



DESIGNING A HEALTHY HOME

Research for guidelines to improve the physical health and mental well-being in dwellings using the passive house concept as basis

 **TU**Delft
BKBouwkunde

JRDY

Colophon

Delft University of Technology
Faculty of Architecture, Urbanism and Building technology
Chair of Architecture and Dwelling

Master Graduation MSc3/4 Research Plan
Studio : Designing for Health & Care (AR3AD110)
Course : Research Plan (AR3A010)
Design tutor : Birgit Jürgehake / Elke Miedema
Research tutor : Leo Oorschot

MSc3 | Fall 2022
November 16, 2022

Jordy S. Knoppert
5189837

Image 01 (on the front page): Healthy homes

ABSTRACT

Most of the time we perceive our own homes as a healthy place. Till the moment we get sick and start to realise that dwellings are not always that healthy. Currently homes are made by following a model to create a healthy home such as Woonstandaard, BREEAM, GGD-richtlijn Gezonde Woningbouw, or one of the many other models. However, these models only look at the physical health influenced by service systems. While health exists out of physical health and the mental well-being. Combined with the pressure on the Dutch national healthcare system demands change. This means not only improving the service systems but changing the way dwellings are designed. Something that will help to improve the health in dwelling is the use of the sun, wind, rain, etc. Something that is already using these elements is the passive house concept from the passive house institute. This concept could be a good starting point to create healthy homes. The question that will be researched is: What are design guidelines based on the passive house concept for physical health and mental well-being for homes with a median transaction price of the third quarter of 2022 in the Netherlands? This will be investigated using literature review, case studies, fieldwork, and simulations. At the end of the desired research paper it will be possible to answer the reached question posed in this document.

Keywords

Physical health, Psychological well-being, Healthy home, Service systems, Environmental factor, Passive house, Median transaction price dwelling

CONTENT

1.0 Introduction	6
1.1 Personal fascination	6
1.2 Relevant problem in the society	6
1.3 Problem statement	7
1.4 Goals	8
1.5 Research question	8
<i>Main research question</i>	8
<i>Sub research question</i>	8
<i>Research boundary</i>	8
1.6 Design hypothesis	8
1.7 Definitions	9
2.0 Theoretical framework	10
2.1 Literature review	10
2.2 Theoretical framework	14
3.0 Methods	16
3.1 Sub question 1	16
<i>Methods</i>	16
<i>Steps & Tasks</i>	16
<i>Output</i>	16
3.2 Sub question 2	16
<i>Methods</i>	16
<i>Steps & Tasks</i>	16
<i>Output</i>	16
3.3 Sub question 3	17
<i>Methods</i>	17
<i>Steps & Tasks</i>	17
<i>Output</i>	17
3.4 Sub question 4	17
<i>Methods</i>	17
<i>Steps & Tasks</i>	17
<i>Output</i>	17
4.0 Research diagram	18
5.0 Planning	20
6.0 Reference list	21
6.1 List of illustrations	21
6.2 Bibliography	21

1.4 Goals

The main goal of the research is to improve the indoor health quality of homes for the occupants. To achieve this goal, the research aims of the project are:

1. Proper understanding of a healthy living environment.
2. Understanding of the passive house concept.
3. Understanding of which environmental element can be implemented in a design.
4. Insight on maximising natural elements into the design to create a healthy home.

1.5 Research question

Main research question

What are design guidelines based on the passive house concept for physical health and mental well-being for homes with a median transaction price of the third quarter of 2022 in the Netherlands?

Sub research question

1. What is designing for healthy homes?
2. What are the characteristics of dwellings in the Netherlands with a median transaction price of the third quarter of 2022?
3. How can the passive house concept be used as base for healthy home design guidelines?
4. How can natural elements be used in the design to create a healthy home?

Research boundary

The research is about improving indoor health in homes not the definition of health itself. The surroundings will not be investigated in this research. This means that the environmental situation of the assigned plot will be considered in the study. However, if the location changes the demand for the dwelling will probably need to be changed as well to create a equal healthy home. This will require new research for the demands of the new location. The surrounding of the appointed plot such as shades from other buildings are also not included in the research.

Health exists out of physical health and mental well-being. Thomas Jefferson declared happiness to be an inalienable right. But anyone who's ever debated with friends on where to go for dinner knows that happiness is subjective. So how do we design for it? (Brandon, 2022). There are however some universal elements that influence the mental well-being of everybody that will be implemented.

This study is zoomed in on a single dwelling with its associated facilities. The gardens of dwellings are included and for an apartment the balcony, stairwell, and parking basement are included. Whereby the research will focus on new dwellings in the Netherlands. With the current economic situation it is not guaranteed that the final design will cost less than the median transaction price of the third quarter of 2022.

Creating homes that are healthy does not mean that they will cure diseases and illness. They focused on preventing, reducing and/or minimise health risk caused by dwellings. In addition will the health of a dwelling not be measured, compared, extended and/or judged with an existing health certificate or model.

1.6 Design hypothesis

This research thesis is not intended to be an extension to one of the existing models or certificates to create a healthy home. The outcome of this research will be a kind of guideline that will be applied in a design for healthy housing types. This design will have a positive effect on its occupant whereby the inhabitants can hypothetically live in a more healthier environment than when they live in an existing standard built dwelling typology.

1.7 Definitions

Build environment	Human made environment in which we live (RIVM, 2021).
Dutch building act	Rules on which all buildings must comply to (Bouwbesluit, 2012).
Environmental elements	Elements occurring naturally in the climate such as sunlight, wind, rain, etc (Bluyssen 2009, p. 3).
Facilities	For this study, facilities are components that are related but not part of a dwelling.
Greenery	Indoor or/and outdoor vegetation such as grass, threes, plants, etc (Moya et al., 2019).
Health certificates	Ranking systems to assets the health of a building (Hasselaaret al., 2019).
Healthy home	A dwelling that does not damage the residents health and aims to improve it (WHO, 1988).
Health standards	The current base line for creating healthy buildings (Hasselaar et al., 2022).
Indoor climate	The climate inside a building (Bluyssen 2009, p. 45).
Living environment	The surrounding in which we live, work, and learn (RIVM, 2021).
Median transaction price	The average price of all types of dwellings throughout the Netherlands sold during a specific time frame. For this study that is the third quarter of 2022 (NVM, 2022).
Passive house	According to the passive house institute a type of dwelling maximizing comfort and health using environmental elements to minimalize energy use (Passive House Institute, 2022).
Physical health	The absolute condition of the human body (WHO, 1988).
Social and Psychological well-being	The sanity of the human being for example: no stress, feeling safe, happiness, etc (WHO, 1988).
Themes	For this study, themes are a single of clustering of different elements.
Transaction price	Price for how much a dwelling is sold (NVM, 2022).

2.0 THEORETICAL FRAMEWORK

2.1 Passive house

Health in the living environment is an extensively researched topic. Most of the research hereby is focused on the impact of air, indoor climate, light, and sound on the physical health, while only a few studies have been done to improve the mental well-being in the build environment.

Passive House Institute (2022) developed the passive house concept, Laskari et al. (2016) presented the Dwelling Environmental Quality Index (DEQI), LCM landelijk centrum (2005) made the GGD-Richtlijn gezonde woningbouw, and Netwerk conceptueel bouwen et al. (2018) presented the Woonstandaard. This are just some of the models of table 02 to create a healthy building. All these models are focused on environmental factors to improve the physical health. Bluysen (2009, p.4-93) dived these into four environmental factors to explains how humans react and perceive physical health in de building environment. But health consists of more than just physical health.

According to the WHO (2021) the mental health needs to be in order before you can be healthy because “no health without mental health” (WHO, 2021). Recently they concluded that depression is currently the biggest ill-ness and disability in the world.

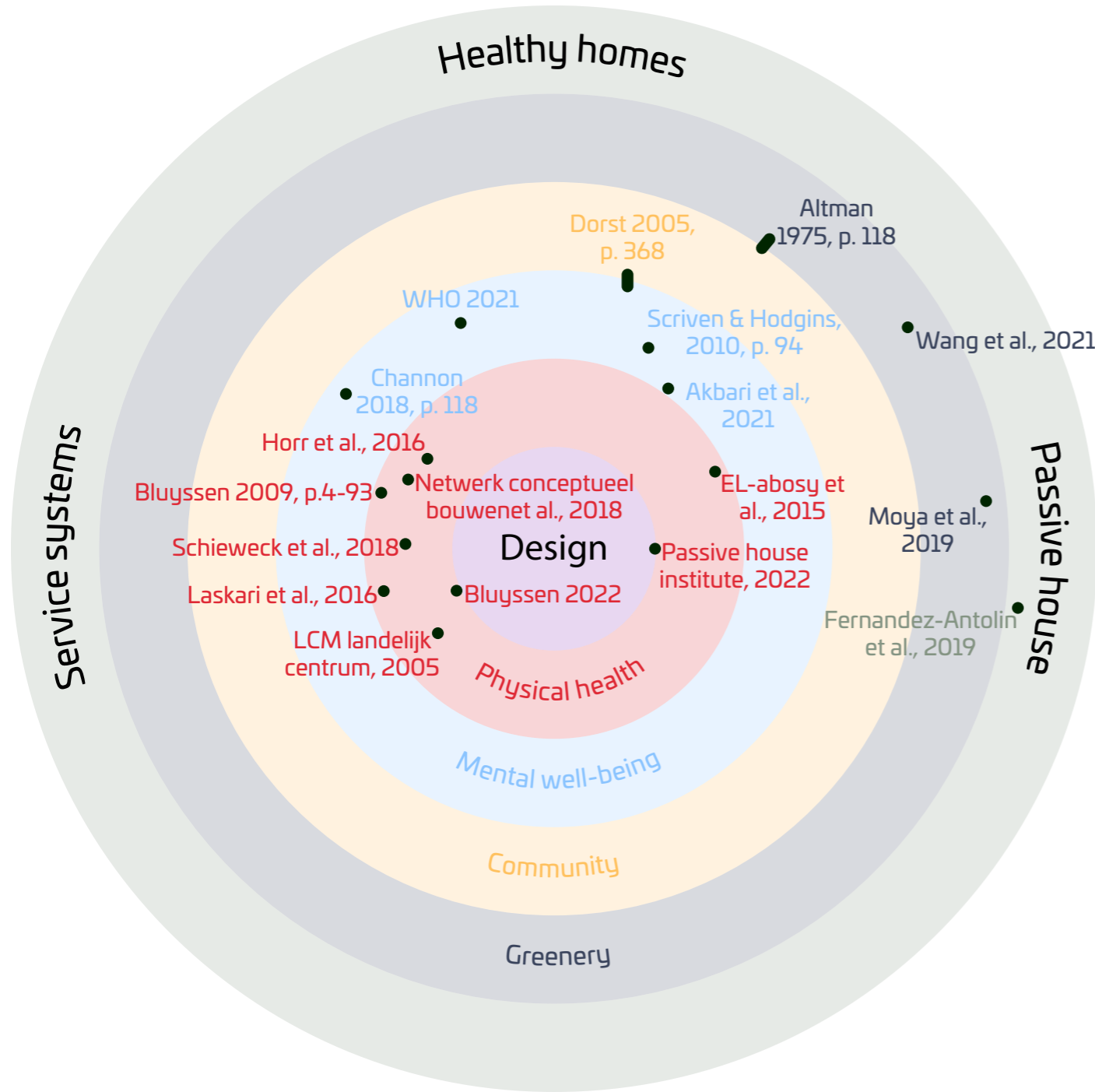
During the lockdown of the Covid-19 pandemic Akbari et al. (2021) investigated the mental well-being in homes during quarantine. This revealed that poor living conditions reduce residential enjoyment and can lead to mental health problems. Research from Wang et al. (2021) revealed that greenery has a positive impact on the mental health. Which is supported by the research from Moya et al. (2019). It also showed that greenery had a positive effect on the thermal comfort, acoustics, and air quality.

According to Scriven & Hodgins (2012, p. 94) includes the mental health other elements as well. The environment, activities, economy, and community determines our health and well-being in the neighbourhoods. Which is also applicable for healthy housing. Dorst (2005, p. 368) states that de quality of life exists out of health, safety, contact with the natural environment, control, and the ability to engage in and avoid social interaction. Whereby the interaction between humans and nature is to be seen as a single element.

All this leads to the findings of Horr et al. (2016) that building a new home requires the consideration of a range of factors beside the indoor climate, light and acoustic. To create a healthy home an in-depth consideration of the occupant well-being is required. Which is consistent with the findings of Bluysen (2022) that all factors are important for the health of the indoor climate, whether they have a positive or negative impact and are an environmental factor or psychological factor they should all be considered in a design.

	Physical health	Mental well-being	Service systems	Air	Indoor climate	Sound	Visual	Views	Sick building syndrome	Design advice	Indoor Environment quality	Energy	Greenery	Stress	Insulation
Akbari et al., 2021		X		X	X	X	X	X	X	X					
Altman 1975, p. 118		X						X					X	X	
Beemer et al., 2021	X	X	X	X										X	
Bluysen 2009, p. 4-93	X		X	X	X	X	X								X
Bluysen 2019		X	X	X	X	X									
Bluysen 2022	X		X	X	X	X					X				
Channon 2018, p. 118		X	X	X	X	X	X	X					X		
Dorst 2005, p. 368	X	X	X	X	X		X	X					X	X	
EL-abosy et al., 2015	X				X						X	X			X
Fernandez-Antolin et al., 2019				X	X							X			X
Hasselaar et al., 2022	X		X						X	X		X			
Horr et al., 2016	X		X	X	X	X	X		X		X				
LCM landelijk centrum, 2005	X		X	X	X	X						X			X
Laskari et al., 2016	X		X	X	X						X	X			
Moya et al., 2019	X	X		X	X	X			X				X		
Netwerk C Bouwen et al., 2018	X		X	X	X	X			X			X			X
Passive house institute, 2022				X	X					X		X			X
Prince et al., 2007		X									X			X	
Schieweck et al., 2018	X		X	X	X	X						X			X
Schnieders et al., 2019				X	X							X			X
Scriven & Hodgins, 2010, p. 94		X						X		X				X	
Sternberg 2009, ap. 6		X						X					X	X	
Wang et al., 2021		X						X		X			X	X	
WHO, 1988	X		X	X	X	X			X	X					X
WHO, 1989	X	X													
WHO, 2021		X						X				X	X	X	

Table 04 Subject in the literature



2.2 Theoretical framework

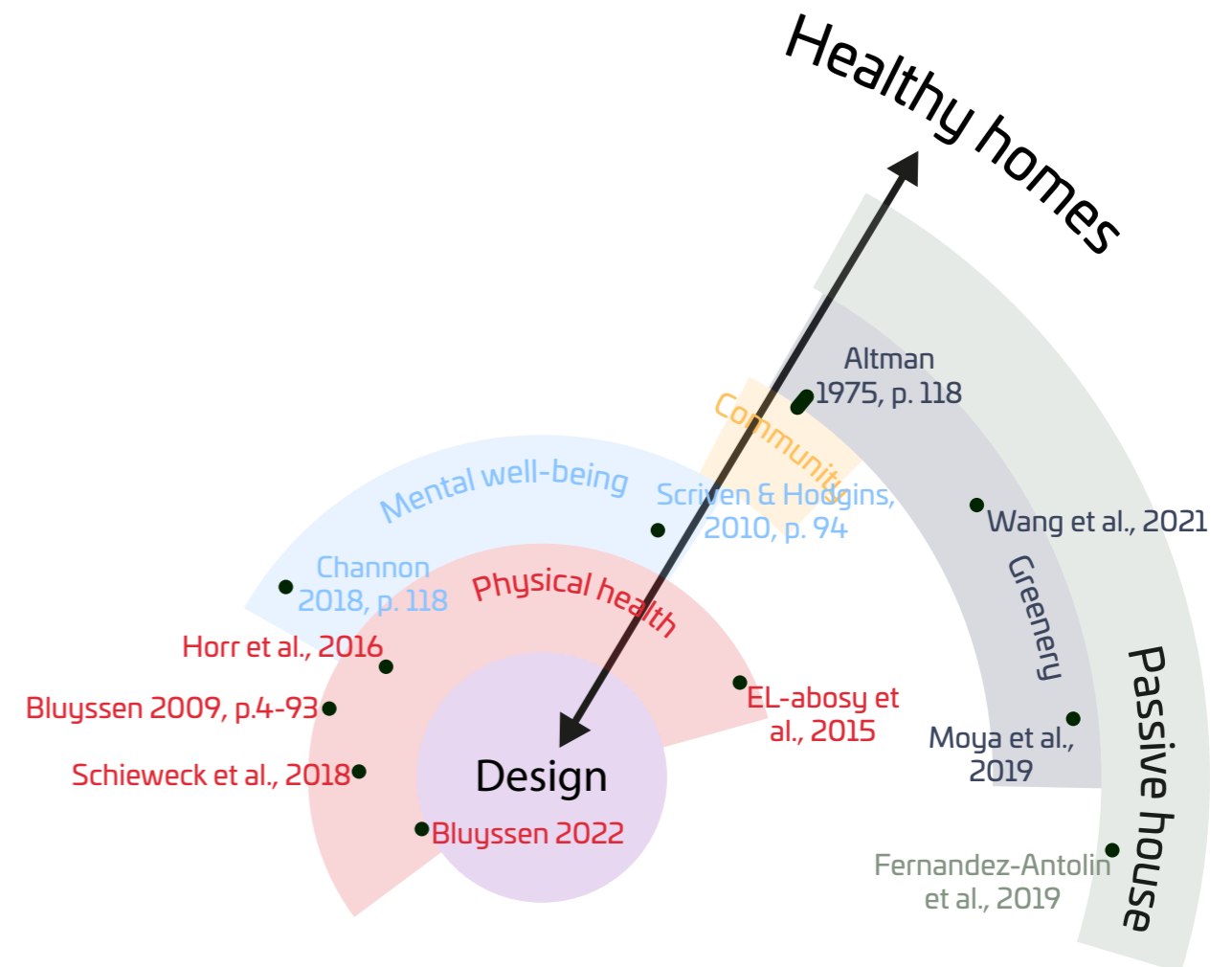
In earlier personal research, it became clear that health certificates don't quite work. It is often more about obtaining the certificate than creating a healthy building. A concept that usually does work is the passive house concept. Fernandez-Antolin et al. (2019) describes the intention of the passive house as a dwelling that maximize the comfort and health while minimizing energy use. This concept uses mainly the natural elements which I think is the key to creating healthy homes. Horr et al. (2016) states that building an environmentally friendly home does not necessary mean that a dwelling is a healthy home. It requires the consideration of a range of factors to create this.

Horr et al. (2016) and Bluysen (2022) concluded that both physical health and mental well-being are important in creating a healthy home. Bluysen (2009, p.4-93) explanation about how physical health is perceived using the four environmental factor is a good base for my research. It divides the various sections into four clear themes. At the same time, it explains why certain items are healthy or unhealthy for us. Which provides better insight during designing.

Mental well-being is more complex. Scriven & Hodgins (2012, p. 94) shows that multiple elements directly and indirectly influence our mental health. Channon (2018, p, 118) divided the elements that influence the mental health in the seven themes light, comfort, control, nature, aesthetics, activity, psychology. Of which I think the theme nature is extra interesting since research from Wang et al. (2021) and Moya et al. (2019) shows that greenery has a positive impact on the mental well-being. Simultaneously greenery also improves the environmental factors. Greenery additionally aligns with my belief of integrating natural elements into the design as well as with the passive house concept.

A theme that the book is not mentioning is interaction. Altman (1975, p. 118) describes this as the public-private connection. People want to be part of the community but at the same time they want to be able to probe their selves. I find this important because this let people feel welcome and safe in their own home.

According to EL-abosy et al. (2015) can the passive house be used to create a healthy home. It only requires investigation and testing at the beginning of the design process. It also requires adaptability of the users to exploit the maximum potential. But according to Schieweck et al. (2018) could this be solved by implementing the smart home. Which creates a great opportunity to ensure the health of dwellings. These research show that both physical health and mental well-being can be improved by using and regulating the natural elements in a passive house.



3.0 METHODS

3.1 Sub question 1

What is designing for healthy homes?

Methods

Literature review

- Books
- Journals

Fieldwork

- Visit Lake House
- Interview Jules Gielen
- Observation dwellings (auto ethnographic)

Steps & Tasks

The interview and home visit during fieldwork will reveal what designing for health means. Which will be complemented by literature review.

Output

This will give a definition of what a healthy design is. Which will be a text that can be transformed in diagrams/sketches for clarification.

3.2 Sub question 2

What are the characteristics of dwellings in the Netherlands with a median transaction price of the third quarter of 2022?

Methods

Literature review

- Journals
- Rapports

Case study

- Analysing different dwellings
- Comparing the different housing typologies

Steps & Tasks

Literature will be used to create a definition and parameter. Different project than will be analysed in these parameters. The different case studies will be analysed and compared with each other to make the characteristics insightful.

Output

The outcome of the compared analyses will lead to diagrams, bullet points, sketches, and pictures of the characteristics of dwellings with a median transaction price.

3.3 Sub question 3

How can the passive house concept be used as base for healthy home design guidelines?

Methods

Literature review

- Journals

Case study

- Analysing passive houses

Fieldwork

- Visit Lake House
- Interview passive house architect

Steps & Tasks

The house visit to the Lake house will give a feeling of what is possible with passive houses. This will be complemented by an interview of a passive house architect and analyses of several passive houses. Combined with the literature review to support the findings.

Output

The outcome will be diagrams and guidelines. These will make it possible to state how the passive house concept can function as basis for design guidelines for healthy homes.

3.4 Sub question 4

How can natural elements be used in the design to create a healthy home?

Methods

Literature review

- Journals

Case study

- Lovell house
- Analysing passive house

Fieldwork

- Visit Lake House
- Interview Jules Gielen

Simulation

- Sketches to research possibilities
- Digital model to research influences
- Model to investigate options and findings

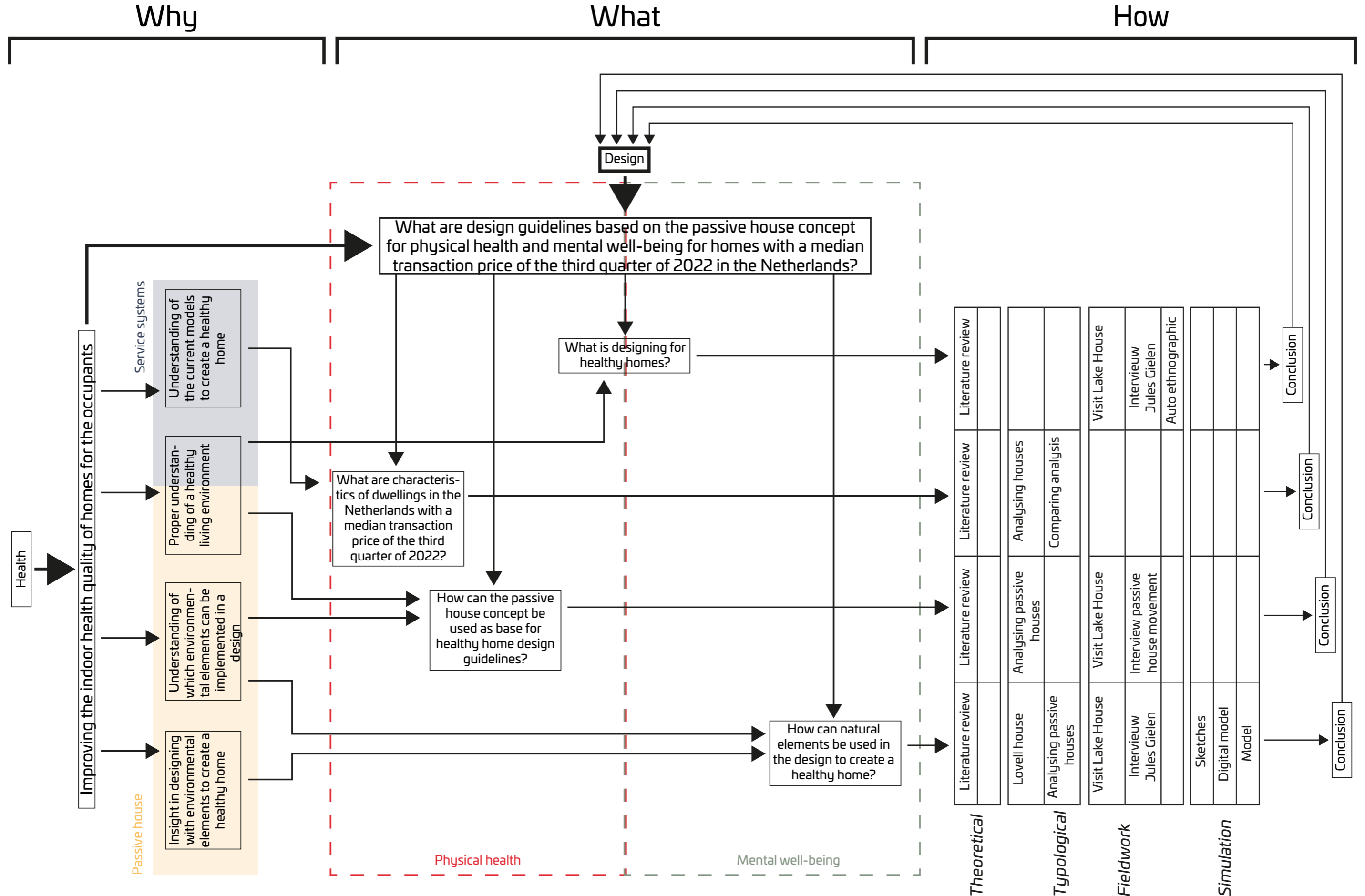
Steps & Tasks

Literature, case study, and fieldwork will be used to establish the function and possibility's of the natural elements. Then simulations will be used to investigate the possibilities of natural elements in a design and see if they can give the desired results.

Output

The outcome of the compared analyses will lead to diagrams, guidelines and sketches. Showing how design can use natural elements to create a healthy home or proof that it is not possible.

4.0 RESEARCH DIAGRAM



5.0 PLANNING

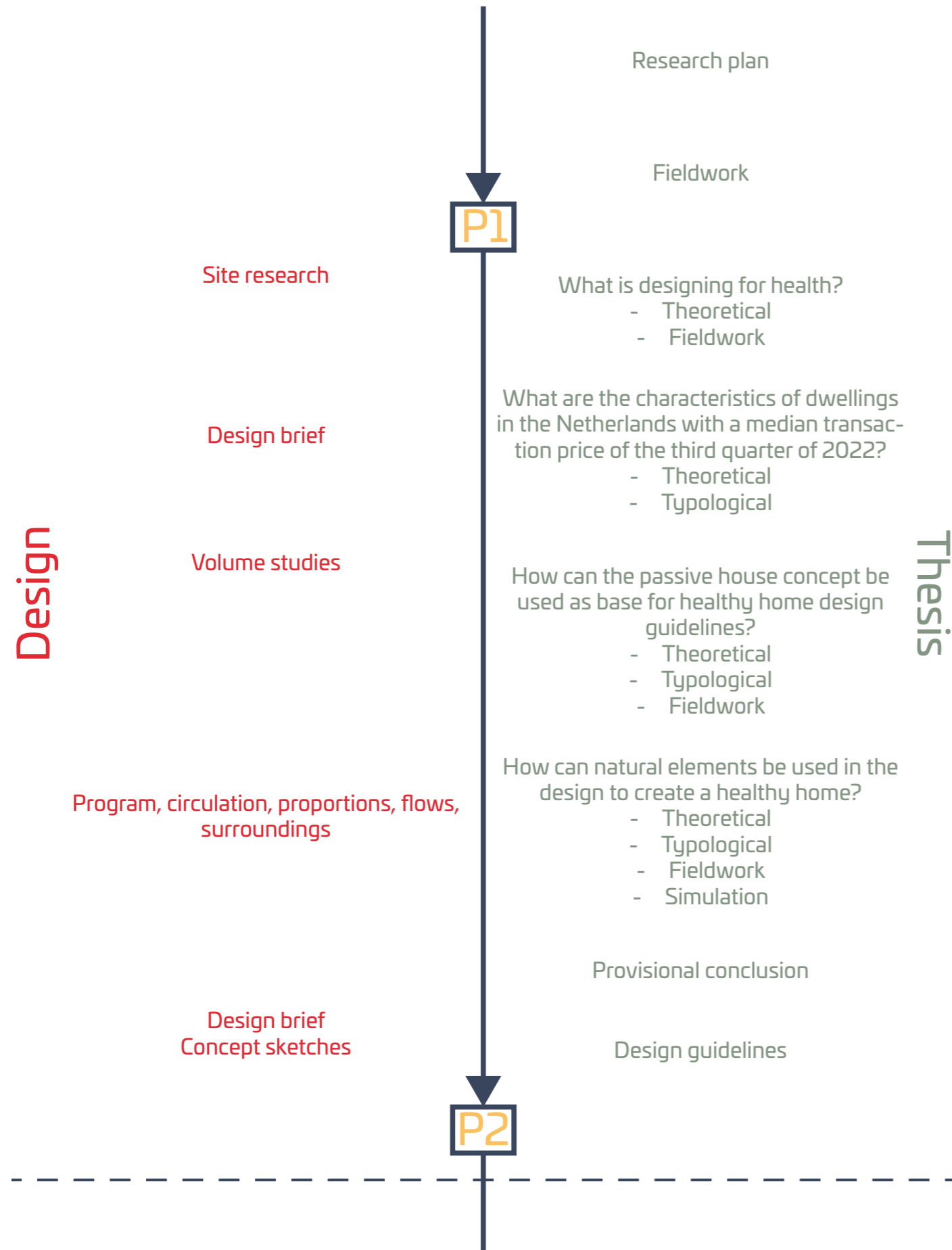


Diagram 08 Planning

6.0 REFERENCE LIST

6.1 List of illustrations

- 01 Knoppert, J., S. (2022). [Image] Healthy homes. Own work
- 02 Knoppert, J., S. (2022). [Table] Ranking of the health certificates. Own work
- 03 Knoppert, J., S. (2022). [Graph] Literature gap. Own work
- 04 Knoppert, J., S. (2022). [Table] Subject in the literature. Own work
- 05 Knoppert, J., S. (2022). [Diagram] Literature review. Own work
- 06 Knoppert, J., S. (2022). [Diagram] Theoretical framework. Own work
- 07 Knoppert, J., S. (2022). [Diagram] Research scheme. Own work
- 08 Knoppert, J., S. (2022). [Diagram] Planning. Own work

6.2 Bibliography

Akbari, P., Yazdanfar, S., Hosseini, S., & Norouzian-Maleki, S. (2021). Housing and mental health during outbreak of COVID-19. *Journal of Building Engineering*, 43, 2352-7102. <https://doi.org/10.1016/j.job.2021.102919>

Altman, I. (1975). *The environment and social behavior : privacy, personal space, territory, crowding* (1st ed.). Brooks/Cole.

Beemer, C. J., Stearns-Yoder, K. A., Schuldt, S. J., Kinney, K. A., Lowry, C. A., Postolache, T. T., Brenner, L. A., & Hoisington, A. J. (2021). A brief review on the mental health for select elements of the built environment. *Indoor and Build Environment*, 30(2), 152-165. <https://doi.org/10.1177/1420326X19889653>

Bluyssen, P. M. (2009). *The Indoor Environment Handbook: How to make buildings healthy and comfortable* (1st ed.). Earthscan.

Bluyssen, P. M. (2019). The need for understanding the indoor environmental factors and its effects on occupants trough an integrated analysis. *Materials Science and Engineering*, 609. <https://doi.org/10.1088/1757-899X/609/2/022001>

Bluyssen, P. M. (2022). Paterns and Profiles for understanding the indoor environment and its occupants. *REHVA 14th HVAC World Congress*, 14. <https://doi.org/10.34641/clima.2022.417>

Brandon, E. M. (2022, October 7). *Can We Design for Happiness?* Metropolis. <https://metropolismag.com/viewpoints/can-you-design-happiness/>

Channon, B. (2018). *Happy by design: A Guide to Architecture and Mental Wellbeing* (1st ed.). RIBA Publishing.

Dorst, M. J. (2005). *Een duurzaam leefbare woonomgeving: Fysieke voorwaarden voor privacyregulering*. [Phd dissertation, Delft University of Technology]. <https://repository.tudelft.nl/islandora/object/uuid%3A6af7e7a1-0572-4678-a5e5-cc31af2d9d3f>

El-abosy, M., Farag, O. M., & Moustafa, W. S. (2015). Indoor Environment Mitigation with Desert Climate Conditions for Affordable Passive Housing. *Mansoura Engineering Journal*, 40 (1). 10.21608/BFEMU.2020.101057

Fernandez-Antolin, M., Río, J. M., Costanzo, V., Nocera, F., & Gonzalez-Lezcano, R. (2019). Passive Design Strategies for Residential Buildings in Different Spanish Climate Zones. *Sustainability*, 11, 4816. <https://doi.org/10.3390/su11184816>

Hasselaar, B., Huijbers, M., & Haaren, A. (2022). Integrating health & comfort into building design. How Active House and other labels can help improve buildings. REHVA 14th HVAC World Congress, 14. <https://doi.org/10.34641/clima.2022.86>

Horr, Y. A., Arif, M., Katafygiotou, M., Mazroei, A., Kaushik, A., & Elsarrag, E. (2016). Impact of indoor environmental quality on occupant well-being and comfort: A review of the literature. *International Journal of Sustainable Built Environment*, 5, 1-11. <https://doi.org/10.1016/j.ijbsbe.2016.03.006>

Jules Design & Development. (2022). Nieuwbouw duurzame schuurwoning. October 7, 2022, from <https://www.julesgielen.com/index#/nieuwbouw-duurzame-woning-weert/>

Landelijk Centrum Medische Milieukunde. (2005). GGD Richtlijn Gezonde Woningbouw (GGD-richtlijn definitieve versie 5/12/2005). GGD-NL. <https://www.rivm.nl/sites/default/files/2018-11/Richtlijn%20Gezonde%20Woningbouw%20%282005%29.pdf>

Laskari, M., Karatasou, S., & Santamouris, M. (2016). A methodology for the determination of indoor environmental quality in residential buildings through the monitoring of fundamental environmental parameters: A proposed Dwelling Environmental Quality Index. *Indoor and Built Environment*, 26(6), 813-827. <https://doi.org/10.1177/1420326X16660175>

Ministerie van Binnenlandse Zaken en Koninkrijksrelaties. (2012). Bouwbesluit (416:2012). <https://rijksoverheid.bouwbesluit.com>

Moya, T. A., Dobbelseen, A., Ottelé, M., & Bluysen, P. M. (2018). A review of green systems within the indoor environment. *Indoor and Built Environment*, 28 (3), 298-309. <https://doi.org/10.1177/1420326X18783042>

Nederlandse Vereniging voor Makelaars (2022). Woning-transacties Q3 2022 (Marktoverzicht Nederland Q3 2022). NVM. <https://www.nvm.nl/media/4chnkmc/marktoverzicht-nederland.pdf>

Netwerk conceptueel bouwen (2018). Handleiding voor ordening vraag en aanbod (Woonstandaard: Basis prestatie-eisen en veelgevraagde aanvullende prestatie-eisen per product-marktcombinatie 2.0). Netwerk Conceptueel Bouwen. https://www.conceptueelbouwen.nl/_files/ugd/b56e43_47cfa63be8aa4dc98551f50871a10baa.pdf

NOS. (2022). Onderzoek: tekort aan zorgpersoneel op lange termijn alleen maar groter. <https://nos.nl/artikel/2413851-onderzoek-tekort-aan-zorgpersoneel-op-lange-termijn-alleen-maar-groter>

Passive House Institute, 2022. Happy Birthday, Passive House. October 13, 2022, from https://passiv.de/downloads/07_20210602_Press_Release_30_years_Passive_House.pdf

Prince, M., Patel, V., Saxena, S., Maj, M., Maseko, J., Phillips, M. R., & Rahman, A. (2007). No health without mental health. *The Lancet*, 370 (9590), 859-877. [https://doi.org/10.1016/S0140-6736\(07\)61238-0](https://doi.org/10.1016/S0140-6736(07)61238-0)

Rijksoverheid. (2022). Welke bescherming biedt de Nationale Hypotheek Garantie (NHG)? <https://www.rijksoverheid.nl/onderwerpen/huis-kopen/vraag-en-antwoord/nationale-hypotheek-garantie-nhg>

RIVM. (2021). Healthy living environment. Retrieved October 27, 2022, from <https://www.rivm.nl/en/healthy-living-environment>

Schieweck, A., Uhde, E., Salthammer, T., Salthammer, L. C., Morawska, L., Mazaheri, M., & Kumar, P. (2018). Smart homes and the control of indoor air quality. *Renewable and Sustainable Energy Reviews*, 94, 705-718. <https://doi.org/10.1016/j.rser.2018.05.057>

Schnieders, J., Eian, T. D., Filippi, M., Florez, J., Kaufmann, B., Pallantzas, S., Paulsen, M., Reyes, E., Wassouf, M., & Yeh, S. (2019). Design and realisation of the Passive House concept in different climate zones. *Energy Efficiency*, 13(8), 1561-1604. <https://doi.org/10.1007/s12053-019-09819-6>

Scriven, A. & Hodgins, M. (2012). Health Promotion Settings Principles and Practice. Sage.

Sternberg, E. M. (2009). Healing spaces: the science of place and well-being (1st ed.). *Belknap Press of Harvard University Press*.

Van der Geest, S., Schut, E., & Varkevisser, M. (2022). Maakt Rutte IV de stevige keuzes die nodig zijn voor een toekomstbestendige gezondheidszorg?. TPEdigitaal. <http://www.tpedigitaal.nl/sites/default/files/bestand/Varkevisser-def-1%20februari%202022.pdf>

Wang, L., Zhou, Y., Wang, F., Ding, L., Love, P. E. D., & Li, S. (2021). The Influence of the built Environment on People's Mental Health: An Empirical Classification of Causal Factors. *Sustainable Cities and Society*, 74, 2210-6707. <https://doi.org/10.1016/j.scs.2021.103185>

World Health Organization. (1988). Guidelines for healthy housing (1988). Regional Office for Europe Copenhagen. https://apps.who.int/iris/bitstream/handle/10665/191555/EURO_EHS_31_eng.pdf

World Health Organization. (1989). Health principles of housing (1989). Geneva. https://apps.who.int/iris/bitstream/handle/10665/39847/9241561270_eng.pdf?sequence=1&isAllowed=y

World Health Organization. (2021). Comprehensive mental health action plan 2013-2030. (action plan). Geneva: World Health Organization. <https://www.who.int/publications/i/item/9789240031029>