## Co-housing For dutch seniors



Research Plan AR3AD110 Dwelling Gradutation Studio Designing for Health and Care Supervisors B. Jürgenhake, L. Oorschot, K. Macco

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## Introduction

### **The Problem Statement**

The increase in care demand as well as the tradi

tionally very high long term healthcare spending in the Netherlands (OECD,2020) was causing such imminent challenges that it forced the government to issue a reform to the care sector in 2015. To quote from a 2019 report on the challenges to the dutch healthcare system, "The reform stimulates elderly who were previously eligible for residential care and admission to nursing homes to stay at home longer, signaling the increased focus on self-sufficiency in our society" (Hoedemakers et al., 2019). In order to accommodate for this transition, architecture and spatial program are main contributors to the extra challenges. Within the group of people above the age of 60, there is a growing mismatch between their current housing and their daily lives and needs. According to a 2017 article, at least 20 percent of senior live in apartments not suited for aging in place (Verheggen, 2017), while many more live in houses much bigger than their reduced households need(WoOn, 2018). With the ongoing housing shortage in the Netherlands, (Overheid, 2022), this mismatch in housing within the elderly generations also offers potential to be realized. The group most affected by this mismatch is the group of empty nesters, as the majority of them still lives in their homes suited to accommodate a family, yet only a couple or a single person is left.

Further, as the graph 1 shows, extracted from the Woon Onderzoek 2021 shows, in the target groups above 65 years, the most common reason they remain searching for a longer period is the lack of suitable options in the desired city / neighborhood. (WoOn,2021)



Figure 1 Main Reason for Age groups not finding adequate housing





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Thus, offering this target group access to new housing forms and stock offers the most potential to transition earlier into an environment suited for aging in place could even open up more family homes for starters or young families.

Another growing issue in the health of the elderly population is increasing numbers of people suffering from loneliness, which 60 percent of people asked over 65 in Rotterdam reported emotional loneliness, while 47 percent reported social loneliness. Due to reduced mobility and the social environment shrinking, many elderly people are left without sufficient interaction with their peers (Wolfers et al., 2021). As isolation is one of the most harmful things for a human being, to the point of being banned by the UN as a punishment, steps tp prevent elderly being isoloated from social contact have to be taken.

With those challenges calling for new interpretations of the task of senior housing, one approach currently in discussion are co-housing variations. As these promise to help with loneliness as well as offering potential to alleviate some of the informal care demand (Rusinovic et al., 2019), the potential to help alleviate some of the problems of the target group is present. Yet, as there are multiple challenges in creating a living environment enticing empty nesters to leave their family home behind for a community based accommodation, research with the target group is necessary. By understanding their wishes and reservations against current offerings in regards to program and architecture, future designs can be be more fit for the target group and therefore offer a better living environment for the target group.

## Relevance / Research Aim

## Relevance

While collaborative housing forms are a topic of discussion in recent research, which many papers being published in the past decade, there is little research focusing on the target group of this research specifically. As especially empty nesters contribute to the very high average living space per person of 65m2 in the Netherlands (Czischke, 2021) and also face the aforementioned challenges, research into their wishes and reservations to current housing projects offers potential for the future. In order to be able to design fro the target group, it is essential to get current and location specific data which consequently can be translated into design and program guidelines. An area currently getting little attention in the Netherlands is collaborative housing with a cooperative ownership structure, commonly present under the name of Baugenossenschaften in German speaking countries. Translating experiences and learnings from the practice of this model, where commonly multiple parties get together to finance and design the project in a participatory way. As this could age an approach suitable to reducing current reservations of people against traditional senior housing, exploring this idea with the users can offer new insight for the research and future designs.

## **Research Aim**

The goal of this research is to investigate which forms of Co-housing are applicable as a means to foster moving dutch seniors to an environment more suited for the aforementioned challenges of the target group. Therefore, the literature and user research will revolve around inquiring about the users wishes, demands and reservations against current offerings. Based on the data gained from both current inhabitants of a community focussed elderly housing facility and people from the target group living in Delft, guidelines regarding organization, spatial program and architectural design can be derived. This will alter on be





Scale of the apartment



Division private and public space





### Organization ownership and care







Spatial Guidelines

Deisgn Guidelines Figure 3 Research aims Illustration

## Theoretical Framework

While the term co-housing has been a topic of discussion in the real estate sector for many years, there is a wide spread of models this umbrella has been used for. The following chapter will elaborate on the different waves of development as well as terminology and organization of Co-housing around the world.

## The history of Co-housing in western countries

In 2015, Helen Jarvis published an article investigating the social architecture of co-housing models by comparing the initial ideas underlying such projects with real observation form multiple projects. In this article, Jarvis lavs out her understanding of the development of conceptual co-housing projects in western countries since brought over from the north. According to this Framework, there were three major waves of community based co-housing in the UK, Australia and the United States of America. In Jarvis' words, the first wave was created ,,with a view to improving the lives of working parents and their children through more efficient and egalitarian housekeeping" (Jarvis, 2015). At the time, the focus of the major UK-based projects was to recreate a close neighborhood network for social benefits in the direct surroundings. When the second wave started to unfold in the united states, further for the time progressive ideas such as conscious abstinence from consumerism and a focus on protecting the environment became part of the focus for the communities.(Jarvis, 2015) The third and last wave according to this frame of reference happened almost simultaneously with the second, yet in rural Australia instead of the US. In this wave, the focus was even more on ideas exceeding the pure issue of housing, with communities focussing on self-sustained living beyond the idea of protecting the environment. While focussing on the development in western countries, Jarvis descriptions also well reflect the scandinavian origins of the cohousing idea.

## Terminology in co-housing

In order to understand the full depth of the field, clarifying the terminology and what can be understood as such is important to create a base for the further assessment. In 2020, Annamaria Babos and colleagues published a paper trying to clarify this terminology and categorize different forms of housing seen under the umbrella of Co-housing. Firstly, it is important to determine what co-housing means in this framework. Thus, babos describes the following as her definition for co-housing. "In co-housing, multiple people not from the same family live together in one building with one building with one unit or one building with several units." (Babos et al., 2020) In their assessment, the first problem with understanding the term lies in the unclarity of what the "co" in cohosting stands for, including terms like collective, communal, cooperative or collaborative. In the article, Babos further highlights how co-housing is an umbrella term for a variety of housing forms, as the graphic below, taken from the paper, shows. (Babos et al., 2020)

Here it also shows an important distinction made in this categorization, as they differentiate between the terms co-housing, which collects all the forms in it, and cohousing, which they define as follows. "Cohousing is a special type of housing with shared characteristics. The shared characteristics must show simultaneously all four following features with a certain strength: sharing of spaces, activities, creation and tenure." Babos et al. 2020) those terms are elaborated on in the graphic below

This already shows a clear differentiation from Jarvis definition, which included goals of impacting the socio-economic structure as part of the definition of Co-housing, while this approach puts this form of community past this general description and defines it as collective housing, matching the heritage in northern countries like the Swedish kollektivhus. This highlights the importance of very clear terminology when assessing this topic to be able to collect ideas from a variety of sources.

Therefore, in the following the terminology introduced by Babos and colleagues will be adopted.



Fiugure 4 The Umbrella Term Co-housing



Figure 5 Dmiensions of Co-housing

Co-housing sub-terms	Characteristic sharing methods from the definitions
Cohousing	share spaces, activities, creation, tenure
Collaborative housing	long-term participative relationships
Collective housing	share spaces, facilities, and maintenances
Collective living/Co-living	share spaces in one apartment
Collective self-build housing	share arrange and commission
Collective self-help housing	reuse properties by a community project
Communal housing	common kitchen and dining facilities
Commune	living together, share possessions and responsibilities
Community-led housing	co-operate, share ownership and management
Condominium	common elements and ownership
Cooperative housing	share ownership, management, and areas
Eco-district	share the objectives of sustainable development
Eco-villages	participatory process and share sustainable solutions
Gated community	share common code of conduct and management
Intentional community	social cohesion and teamwork, share a common vision

Figure 6 Co-housing terms defined by Babos et al. 2020

				``
llaborative housing	Collective housing	Collective living / Co-living	Cooperative housing	
ommunal housing	Commune	Community- led housing	Condominium	
Gated mmunity	Intentional community			

Sharing methods
Common idea formulation
Participatory design process
Community self-development
Community self-construction
Joining to collaborative housing movement
Regular collective meetings
Common daily activities
Common property maintenance
Spontaneous social interaction
Social events within the community
Activities open to the wider community
Community service or production
Share vision or value
Shared rental
The mixed form of ownership
Collective non-profit organization
Residential cooperative
Common private society
Urban housing network

# Theoretical Framework

## Legal and organizational structures

While the term Co-housing has been used and discussed around the world, the way it materializes differs strongly from country to country, as cultural and legislative background influence the projects organization and structure.

In the Scandinavian countries, like for example Sweden and Denmark, where Co-housing had its first rise during the 20th century, many projects known as co-housing are actually affordable housing projects, which are pre-financed by the government and then subsequently users are offered to by shares in the project, which are fractionally subtracted from the rent. In this system, the community based approach of the initial Cohousing idea is mostly forgotten and reduced to an organizational ownership structure.(Egero, 2014)

In comparison, in German speaking countries, the most common form of co-housing is known under the name of the Baugenossenschaft. In this approach, frequently multiple parties looking for housing unite under the organizational structure of the Genossenschaft, translating to to cooperative, to hire planners and finance the project. As often the future users share common ideas and values, the social bond between the users is often stronger compared to more functional co-housing communities like present today in Scandinavia.(Wohnungsbaugenossenschaften in Deutschland, 2019)

Both those forms are possible to realize in the Netherlands, yet for the target group the more community based approach is most promising. In the context of this research, being located in the Netherlands, another legislative factor comes into play. Based on the scale of the desired housing type, the dutch housing subsidy system could be another factor influencing the future design guidelines. As housing subsidy is only applicable for self-sustained units(Belastingsdienst, 2023), in case the users demand a smaller scale facility, designing with individual entrances and addresses can make the project more financially feasible and accessible for more people. Based on these factors, the local and legislative context influences the design and materialization of housing facilities.

In conclusion, each of the three papers adds factors which can be used to guide and assess the future design. Babos paper preseted the four dimensions of sharing, namely space, shred creation, shared activities and shared tenure. Helen Jarvis paper contributes the concept of sahring a higher social idea for the community. And finally, the legal and organisational structure can provide multiple frameworks for the setup of the process and design, based on characteristics like size and desired ownership, which will be derived later from the research findings.



Figure 7 Projected care sopending relative to GDP per country

# Scope / Hypothesis

This section will give describe the scope of this Hypothesis research and how exactly its target group is defined. Firstly, this research aims at investi-Amidst the growing housing shortage as well gating the housing wishes of the group of seas the growing number of singe households niors in the Netherlands. Therefore people liin the Netherlands throughout all age groups, ving outside of the Netherlands or the direct especially seniors and empty nesters require surroundings will be excluded from this renew typologies to help them to progress their search, as well as families still living with their housing careers into an environment more fit for aging in place. With other challenges children. In order gain insight on their current housing situation and the wishes of potential such as loneliness and a growing demand for formal and informal care, collaborative houfuture residents, the research will be done with two groups. Firstly, during the filed work week, sing forms promise to offer potential to act as more suitable and healthy living environment the research will focus on inhabitants without a high care demand, as the research focuses on for many people. Further, it is hypothesized seniors who are still able to live self sustained. that cooperative and participatory design pro-The second part of the research will be conduccesses could alleviate current reservations of ted with residents of Delft falling into the tarempty-nesters regarding a move to a commuget group of seniors to investigate the wishes nity based housing form. This hypothesis will of people still living in their family home. Thebe tested throughout the following research, refore people above the age of fifty currently for which the guiding research guestion will living alone or as a couple will be considered. be the following. while families or younger singles/ couples will be excluded.



Figure 8 Illustration of hypothesized movement of singles and emopty nesters

Which spatial and architectural characteristics can allow Co-housing to alleviate the housing mismatch for mainly dutch seniors and prepare them for aging in place?

What housing situation is the target group currently in regarding type and ownership?

What forms of Cohousing exist currently in Europe?

Which spatial and organizational characteristics would the target group require to be attracted by?

What amount and groups of people would the target group like to live with?

How can architecture help to reduce stigma attached to senior housing institutions and make moving more attractive to the target group?

## Research Methodology

### Literature Review

The literature study is going to give the insides needed to understand co.housing as a concept as well as to deepen the knowledge of the challenges faced by the target group. For this, literature in the fields of senior housing and co-housing, published within the last 5-10 years will be considered. The focus of this study is to learn form past evidence on the Strengths, weaknesses, opportunities and threats of Co-hosuing projects around Europe.

From this literature, both knowledge for the interviews as well as evidence regarding the benefits of and conditions for successful co-housing can be derived.

### **Case Studies**

The case studies will consist of two categories, first historic projects and secondly current offerings in the field of co-housing as well as senior housing. For the first group, the case studies will be the Hofjes typology present in Den Haag marking the first dutch collective housing project, as well as the Saettedamen project in Denmark, the beginning of the Scandinavian 1960s Cohousing movement. For the current projects, they will be selected from projects currently operating in Europe, with a focus on projects in the Netherlands. The aim is to present a spectrum of different forms of co-housing, so during the interviews these can be used to gauge the users wishes. For this step, it is essential to derive simple analyses of the case studies, as the untrained Inhabitants of the housing facility need to able to understand the core ideas of the project.

For the case study's, the cases will be separated in two further groups, historical projects marking the beginning of co-housing as well as multiple contemporary projects in Europe, which are presented to the interviewees. For those cases, both senior housing facilities as well as open co-housing projects will be considered, while housing for other special groups such as students or projects exclusively for people with a high care demand are excluded.

#### HIstorical 1 - Saettedamen, early cohousing in Denmark



ne of the first cohousing projects in Denmark Located 30 miles north of Copenhagen Built in 1968 for 30 families Born out of their own initiative

Independent family homes featuring all necessary amenities Arranged around shared courtyard in elliptical shape Common house with shared facilities like common kitchen and guest rooms Design with strong focus on the community and support for each other in many daily task Containing social idea as wall as inst housing.



ntemporary 2 - Type apartment Building Bijgaardehof Gent, Belgium









Figure 9 Examples of case studies

#### Historical 2 - Hofjes Den Haag, example How van Vouw



Housing organized around a central, shared courtyard fype reaching back to the late 16th century, especially popular in Den Haag Usually housed homogeneous group of people (students, elderly, ...)

Example from 1647 17 units around three sided around a courtyard All inhabitants single, above 50 and living without pets Today housing a small bed and breakfast operated by the owners Existing community until bresent



Restauratie tuinplan schant. Hofe van Juff. Corn.van Wouw



#### ing



in German speaking countries a private initiative ss e the architect t Architekten, Munich ustered around communal living



LivInn By Habion, Hilversum

First location in Hilversum, which is presented from here



Transformed from a traditional nursing home typology into a Habions Flagship project representing their concept for the future Community based, inhabitants are supposed to organize themselves as much as possible Reminds more of as student hotel than a traditional retirement facility Tries to remove itself from the nursing home image



# Research Methodology

### User Research

The final step of the research is going to be conducted in two phases, both directly with current and future users of senior housing facilities. Firstly, during the fieldwork week in a community focussed dutch senior housing facility current inhabitants the research focuses on observation as well as interviews. The observation exercises revolve around three focus points. First, the interaction of the inhabitants with the common spaces in the building will be recorded, based on three daily time slots in the morning, noon and evening. Further, the movement of people through the building will be recorded by marking the daily movement in digital maps of the building / and surroundings.

For the interview phase, this will be done via both surveys handed out to the inhabitants of the housing facility, which investigate previous and current experiences with housing forms as well as their wishes, as well as in depth interviews. In the interviews, more qualitative data can be gained by talking to inhabitants long form and with a flexible interview outline.

In this phase, a workshop will be held to understand priorities and wishes of the target group in regards to housing and facilities connected to it. For this, the users will be able to place the facilities and amenities around their apartment on an abstract map to understand their relevance and desired proximity to the target group.

Secondly, similar research will be conducted with inhabitants of the city of Delft and surroundings. Via street interviews, the wishes of people who are currently living in their family homes will be investigated to be able to derive guidelines for designs for this specific target group.

### Survey Focal points

handed out to all inhabitants

Current housing situation

Usage of common spaces

Frequency and type of social interaction

Health and activity

Figure 10

Survey among inhabitants



## Dear XXX Community



5-10 interveiws with inhabitants

Experiences in current cohousing

Interaction with communtiv

Reservations regarding elderly housing

Process and motivation of moving



In- Depth Interviews Figure 11



## Workshop focus

Prioritization of facilities

Desired proximity to given amenities

Division between private and shared spaces in the facility

Desired scale of the accomodation

Spark conversation to get further in depth information

Figure 12 Workshop Illustration

# Research Diagram



Figure 13 Research Diagram

- Baugenossenschaft together, sometimes for collective financial profit.
- Co-housing graphic below and in theoretic framework
- Empty Nesters A person or couple who's children have grown up and moved out. (Cambridge dictionary)
- Housing mismatch Difference between the actual needs of a target group in comparison to their current houses, binding them to maintenance and responsibility.
- Swedish name for collaborative housing project. Existing term since the 1970s also Kollektivhus reflecting the idea of cohosting in the country
- SeniorsInhabitants of the Netherlands over the age of 60 years
- Self sustained living Living without a long term care need or institutional organization
- Co-housing graphic below and in theoretic framework. Copy of Figure 5

Table 1. Characteristics sharing methods of co-housing sub-terms in alphabetic order: co-housing sub-terms (black) and co-housing sub-terms with special focus (grey)

Co-housing sub-terms	Characteristic sharing methods from the definitions			
Cohousing	share spaces, activities, creation, tenure			
Collaborative housing	long-term participative relationships			
Collective housing	share spaces, facilities, and maintenances			
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Condominium	common elements and ownership			
Cooperative housing	share ownership, management, and areas			
Eco-district	share the objectives of sustainable development			
Eco-villages	participatory process and share sustainable solutions			
Gated community	share common code of conduct and management			
Intentional community	social cohesion and teamwork, share a common vision			

## Definitions

Organizational structure for Co-housing, common in the German speaking area. Based on multiple future owners coming together and financing and designing the project

Used according to the terminology introduced by Babos et al in 2020. Umbrella term for the collaborative housing forms. Further definitions of the individual sub terms according to

housing situation. In the case of this research, it focusses on empty nesters living in large

Used according to the terminology introduced by Babos et al in 2020. Umbrella term for the collaborative housing forms. Further definitions of the individual sub terms according to

## Appendices

## **Appendix 1 Questions User Survey**

#### Beste bewoner van Liv Inn Hilversum,

Algemene informatie

Man

🗌 Ja

Appartement Vrijstaand huis

Huurwoning

Koopwoning

Anders, nameliik:

Anders, namelijk:

Sociale huurwoning

Wonen

2. Geboortejaar:

1. Geslacht:

Voor ons afstudeerproject aan de TU Delft logeren we deze week in Liv Inn. Om een goed beeld te krijgen van Liv Inn en de bewoners willen we u vragen om ons te helpen door deze korte vragenlijst in te vullen. Alvast bedankt!

Zou u de ingevulde vragenlijst vóór vrijdag 17 november willen inleveren in de doos in het Hart? Als u hulp nodig heeft bij het invullen of met ons wilt kennismaken, wij zijn op dinsdag en woensdag in het Hart (en vast nog vaker).

Zeg ik liever niet

Vrouw

3. Woont u in het gebouw verbonden aan 'Het Hart'?

Nee

Twee-onder-een kap / Rijtjeswoning

5. Wat was de eigendomsverhouding met uw vorige woning?

6. Wat was de voornaamste reden dat u naar Liv Inn kwam?

Omdat ik in de toekomst zorg nodig zal hebben

Omdat mijn omgeving vond dat dit beter voor mij was

Omdat ik op dat moment zorg nodig had

Omdat ik behoette nau aan oostaan Omdat mijn huis niet meer geschikt was Omdat ik behoefte had aan sociale contacten

4. Wat was uw woonsituatie voor Liv Inn?

7. Hoe bevalt het wonen in Liv Inn?
Zeer tevreden
Tevreden
Neutraal
Ontevreden

- Zeer ontevreden

### 8. Waar spendeert u de meeste tijd gedurende de dag?

. . . . .

- Appartement Gemeenschappelijke ruimte 'Het Hart'
- Gemeenschappelijke ruimte 'Het Ha Andere gemeenschappelijke ruimte
- Buiten
- Buiten
   Ergens anders dan Liv Inn

#### 9. Wat is uw favoriete plek in de woonomgeving?

#### 10. Wat zou u willen toevoegen?

In Liv Inn:

In uw appartement:

#### 11. Wat bent u bereid om met anderen te delen?

- (meerdere antwoorden mogelijk)
- Keuken
- Badkamer
- Wasmachine
- Auto
- Fiets

- Z.O.Z.

14. Voelt u zich eenzaam? 🗌 Vaak Af en toe Bijna nooit 15. Voelt u zich verveeld? 🗌 Vaak Af en toe Bijna nooit 16. Hoe vaak komt u in de buitenlucht? Meerdere keren per dag ☐ Elke dag Om de dag

Gezondheid

12. Hoe fysiek actief voelt u zich?

Gemiddeld actief

13. Ontvangt u ondersteundende hulp?

Een beetje actief

Heel actief

(Thuis)zorg

1 Mantelzorg

Huishoudelijke hulp

### Wekelijks Minder dan bovenstaande

#### 17. Welke activiteiten doet u? (meerdere antwoorden mogelijk)

### Wandelen in het gebouw

- Wandelen buiten (bijvoorbeeld naar de winkel)
- Fietsen
- De trap gebruiken Tuinieren
- Zwemmen

Z.O.Z.

11

- Yoga / Pilates of iets dergelijks
- Fysiek inspannende sport, zoals: Fitness, Hardlopen, voetbal
- Anders, namelijk: Z.O.Z.

Einde. Nu kunt u hem inleveren in de doos. Hartelijk bedankt! Arno, Eline, Jan & Thyrza

Survey Spread between all inhabtants of Liv Inn Hilversum Desired data: How are the inhabitants living? Why Liv Inn Health of the Users Community and interaction

Logeerkamer Loge Grotere woonkamer Hobbyruimte

- Gereedschap
- Scootmobiel
- Computer
- Boeken

#### Gemeenschap

#### 18. Bent u lid van de vereniging Liv Inn? 🗌 Ja Nee

#### 19. Hoe vaak doet u iets voor de gemeenschap?

- Dagelijks
   Wekelijks
- Maandelijks
  Nauwelijks / nooit

#### 20. Kruis aan hoe vaak u de faciliteiten in Liv Inn gebruikt

#### Dagelijks / Wekelijks / Maandelijks / Nauwelijks

Het Hart		
Gem. keuken		
Fitnesszone		
Familiekamer		
Huistheater		
Café / de soos		
Kapper		
Leeftuin, buiten		
Werkplaats		

#### 21. Mijn sociale kring bevindt zich:

- Voornamelijk in Liv Inn
- In en buiten Liv Inn
- Voornamelijk buiten Liv Inn

### 22. Wat is voor u het belangrijkst in een gemeenschap (kies 1)

- Privacy
- Gemeenschappelijke activiteiten
- Verschillende leeftijden
   Dezelfde leeftijden
   Diversiteit
- Dezelfde idealen

## Appendices

## **Appendix 2 Guidelines in Depth inteviews**

Based on apst experiences with the target group, the decision was made to not provide a rigid interview structure, yet providing focal point twowrds which the conversation will be led. As the interveiws are conducted with voluntary participants, the exact path of each interiew wil differ based on the conversation.

The aim is to conduct 5-10 short interviews of aroudn 10 minutes Parts of the topics could also be asked about during unplanned interactions in the building

The main points to touch upon are

Finding out about the Use of the building Whats your favorite spot in the building (starter Question) Spaces one doesnt like going / doesnt feel comfortable When using the Hart, do you go there to use the facilities or to seek interaction with users?

Case studies Out of the 5 cases, which one would be most suited to you regarding Spaces Users Organization Archtiectural preference

Experiences with community based living

what are the stumbling stones in living together how did integrating into LIV Inn feel for you Conflits between users

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## Image Sources

### Image Sources

### Figure 1

WoON (2018). Ruimte voor wonen. De resultaten van het WoonOnderzoek Nederland 2018. Den Haag: Ministerie van Binnenlandse Zaken en Koninkrijksrelaties. Geraadpleegd op 10 mei 2020, https:// www.woononderzoek.nl/document/Ruimte-voor-wonen--de-resultaten-van-het- WoON2018-(interactief)-/174

### Figure 2 and 3

Made by the author

based on Wolfers, M. E. G., Stam, B., & Machielse, A. (2021). Correlates of emotional and social loneliness among community dwelling older adults in Rotterdam, the Netherlands. Aging & Mental Health,

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### Figure 4,5,6

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### Figure 7

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Figure 8 Made by the author

### Figure 9

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Figure 10 - 13 made by Author