to solve these barriers from their perspective.

With the thematic analysis, 5 different processes, were identified, with each of these processes having their different goals, actors, and responsibilities. The identified processes, were, development of POR, choosing the technology (supplier), Design and installation process, the cost allocation and lastly the operation and maintenance phase, these phases will be modelled in the next section, under treatment design.

Key barriers were identified across all different project phases, with financial constraints as the most prominent. Stakeholders face uncertainty who should pay for the technology or takes responsibility for different parts in the process. Other mentioned barriers include the misalignment in benefits, limited knowledge amongst users and privacy concerns. These issues contribute to delays, inefficiencies, and projects not coming of the ground.

To address these challenges, the experts also provide several solutions, that could be integrated in a new process. Solutions mentioned are, improved collaboration, and early stakeholder involvement, including the informal carers and building developers. To reduce the risks of misunderstandings. Also mentioned was increasing subsidies to bridge the financial gaps.

The insights from this chapter support the findings from the literature review and add valuable perspectives from practice. These findings will serve as input for the next stage of the research and help to link the different phases and responsibilities to each other and the right stakeholder.

4.3. Treatment design / model development

Based on the findings in the problem investigation phase, this chapter outlines the development of structured models, to improve the decision making in the implementation of SHT in clustered VPT housing. The goal of this model is to provide clarity in stakeholder responsibilities, improve coordination in the process, and address the known barriers. The model captures the current implementation landscape and introduces a refined process that can guide stakeholders towards a more successful implementation of SHT. This section firstly describes the different phases of the current process, and how these phases relate to each other, and how they will be modelled. The next sections will show the different models of these phases, how they can be improved and what further actions can be taken to improve the implementation of SHT in clustered VPT housing.

4.3.1. Process phases

This section will briefly describe the identified process phases identified in the problem investigation phase, and how these phases relate to each other. In Figure 20 a simplified process model is shown to indicate the most important phases for the implementation phase of SHT in clustered VPT housing in the Netherlands.

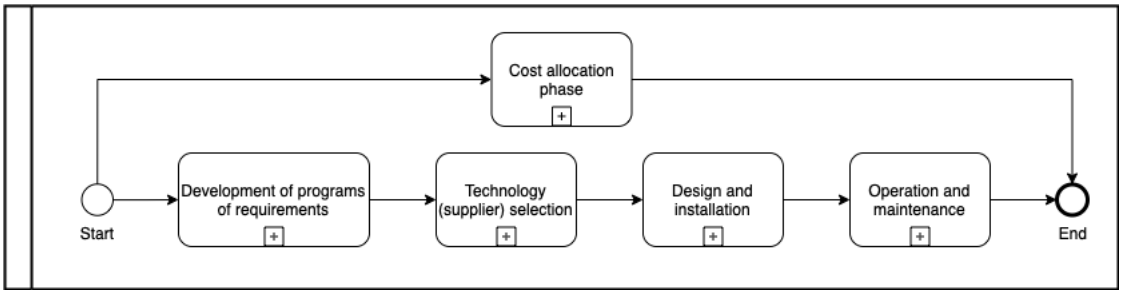


Figure 20 Simplified implementation process

In the interviews it became clear that these phases are the most important in the implementation process of SHT. The figure shows, a line going from the Development of process of requirements all the way to the operation and maintenance phase, and parallel to that a cost allocation phase since this phase relates with all the phases.

The 5 phases that will be modelled are described below and will be fully explained further on in this chapter.

Phase 1: Development of program of requirements

This phase involves defining the program of requirements (POR), where care organizations gather input from work groups, to determine the necessary functionality and technical needs for the SHT. These requirements form the base for the following phases and ensures that it is aligned with the user needs before the actual design and implementation of the technical solutions.

Phase 2: Technology (supplier) selection

After the POR is developed, care organizations issue a tender to select the best technology supplier / solution. The POR is shared amongst multiple technology suppliers, who all can make a bid. These bids are then evaluated by the care organizations, ensuring a transparent and competitive selection. Aligned with the earlier determined program of requirements.

Phase 3: Design and installation

During this phase, the selected technology will be integrated into the building design. Collaboration between the building developer, and other designers ensure that the technology will match the building, and that the building is equipped with the necessary connectivity so that the technology can be installed before operational use.

Phase 4: operation and maintenance

In this phase, SHT is used in the daily care routines. The notifications are monitored by a central report room. Which distinguish between care related and technical issues. On the type of issue, the right stakeholder is contacted to solve the issue.

Phase 5: Cost allocation

This phase determines how the financial responsibilities of SHT implementation are allocated. It involves the standards payment scheme for VPT care., with the focus on the technology implementation.

4.3.2. Process mapping

This section focuses on the development of process map framework in the Business process map notation (BPMN). Therefor first the process goals and assumptions are elaborated. Then the parts of the process that will be mapped will be explained.

The primary goal of the process maps is to provide an overview of the implementation process of SHT in clustered VPT housing. This process can be either for new developments, or existing buildings that are subject to a new technical installation. By dividing the process into distinct phases, Stakeholders can identify their roles tasks and information that needs to be send between different actors. By connecting these phases, it is ensured that decisions made early in the processes, are carried through and aligned with the later stages. By assigning clear tasks and responsibilities to the different stakeholders in each phase, miscommunication and delays should be avoided. A well-defined process map should support smoother collaboration, informed decision making and a successful operation of SHT in the clustered VPT care.

These process maps, should guide policy makers in care organization, or developers who want to develop care specific housing with integrated smart home solutions in the Netherlands, to see in what stage of the building cycle their specific role and tasks are regarding the implementation and operation of the SHT. It is also a manual for other stakeholders involved in the process, to see what is expected from them in the process, such as the informal workers, and technology suppliers.

Sub-process 1: Development program of requirements

The first step in the is to create a functional and technical program of requirements (POR), what creates the context, on what the technology should comply to.
The interviews showed, that both the interviewed care organizations make use of work groups to develop the POR, these work groups consist different employees in the organization, ranging from care staff to technical staff. All parties have something to say about it. Figure 21 gives an overview of this phase.

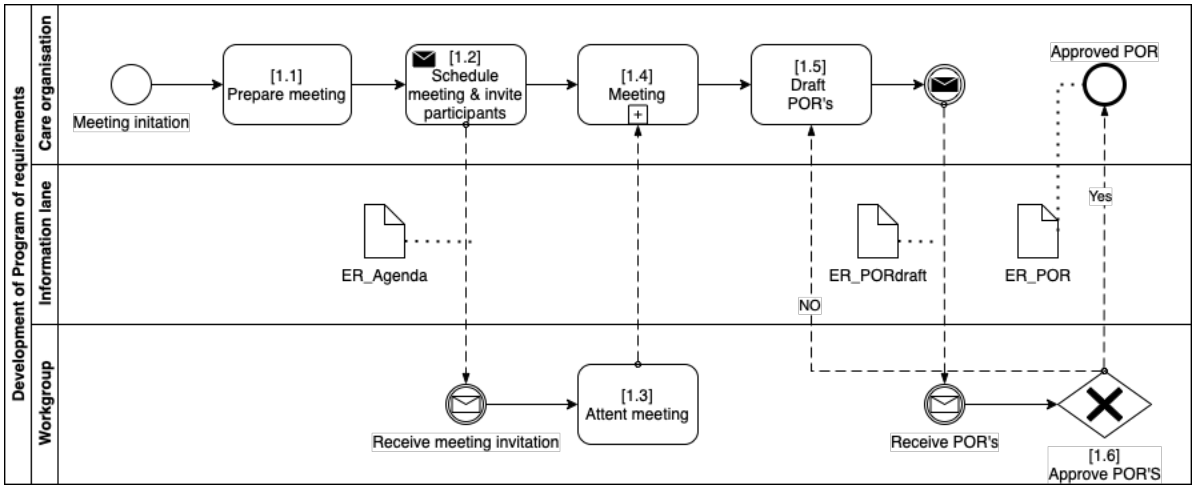


Figure 21 Development of POR

Start of development POR: This phase starts with the care organization initiating a meeting, with the work group.
End of development POR: This phase ends when the POR is approved by all the different stakeholders who developed it.
Involved Actors:

- Care organization
- Work group – consisting of care workers and technical staff of the care organization

The first step of the implementation starts, with developing a program of requirements (POR), this process is initiated by the care organization. This care organization invites a special work

group to a meeting to discuss the functional and technical requirements, before this invite is sent the care organization should create a meeting agenda and prepare the meeting so that the meeting can be as streamlined as possible [1.1]. After this agenda is created, the care organization should invite this work group[1.2]. Including with this should be the agenda for the meeting, and if available extra information so that the work group can prepare on the meeting (ER_Agenda).

This work group consists of the different disciplines within the care organization, namely care workers who will work with the technology, and the technical department that is responsible for the technology later. By using this work group for input in the development of the POR, the needs and preferences of end users will be incorporated in the POR.

The meeting together with the care organization and the work group is modelled, as one session [1.3], however, keep in mind that this could be several work sessions to come to the desired result. After this meeting the care organization should develop a draft POR [1.5] on functional and technical level, these drafts should then again be approved by the same work group [1.6] as before to see if their input is included in the POR. If the work group does not accept the POR, the care organization should revise their draft, and send the results back to the work group. If eventually the draft is accepted by the work group, it can be sent to technology suppliers, with the question if they can offer a solution. This tendering process will be described below.

The development of the POR phase involves the next exchange requirements:

1. ER_Agenda
2. ER_PORdraft
3. ER-POR

Sub-process 2a: Technology (supplier) selection

After the technical and functional program of requirements is approved, the next step in the process is to start the tender phase, this process is initiated by the care organization by inviting several technology suppliers, to do a bid, with what they think is the best solution for the use cases. This tender process is split into two parts, the bidding phase and the assessment phase. In Figure 22 the process model of the tender bidding is shown, it will be further explained below.

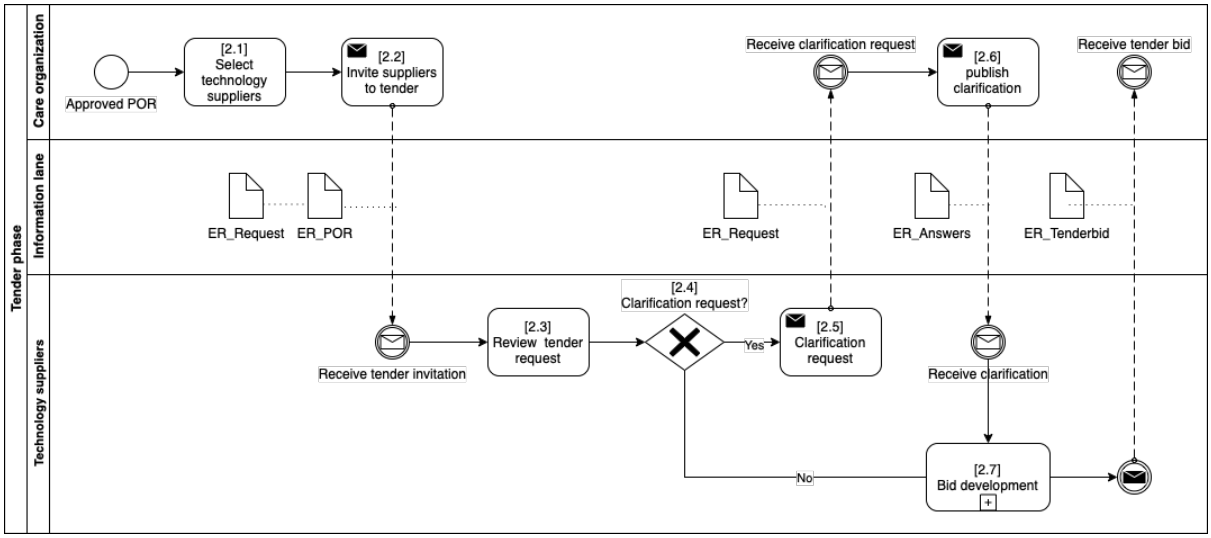


Figure 22 Tender Bidding

Start of tender phase: Approved program of requirement from phase one.
End of tender phase: Receiving the tender bids
Involved actors:

- Care organization
- Technological organization

After the final version of the POR is approved by the workgroups and finalized by the care organization, several technology suppliers will be selected [2.1] this is usually a selection of three or four so that there is a fair competition amongst the suppliers. If the suppliers are selected the care organization will invite these to participate in the tender [2.2.] by providing them with the tender details and the program of requirements on which their bid must fulfil.

When the technology suppliers, receive their tender request, they have a limited time to review it [2.3], and ask questions about the request [2.4] this request must be submitted before the deadline set in the tender request [2.5].

After this deadline, the care organization collects all the clarification requests, and publish the answers to the requests publicly [2.6] so that all the technology suppliers have the same information.

With these answers received, or if there were no answers at all the technology suppliers can form their bid [2.7] this process is not modelled since it is not relevant to this research and is more about the tender bid development of the technology supplier. With the final bid developed the technology suppliers should deliver their bids to the care organization, again before the deadline set in the tender request. So that each supplier has the same time to work on the bid. The bids should consist of the same information, so that the can be compared in a later stage.

The tender bidding consists of the following exchange requirements.

1. ER_FPOR
2. ER_TPOR
3. ER_Questions
4. ER_Answers
5. ER_BID (consisting of financial etc…)

Sub-process 2b: Technology (supplier) selection

Out of these bids the best supplier needs to be selected, the process on how this is done is shown in the process map in Figure 23 and described below.

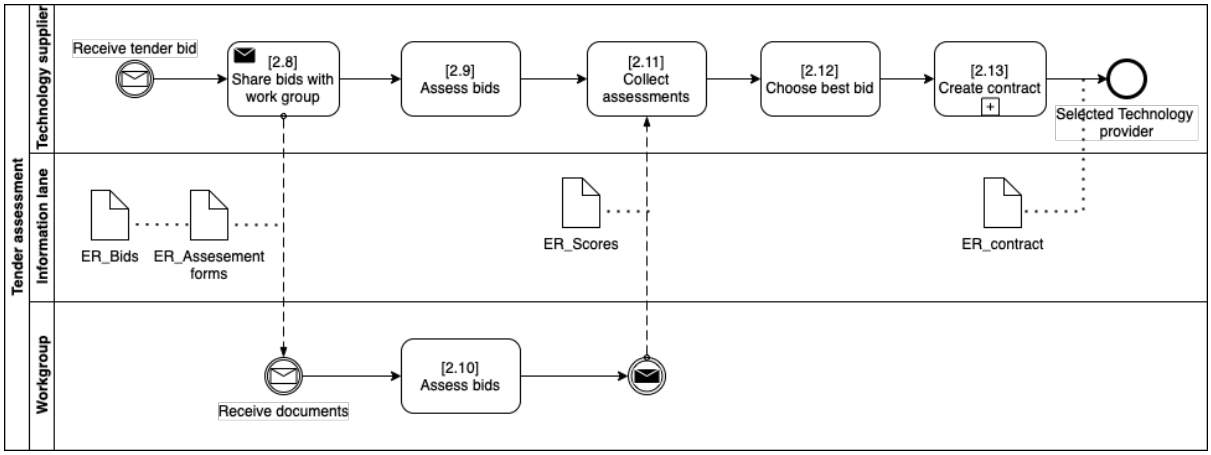


Figure 23 Supplier selection

Start tender assessment phase: Care organizations collects bids from technology suppliers.
End of tender assessment phase: A final selection is made, and one technology supplier gets offered a contract.

Actors

- Care organization
- Work group

After the care organization receives the bids of the technology suppliers, the bids should be assesed, this is done by the policy makers of the care organization and again a work group with employees. After the technology suppliers have handed in their bids, and they are collected by the care organization, they are shared amongst members of the workgroup [2.8] accompanied with assessment forms so that they can be compared in a later stage. In the meantime, the care organization assess the bids for themselves, on a financial and technical level [2.9].

The work group has received the bids, and the assessment forms, then they should assess the bids [2.10] and hand them back to the care organization before the set deadline.

When all assessments are completed, the care organization collects these [2.11]. Based on the collected assessments the care organization will choose the best bid [2.12], For the winning bid, the care organization should provide a contract that is created based on the offerings in the bid [2.13]. with the contract made this phase ends.

Furthermore, the following exchange requirements arise in this phase:

1. ER_BID
2. ER_Assesement form.
3. ER_Assessment scores.
4. Supplier contract

Sub-process 3: Design / installation

With a chosen technology supplier and list of technology the phase starts, with design and installation phase. This phase in imitated by the technology supplier, the whole process is shown and explained below.

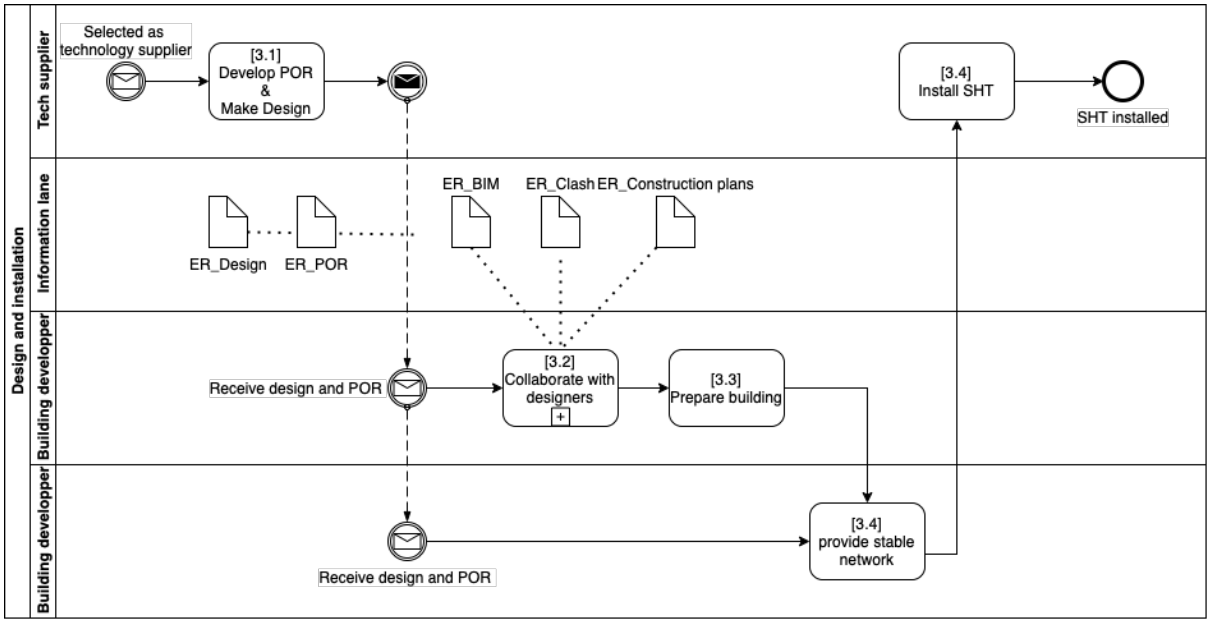


Figure 24 Design and installation phase

Start design / installation phase: after the technology supplier receives and signs the contract the next phase starts.
End design / installation phase: All the technology is installed in the building and ready for operational use.
Actors:

- Technology supplier
- Building developer
- Care organization

After the technology supplier is selected and contracted, the design and installation phase start. When the technology supplier gets offered a contract, the first step is that a detailed design gets worked out with an extra program of requirements what is needed in a building to install their technology [3.1], this is then send to the building developer, who collaborates with other designers such as architects and engineers [3.2], this collaboration includes of combining designs clashing BIM files and finalizing construction plans etc. If all the designs are set up with each other and there are no more clashes lefts, the developer can prepare the building with the necessary pipes, and access points so that it is fully prepared for the instalment of the SHT [3.3]. In the meantime, the care organization received the requirements for the network, that it is their responsibility to provide [3.4] in the prepared building. After all this is done, the technology supplier can install their technology in the building [3.5].
ER:

1. ER_POR
2. ER_BIM model.
3. ER_contruction plans.
4. ER_Clash reports

Sub-process 4: Operation and maintenance

When the SHT is installed, the building is ready for use, this phase is related, and is a different kind of process as the phases described earlier. The model below will show a simplified view from the reality, since the process of a care organization is complex and does not match the scope of the research, therefor the focus is on the process of what happens if there is a

notification from the implemented SHT, and what party should take ownership of it. The process can be seen in the process map below.

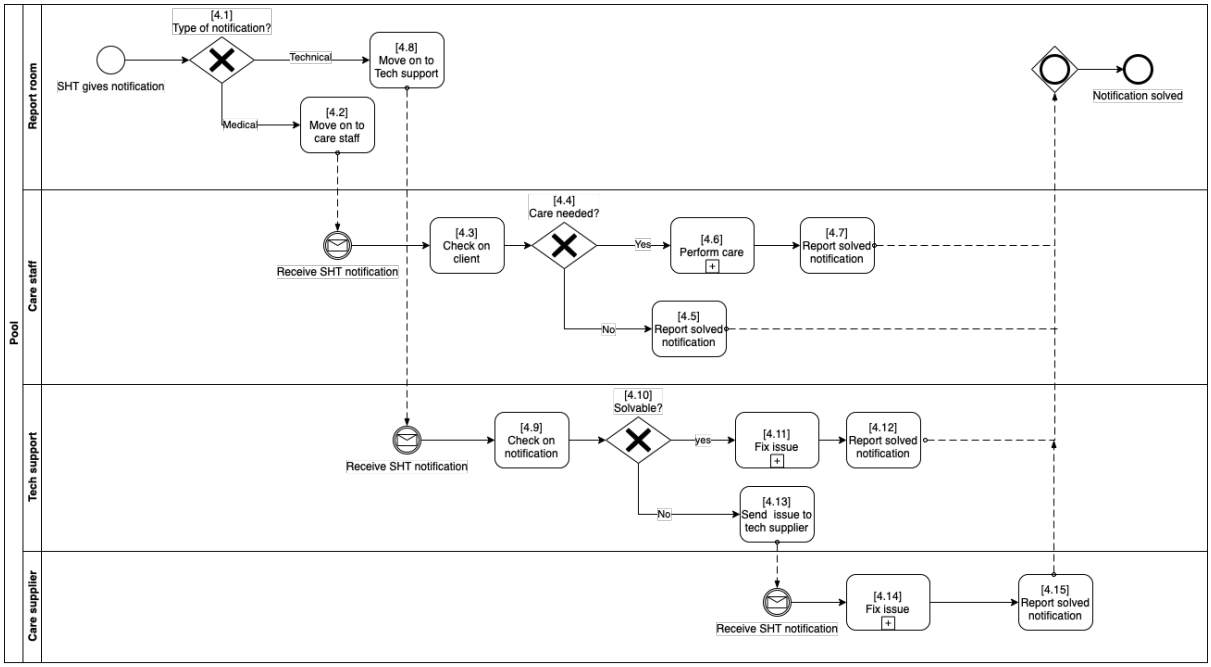


Figure 25 Process operation / maintenance phase

Start event operation phase: The Report room receives a notification from the SHT.
End event operation phase: notification solved.
Actors:

- Report room
- Care staff
- Tech support
- Care supplier
-

This process starts, with the report room receiving a notification from the implemented SHT. This notification will be assessed to see if it is a technical or care related issue [4.1].

If the issue is care related, the issue will be sent to the care staff [4.2] who will receive the notification on their device, or application. After they received and accepted the notification, they will check up on the client [4.4]. There they will assess if the client needs care, if no care is needed, the notification can be reported as solved to the report room [4.5]. If care is needed, then the care worker should perform care[4.6], this process is modelled as one step, since the care could be anything from providing in dinner, or help a fell over senior. If the care is performed, then the notification should be reported as solved to the report room [4.7]

When the report room classifies the notification as technical [4.1], the notification gets redirected to the technical staff of the care department [4.8], they should check on the notification [4.9] and assess if they can solve it themselves or extra service is needed [4.10], if the tech department can solve the issue, they should fix it [4.1]] and report it as fixed to the report room [4.12]. If the tech department is not able to fix the issue, then they should redirect it to the tech supplier [4.13] so that they can fix the issue, or replace the malfunctioning technology [4.14], after this is done they should report to the report room that the issue is solved [4.15].

Related exchange requirements:

1. ER_notifications

4.3.3. Flowchart

This section describes the final part of the VPT technology implementation process that will be modelled in this study. The focus is on the financial and service relationship between stakeholders related to the technology implementation in the VPT. Unlike the previous phases, this part is not modelled with the BPMN. Since that method is suited to representing a step-by-step linear process and decisions, it is less effective for visualizing bidirectional (financial) relationships between organizations. To represent these flows in a BPMN model would likely result in an overly complex and unclear diagram. For that reason, a simplified flowchart visualization has been developed instead shown in Figure 26.

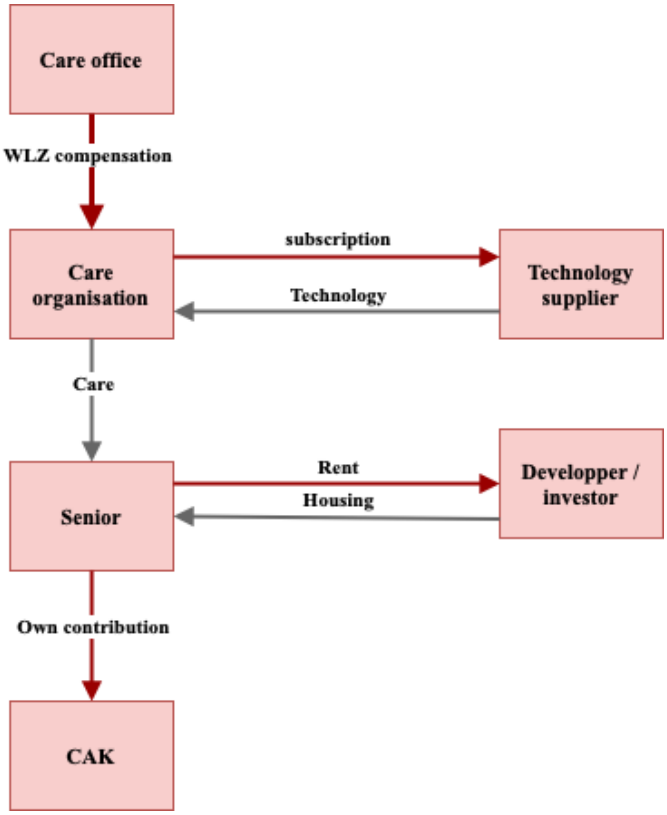


Figure 26 Cost allocation model

The figure presents a schematic overview of how financial transactions and services flow between the involved actors. With the red arrows the financial transactions are shown, and service or resource flows are shown with the green arrows. Creating a transparent structure where it is clear what stakeholder is responsible for what. This flow chart is based on the payment scheme of VPT care.

One of the key characteristics of the VPT is visible in this flowchart, namely that the senior pays for their own housing, and pays an own contribution for their received VPT care to the CAK. In return of that rent the developer provides housing to the seniors.

In the meantime, the care organization, receives a contribution from the Careoffice for the delivery of the care, the link between CAK and the care office is not shown, since it is not directly from the same financial source.

From the contribution that the care organization receives, it should deliver the care to the seniors including the payment of the implemented SHT in the building. The technology in the Care housing arrangements is installed and provided by technology suppliers, who are paid by the care organizations. Not shown in this flowchart is the maintenance, this service is also offered by the technology suppliers, depending on the type of contract that was chosen.

Section 4.3.4 till 4.3.9 provided detailed process models developed based on the interviews, the different phases of the implementation process where breakdown in critical events, decision points and actors, these insights provide the foundation for policy makers to implement SHT in the clustered VPT setting. The following section will present other actions that could improve the implementation of SHT.

4.3.4. Improvements in the current process

The developed process maps outline the steps involved in implementing smart home technology in clustered VPT housing in the various phases. However, the expert interviews revealed that many challenges encountered in the process are not directly related to a single phase but may impact multiple phases of the implementation process. These cross-phase issues include stakeholder misalignment, unclear responsibilities, and financial ambiguities, which collectively challenge the implementation of SHT in the cluster VPT setting.

To address this, this section will present possible process improvements in a solution-based approach, presenting the improvements that address the recurring challenges, regardless of where they occur in the process, rather than discussing the phases in isolation. This creates a focus on the overall process improvement. The improvements are based on the results from the expert interviews and aims to contribute to a more integrated, efficient, and collaborative decision-making process.

Table 27 Overview improvements current process

Theme	*Action*	*Impacted phases*	*Expected result*
Clarification of roles and responsibility	Develop process map	1,2,3,4 and 5	- Clear distinction of roles and responsibilities
Early involvement of stakeholders	-include actors (social workers, technology developers) in the work groups	1,2,3,4 and 5	- Align expectations - User centric design - Reduced fraction against technology
Transparent financial communication	Add extra phase, to discuss finances	1,2,,4 and 5	- Clearer responsibility - Clear expectations
Education	Train care workers	1,2 and 4	- Less reliance

	Teach senior and support provders		-	More willingness to pay / use etc.
Improved subsidies	More subsidy Or insurance	1,2 and 5	-	Remove the responsibility question, with significant budget

Clarification of roles and responsibilities

Many interviewees emphasized the absence of clear ownership across the process, the process maps presented in the previous sections should offer structure in these roles and responsibilities and can be used as a guideline in future projects.

Early involvement of stakeholders

A reoccurring theme amongst the interviewees was the lack of comprehensive stakeholder involvement at the start of the project, currently. Developers, building owners, technology suppliers and informal workers are often brought in only after key decisions have already been made. This can lead to misaligns expectation, unaddressed user needs and eventual friction during the maintenance and operation phase.

To mitigate this, the experts proposed to include these actors at the beginning of each implementation project and extend the work groups that decide on the program of requirements with informal carers, and building owners, to add an extra dimension in the program of requirements. Figure 27 shows an improved process, on how the extra work group could be added to the development of program of requirements. This work group is similarly involved as the other work group with the care workers.

The new work group will consists of building owners / developers, technology suppliers and informal workers. To cover all the stakeholders in this phase of implementation.

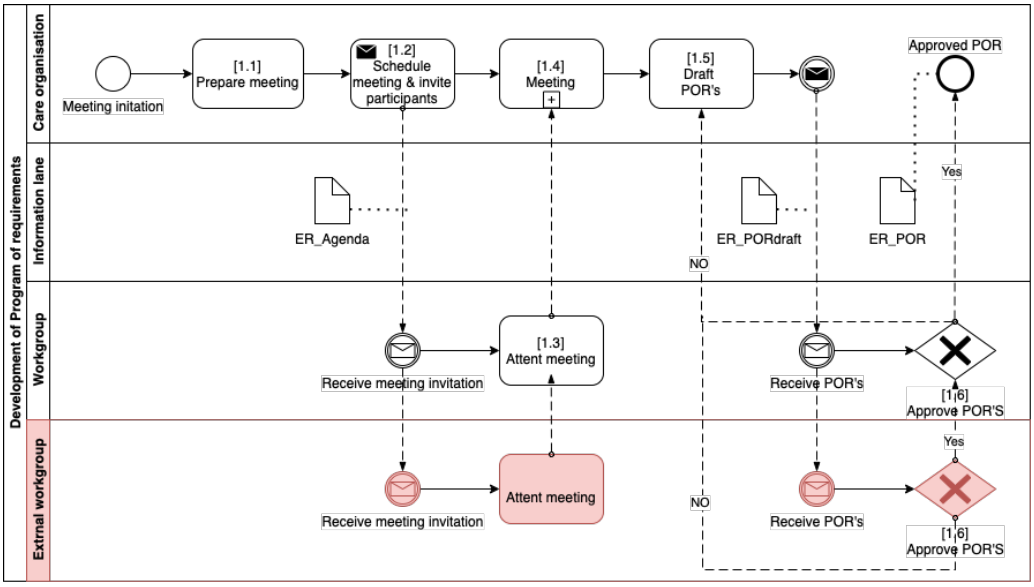


Figure 27 Improved phase 1 Development of program of requirements

By involving the building developer / owner early in the process, it knows what it can expect at the design and installation phase, the earlier it has the information the quicker something could be realized, or mistakes could be prevented.

By involving the informal care workers more from the beginning, there is also another group that can come up for the needs, of the seniors, who cannot do it themselves. This will result in less issues in the implementation phase and create a better understanding for the implementation of the technology.

Action: Invite informal care givers, technology suppliers and developers in the work group
Impacted phases: 1,2,3,4,5
Expected result: by involving more actors early on the process, the process gets more streamlined, the informal workers know more what to expect.

Transparent financial communication

Several stakeholders mentioned the lack of financial transparency, as a significant barrier to trust and cooperation, each party often keeps budget constraints and expected margins private to fear disadvantages while negotiating. This lack of openness can result in funding conflicts or even project cancelation. Several experts proposed to align the financial goals and room at the start of the project, this would provide space for each actor to present their constrains and investment expectations. By openly discussing who carriers the costs and benefits of the technology implementation, stakeholders can collaboratively design the cost-sharing models. Friction can be reduced later in the process, and the margins can be divided fairer.

Action: Discuss the finances regarding the implementation of SHT, early in the process openly with the different actors
Impacted phases: 1,2.4,5
Expected results: Reduced friction, more collaboration, and release of financial burden.

Education

The lack of knowledge amongst staff members and seniors and informal cares, is often called a challenge by the interviews, Seniors often do not understand the purpose of functionality of the SHT, and care workers might feel unprepared to support the use of the new SHT.

Relating the staff, extra training should help them to see the benefits of the technology and create a more open attitude to work with it. Training also reduces the need for unnecessary support requests or false alarms.
For seniors and informal carers, they should be including more earlier on in the process and have more education on the benefits of the SHT and what it can do for them. This education cannot directly be placed in the existing phases, therefor it can be seen as a separate phase, that must be executed before the technology is in use.

Action:

- Train staff, with the SHT
- Educate and involve seniors and care workers before implementing.

Impacted phases: 1,2,4
Expected results: Open attitude from care workers, and end users. Less mistakes in practice.

Improved subsidies

The most constraining factor for the implementation of SHT in the clustered VPT setting remains, the lack of funding, with care organization indicating that they do not have the budgets to implement such technology into their organization. A solution for this could, be that either an increase in the Wlz budget, or extra subsidy for implementing such technology is made available from the government, to make projects financially viable. The figure below indicated an extra arrow flowing from the care office to the care organization. By increasing the budget for the care organization, the financial barrier to implement more SHT in the building is reduced. This extra subsidy does not have to come from the care office but is something that can also come from insurance providers. However, for the to be policies have to change.

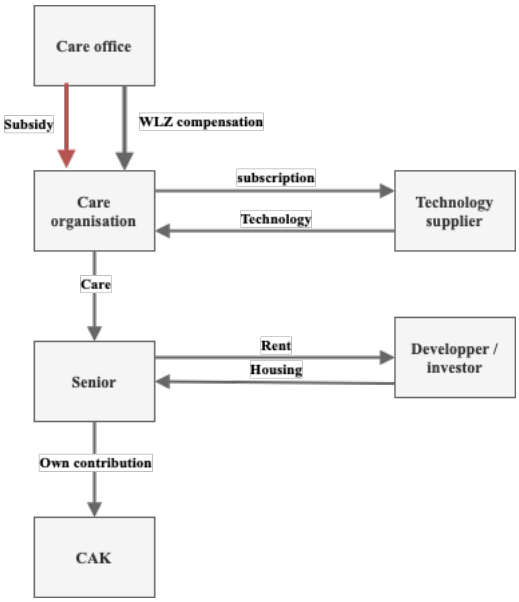


Figure 28 Improved cost allocation

Action:

- Create subsidy, for SHT implementation in clustered VPT housing.
- Increase WLZ budgets.

Impacted phases: 1,2,5

Expected results: Implementation of SHT is financially possible for care organizations.

4.4. Conclusion

The interviews presented in this chapter, made it clear that the current implementation process of SHT in clustered VPT housing is fragmented, informal and lacks a structured approach. The Expert interviews confirmed the inconsistencies found in the literature, revealing unclear responsibilities, mismatched expectations among stakeholders, and recurring inefficiencies in communication and funding structures. These issues are not from lack of interest, but rather from a systematic misalignment and absence of a clear process.

Through process mapping and stakeholder input, a clear structure of the implementation process emerged, consisting of five key phases: Development of program of requirements, technology (supplier) selection, design and installation, operation and maintenance and the cost allocation phase. Although these phases vary in practice, they could serve as a valuable framework through which the complexity of the stakeholder involvement and decision-making can be understood. Each phase revealed specific challenges, such as limited stakeholder

engagement in the initiation phase, and fragmented coordination during the operation and maintenance phase.

The research also revealed that many barriers such as resistance from care staff, lack of financial transparency, could be addressed through relatively simple interventions, Proposed solutions include earlier involvement of stakeholders, clearer role definitions, etc. By integrating these solutions into process map, the model not only reflects the current practice but also acts as framework toward improved implementation.

Ultimately, the chapter demonstrates that the implementation of SHT in clustered VPT housing is not solely a technical or financial issue, but a complex, multi-stakeholder process, that requires planning and clear communication, the outcomes of this chapter from the basis of this report.

5. Conclusion, discussion, limitation, and recommendations

This research contributes to the field of Smart Home Technology (SHT) implementation in clustered VPT housing by analyzing the current implementation process and identifying the roles, responsibilities, and interactions of key stakeholders. Based on this analysis, a structured five-phase process-map framework was developed, alongside some targeted improvements to address existing barriers in the current implementation. This concluding chapter summarizes the main research outcomes, reflects on the scientific and societal relevance, discusses the limitations of the study, and offers recommendations for future research and practical application.

5.1. Conclusion

This study aims to enhance the implementation of SHT in clustered VPT housing in the Netherlands. In the face of increasing demand for care, shortages in the workforce and limiting budgets, SHT presents an opportunity to support ageing in place and reduce the strain on the current care system. However, the current implementation process is lacking, inconsistent and based on unsupported decision-making frameworks. The objective of this research was to develop a process map framework to guide SHT implementation in the clustered VPT setting. This research states the following research question: ***"How can a process map be developed to support stakeholders in understanding and in improving the implementation process of smart home technologies in clustered VPT senior care housing?"***

A process map can be developed to support SHT implementation in clustered VPT housing by identifying and structuring the critical phases, actors and decision points involved in the process. This research combined a literature review and expert interviews with thematic analysis to analyse existing barriers, such as unclear responsibilities, misaligned incentives, and fragmented decision-making. Based on these insights, a five-phase process map was created using BPMN process modelling, offering a visual and structured framework for implementation.

The phases include: developing the program of requirements, selecting a technology supplier, installation phase, the operation and maintenance phase, and allocating costs. Each phase clearly defines stakeholder roles — including care providers, developers, and technology suppliers — and outlines the sequence of actions needed for effective collaboration. By increasing transparency, role clarity, and process consistency, the framework supports evidence-based and proactive decision-making, thereby addressing the key challenges that currently hinder the uptake of SHT in elderly care environments.

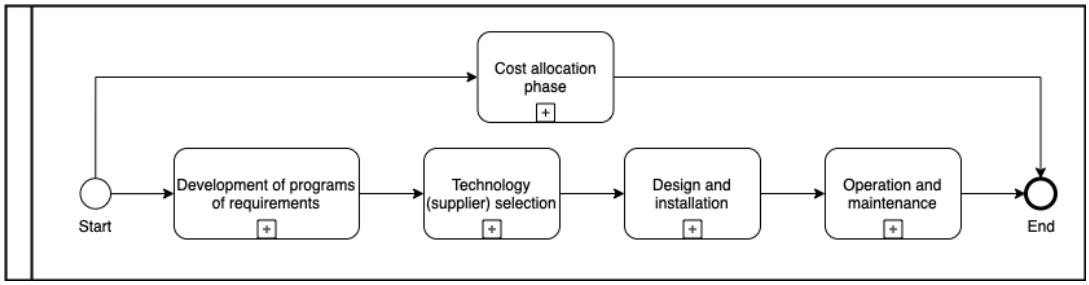


Figure 29 Schematic overview implementation process

SQ1: What Smart home technology is available?

The first sub-question is about the current state of the art of Smart Home Technology (SHT), and what types of technology are available. This study distinguished four different categories of smart home technology: wearable technology, Smart home technology, information and communication technology and sensor systems. This thesis only focuses on Smart home technology and sensor technology since these are embedded into the building. Examples of these technologies are lifestyle monitoring, access control and smart lighting.

It was found that these technologies could provide significant benefits, for ageing in place or delivering care for the seniors who age in place. SHT can improve the quality of life, improve the sense of safety, or reduce the work burden on care workers. Despite these proven benefits, the implementation of SHT in care settings is far from straightforward. The analysis in this section has shown that these systems come with significant barriers to adoption. Challenges such as non-committal government policies, upfront investment costs, fragmented knowledge, insufficient training among care staff, and the absence of system standardization all hinder implementation.

SQ2: How are decisions currently made in SHT implementation? Which stakeholders are involved and what are the barriers and interests?

The second sub-question examines how decisions regarding the implementation of SHT are currently made and what barriers hinder the process. The research revealed that the implementation can be divided into five distinct phases: the development of the program of requirements, technology supplier selection, the installation phase, the operation and maintenance phase and the cost allocation phase. The most influential actors across these phases include care providers, care workers, technology suppliers, and developers or building owners, each responsible for specific tasks within the process.

Although the involvement of these actors is essential in each stage, their roles are often poorly defined, and their interests are frequently misaligned. Care organizations tend to focus primarily on care delivery, while housing stakeholders emphasize long-term asset value. The absence of a shared process framework worsens the coordination challenges, resulting in inefficiencies, delays, or no implementation at all.

Moreover, decision-making in. practice tends to be reactive and ad hoc. Many care organizations depend on subsidies or pilot projects, which threatens continuity and prevents standardization. Additional barriers include the lack of unclear responsibilities and insufficient alignment of stakeholder incentives. These factors contribute to a process that lacks transparency, consistency, and accountability.

SQ3: How can the stakeholders, criteria, and roles, be translated into a practical process map framework to overcome the barriers?

The third and final sub-question explored how stakeholder roles, and decision-making criteria, could be translated into a practical process map framework to overcome the barriers and to support the implementation of SHT in clustered VPT housing. A review of existing decision-support methods in the construction and healthcare sector indicated that process modelling was the most appropriate approach for this problem. With the Business process model notation (BPMN). This notation was selected for its ability to clarify stakeholder interactions, decision points, and the sequential phases of implementation.

Using this modelling technique, resulted in a structured five-phase framework. The modelled phases are the same as the phases found in the current process. Each phase was defined and

elaborated on the insights gathered from the expert interviews and literature review. The resulting process map should: clarify the roles of the key stakeholders, support the alignment of responsibilities, and address the implementation barriers through a structured and replicable approach.

Additional improvements

In addition, to the development of the process maps, this research also identified and proposed several improvements that, while not all of them could be directly embedded in the process model, contribute to the broader goal of improving SHT implementation in clustered VPT housing. These improvements address the recurring practical challenges mentioned by the experts. Improvements that are proposed are, involving all stakeholders early in the process, Training and educating, care staff and support providers before implementing SHT and raising the subsidies for SHT in VPT settings. These improvements do not solve all the barriers to SHT implementation however, they could help organizations in the future.

5.2. Academic relevance

As outlined in the introduction, the existing literature on Smart Home Technology (SHT), in senior care housing mainly focuses on user acceptance, technological feasibility, and health benefits. However limited research has been done, on how it is implemented, particularly in the context of clustered VPT housing where multiple stakeholders including care providers, housing developers, and technology suppliers must collaborate. This research addresses that academic gap, by offering a process-based perspective on SHT implementation. Based on stakeholder dynamics and the complexity of the decision-making. The development of a BPMN-based process map creates a framework for interdisciplinary collaboration in VPT housing projects. This approach adds new insights into an under-researched field.

5.3. Societal relevance

The Netherlands is facing a demographic crisis, with an ageing population and a rapidly increasing demand for elderly care. Estimates suggest that by 2040, 40% of the Dutch population will be aged 65 or older, and the demand for care staff is expected to rise by 76%—a rate the current labour market cannot support. Concurrently, the financial burden on the healthcare system is projected to double, rendering the current model unsustainable. In this context, SHT offers a promising avenue to mitigate both labour and financial pressures.

This study contributes to society by promoting the efficient and effective deployment of SHT in settings where it can have the most impact: clustered VPT housing. The developed decision-support framework aims to make the implementation of these technologies more transparent, inclusive, and streamlined, ensuring that care organizations, developers, and policymakers can make better-informed decisions. If widely adopted, the proposed model could help reduce avoidable hospitalizations, enable elderly individuals to age in place more safely, and reduce workload on healthcare professionals.

Moreover, by including informal carers, technology suppliers, and developers as stakeholders in the framework, this research acknowledges the complexity of real-world decision-making in eldercare and proposes a more collaborative approach to innovation in healthcare settings.

5.4. Discussion and limitations

The findings of this research show that a large obstacle to SHT implementation in clustered VPT housing is not in the technical feasibility itself, but more in the organization complexity and stakeholder fragmentation. While there is no shortage of capable technologies, there is a noticeable absence of collaboration, coordination, ownership, and structured processes among

the parties involved in the implementation. This is aligned with the literature, regarding this topic.

The framework developed in this thesis should address these issues by making the implementation process more transparent and predictable. By outlining who needs to do what, when and with whom. The framework should introduce structure in what is often an unstructured and improvised process. In doing so, it should enable better align the interests of the stakeholders, reduce implementation risks and delays, and increase the chance of success.

Nevertheless, several limitations must be acknowledged. First and foremost is the absence of a practical validation phase, a critical step within the design cycle as outlined by Wieringa. While this study, completed the problem investigation and treatment design stages, the final phase treatment validation, was not conducted. Ideally, the process model would be tested in a real-world implementation of SHT within a clustered VPT housing project. However due to the scope of this research, limited access to ongoing projects and the complexity of coordinating multiple actors within a care environment, this step was not feasible within this research.

As a result, the developed framework remains theoretical. While it is grounded by expert insights and literature, its usability, and effectiveness cannot be fully assessed without empirical testing. Issues such as stakeholder resistance, budget constraints, or organizational misalignment may arise only during actual implementation. This limitation affects the robustness of the research and highlights the need for follow-up studies that validate its applicability in practice.

In addition, the studies relied on a limited number of expert interviews, which while deemed sufficient for this study, may not fully capture the diversity of perspectives within the field/ Some relevant stakeholder groups were underrepresented or excluded, such as governmental actors and care recipients, due to either the timing of their inclusion in the stakeholder analysis or ethical constraints. This may have affected the comprehensiveness of the identified barriers and stakeholder dynamics.

The use of semi-structured interviews allowed for valuable insights by enabling the interviewees to reflect on their own experiences. However, this method also led to a variation in the depth of responses to some of the questions. While this did not compromise the overall findings, it may have influenced the consistency of the data across interviewees.

5.5. Future recommendations

Although this research presents a structured framework to support the implementation of Smart Home Technology (SHT) in clustered VPT housing, further steps are needed to ensure its practical relevance and usability. Future research should focus on validating the proposed process map in real-world projects. Empirical testing would allow us to evaluate the framework's usability, its ability to clarify stakeholder roles, and its overall effectiveness in guiding structured and collaborative decision-making. Feedback from real-world applications could refine the framework to support its adoption by care providers, developers, and technology suppliers.

To support implementation in practice, the development of a more, user-friendly tool is recommended. These could include a digital template, flowchart, or checklist, that aligns with the five-phase process model. Making the framework accessible in this way could lower the barrier to entry for organizations lacking in-house experience in the process. Furthermore,

training initiatives aimed at the care workers would help to build the capacity needed for SHT integration. These programs should not only address the technical skills but also teach about collaboration across the disciplines and what the overall benefits are.

In addition, future research should include the perspectives, of the elderly residents, who were not directly involved in this study. Their experiences and preferences can reveal factors relating to technology acceptance and daily usability. Including these groups can improve the relevance and acceptance of the solutions being implemented.

Lastly, financial models, and subsidy policies, regarding SHT implementation could be further investigated. Since the financial constraints currently hinder the implementation decisions. Research into cost-sharing mechanisms, financing schemes, subsidies and insurance coverage can help to overcome these barriers.

In Summary, to move from concept to application, future work should focus on the validation, developing a more practical tool, stakeholder education, user inclusion and financial alignments. These efforts can improve the contribution to a smarter ageing in place.

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Appendix A: Guidebook expert interviews (NL)

Introductie
Het doel van dit interview is om de belanghebbenden, besluitvormingscriteria en besluitvormingsprocessen met voor de implementatie van Smart Home Technology (SHT) in geclusterde-ouderenzorgwoningen te valideren. Daarnaast wordt er input verzameld voor een beslissingsondersteuningstool die dit proces kan vereenvoudigen. (Het interview is semi-gestructureerd, waardoor de geïnterviewde de ruimte heeft om waar nodig of wenselijk verder uit te wijden.)

Deel 1: Persoonlijke Achtergrond

1. Kunt u uw rol beschrijven en hoe lang u deze functie al vervult?
2. Wat is uw ervaring met de implementatie van Smart Home Technology (SHT) in (geclusterde) ouderenzorgwoningen, en met welke technologieën heeft u ervaringen?

Deel 2: Besluitvormingsproces

Mapping van het Besluitvormingsproces

1. Kunt u het besluitvormingsproces voor de implementatie van SHT beschrijven? (hoe word er voor welke technologie gekozen)
    - Wat is de volgorde van gebeurtenissen? (optioneel)
    - Wie is betrokken bij elke fase van de besluitvorming? (optioneel)
2. Wie heeft de uiteindelijke beslissing over de implementatie van SHT?
    - Wat zijn de belangrijkste fasen waarin belangrijke beslissingen worden genomen?
3. Hoe werken belanghebbenden samen of onderhandelen zij in dit proces?
4. Zijn er vaak voorkomende conflicten of tegengestelde belangen tussen belanghebbenden?
5. Hoe beïnvloedt de feedback van zorgontvangers of eindgebruikers de uiteindelijke beslissing? (optioneel)

Deel 3: Identificatie van Belanghebbenden en hun Rol in het Besluitvormingsproces

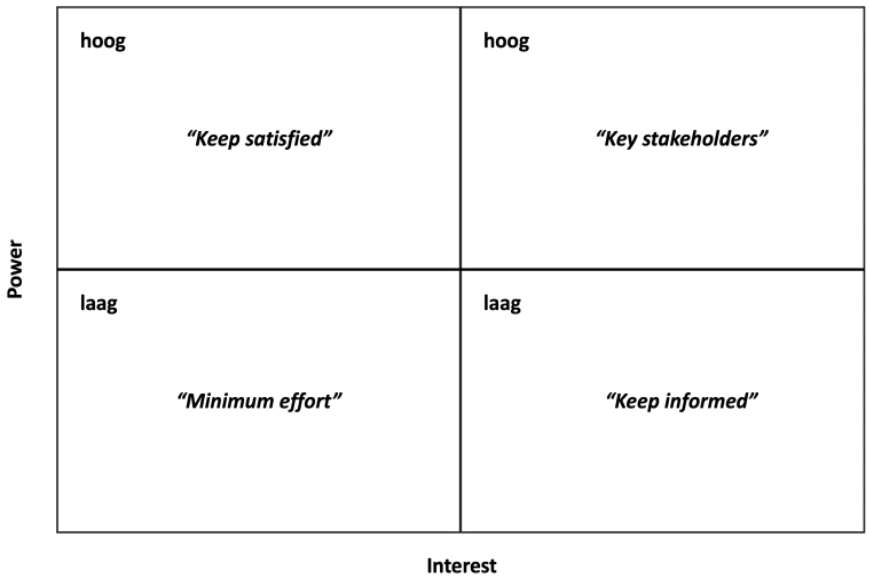
In dit deel worden de relevante belanghebbenden gevalideerd. Uit een literatuurstudie blijkt dat verschillende belanghebbenden betrokken zijn bij het implementatieproces. Deze worden gepresenteerd aan de geïnterviewden in een tabel met een korte beschrijving. Vervolgens wordt gevraagd of de geïnterviewde akkoord kan gaan met de lijst en over zijn/haar ervaringen met deze belanghebbenden kan vertellen.

Belanghebbende	**Beschrijving**
1. Zorgontvangers / ouderen	De eindgebruikers / bewoners van het wooncomplex die zorg ontvangen
2. Ondersteuners / mantel zorgers	Informele zorgverleners, zoals familie en vrienden van ouderen die onbetaalde zorg verlenen
3. Zorgmedewerkers	Betaalde professionals, zoals verpleegkundigen, artsen, enz.
4. Zorgaanbieders	Organisaties die zorg leveren en woningen beheren
5. Technologie-aanbieders	Bedrijven die technologie ontwikkelen en produceren

6. Gebouweigenaar / investeerder	Ontwikkelt/beheert het eigendom

Herkenning en Rollen van Belanghebbenden

1. Herkent u deze lijst van belanghebbenden als de belangrijkste spelers bij de implementatie van SHT in ouderenzorgwoningen?
    - Kunt u hun rol in het besluitvormingsproces beschrijven?
2. Hoe zou u het belang of de macht van elke belanghebbende beschrijven in het besluitvormingsproces? (vul het onderstaande schema in met de nummers van de belnghebbendetabel)



    - Wie zijn de meest invloedrijke belanghebbenden bij het beslissen welke technologieën worden geïmplementeerd?
3. Denkt u dat er belanghebbenden over het hoofd zijn gezien? Zo ja, wie zijn zij en wat zijn hun primaire zorgen of interesses bij de implementatie?

Deel 4: Validatie van Criteria voor Besluitvorming

De validatie van de criteria door experts wordt uitgevoerd. Gebaseerd op de literatuurstudie wordt een lijst van criteria gepresenteerd aan de geïnterviewden. Deze worden gepresenteerd in een tabel met criteria, subcriteria en uitleg. De geïnterviewden kunnen hun mening geven over de gekozen criteria, of ze akkoord gaan of dat er iets ontbreekt.

Criterium	**Subcriterium**
Onafhankelijkheid	- Ondersteunt basisactiviteiten
	- Vermindert afhankelijkheid van (in)formele zorgverleners
Gebruiksvriendelijkheid	- Gebruiksgemak

	- Niet storend in de omgeving
	- Nauwkeurig
	- Stabiel (werkt altijd)
	- Integreerbaar
Financieel	- Investeringskosten
	- Maandelijkse kosten
	- Arbeidsbesparing
Sociale acceptatie	- Toegevoegde waarde
Monitoring	- Alarmfunctie
	- Informatieverstrekking
	- Beschikbaar voor informele zorgverleners
	- Detectie van functionele achteruitgang
Sociale interactie	- Bevordert interactie
Beveiliging	- Privacy / gegevens

1. Wanneer u naar de criteria/subcriteria kijkt, bent u het ermee eens dat dit de belangrijkste factoren zijn bij het nemen van beslissingen over SHT?
    - Waarom wel of niet?
2. Denkt u dat er andere belangrijke criteria/subcriteria zijn die moeten worden toegevoegd?
    - Zo ja, welke zijn dat en waarom zijn ze belangrijk?
3. Gebruiken belanghebbenden in uw organisatie deze criteria bij hun besluitvormingsproces?
    - Hoe worden deze criteria gewogen in de besluitvorming?
4. Welke soort data kunt u koppelen aan deze criteria? (bijvoorbeeld kosten, maandelijkse kosten, arbeidsbesparing, enz.)
    - Worden deze gegevens gebruikt in het besluitvormingsproces?

Deel 5: Vereisten voor een Beslissingsondersteuningstool

De beslissingsondersteuningstool is bedoeld om het besluitvormingsproces voor de implementatie van SHT te vereenvoudigen en te begeleiden (doel van het onderzoek).

Vereisten en Functionaliteiten van de Tool

1. Wat zijn volgens u de belangrijkste vereisten voor een beslissingsondersteuningstool die kan helpen bij de implementatie van SHT?
    - Welke informatie zou de tool moeten verstrekken?
    - Welke outputs zouden het meest nuttig zijn voor u en andere belanghebbenden?
2. Wat is de belangrijkste beslissing waarbij de tool moet helpen?
    - Wat zou de uiteindelijke output van de tool moeten zijn? (bijv. een aanbeveling, een ranglijst van opties)
3. Wat is de ideale tijdlijn voor besluitvorming bij de implementatie van SHT?
    - Hoe kan een tool helpen bij verschillende stadia van deze tijdlijn?
4. Wie denkt u dat de tool zou moeten gebruiken, en op welk moment in het proces?

Appendix B: Guidebook expert interviews (EN)

Introduction

The purpose of this interview is to validate the stakeholders, decision criteria, and decision-making processes involved in implementing Smart Home Technology (SHT) in clustered senior housing. It will also gather input on the requirements for a decision support tool that can assist with this process. (note that the interview is semi structured, and there is room for the interviewees, to elaborate where possible or necessary)

Introduction of the interviewer

- Introduce yourself, explain the purpose of the interview, and describe the structure of the interview (stakeholders, decision-making process, criteria validation, decision support tool).

Part 1: Personal Background

1. **Can you describe your role and how long you have been in this position?**
2. **What is your experience with the implementation of Smart Home Technology (SHT) in senior care housing, and what have you used?**

Part 2: Decision-Making Process

Mapping the Decision-Making Process

1. **Could you describe the decision-making process for implementing SHT?**
    - **What is the sequence of events? (optional)**
    - **Who is involved in each phase of decision-making? (optional)**
2. **Who has the final say in the decision to implement SHT?**
    - **What are the critical stages where key decisions are made?**
3. **How do stakeholders collaborate or negotiate in this process?**
4. **Are there any common conflicts or competing interests between stakeholders?**
5. **How does the feedback from care recipients or end-users influence the final decision?(optional)**

Part 3: Stakeholder Identification and Role in the Decision-Making Process

This part is about the validation of the relevant stakeholders, The literature review will find several stakeholders involved in the implementation process. These will be presented to the interviews with a short description in a table. Then questions will be asked if the interviewee can agree with the list and talk about their experience with these stakeholders.

	Stakeholder	Description
1.	Care receives / seniors	The end-users / residents living in the housing complex, and receiving care
2.	Support providers	Informal caregivers, e.g., family and friends of seniors providing unpaid care

3.	Care workers	Paid professionals, (nurses, doctors etc.)
4.	Care providers	Organizations managing care delivery housing etc.
5.	Technology providers	Companies that develop and manufacture technology
6.	Building developer / investor	Develop / own the property

Stakeholder Recognition and Roles

4. **Do you recognize this list of stakeholders as key players in the implementation of SHT in senior housing?**
    - can you describe their role in the decision-making process?
5. **How would you describe the importance or power of each stakeholder in the decision-making process? (fill in the figure below, using the numbers of the stakeholder table above)**
    - Who are the most influential stakeholders in deciding which technologies are implemented?
6. **Do you think any stakeholders have been overlooked? If so, who are they, and what are their primary concerns or interests in the implementation process?**

Part 3: Decision-Making Process

Mapping the Decision-Making Process

6. **Could you describe the decision-making process for implementing SHT?**
    - What is the sequence of events?
    - Who is involved in each phase of decision-making?
7. **Who has the final say in the decision to implement SHT?**
    - What are the critical stages where key decisions are made?
8. **How do stakeholders collaborate or negotiate in this process?**
    - Are there any common conflicts or competing interests between stakeholders?

5. **How does the feedback from care recipients or end-users influence the final decision?**

Part 4: Criteria Validation for Decision-Making

The validation of the criteria by the experts will be done. Based on the literature study a list of criteria will be made a presented to the interviewees. It will be presented in a table with the criteria, sub criteria and explanation included. The interviewees can give input on the chosen criteria, if they agree, or are missing something.

Criterion	Sub criterion
Independency	○ Support basic activities ○ Reduce reliance on (in)formal caregivers
Useability	- Easy to use - Not disruptive in environement - Accurate - Stable (works every time)

	- integratebale
Financial	- Investment costs - Monthly costs - Labor saving
Social acceptance	- Added value
Monitoring	- Alarm function - Provide info - Available for informal carers - Detect functional decline
Social interaction	- Promotes interaction
Security	- Privacy / data

- **Looking at the criteria / sub criteria, do you agree that these are the key factors in making decisions regarding SHT?**
  - Why or why not?
- **Do you believe there are other important criteria / sub criteria that should be added?**
  - If so, what are they, and why are they important?
- **Do stakeholders in your organization use these criteria in their decision process?**
  - How are these criteria weighted in decision-making?
- **What kind of data, can you link to these criteria: (e.g., costs, monthly costs, labor savings, etc.)**
  - Is this data being used in the decision-making process?

Part 5: Requirements for Decision Support Tool (15-20 minutes)

The decision support tool is intended to help simplify and guide the decision-making process for SHT implementation.(goal of research)

Tool Requirements and Functionality

5. **In your opinion, what are the most important requirements for a decision support tool that would assist in the implementation of SHT?**
   - What type of information should the tool provide?
   - What outputs would be most useful for you and other stakeholders?
6. **What is the most important decision the tool should help with?**
   - What should the final output of the tool be (e.g., a recommendation, a ranking of options)?
7. **What is the ideal timeline for decision-making in the implementation of SHT?**
   - How could a tool assist at different stages of this timeline?
8. **Who do you think should use the tool, and at what stage of the process?**

Conclusion

Wrap-Up

- Thank the interviewee for their time and input.

- Is there anything else you would like to add or clarify regarding the decision-making process or criteria for SHT implementation?