



Licentiate Thesis in Technology and Health

Home is where the (home care) worker is

A human-centered exploration of
home care in the bathroom

ANNAKLARA STENBERG GLEISNER

KTH ROYAL INSTITUTE OF TECHNOLOGY



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home care in the bathroom

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This thesis is dedicated to my mother Cajsá

Abstract

Introduction: The demographics of the world's population are rapidly changing. Many elderly people will have to age-in-place and receive care in their own home, and their homes will become work environments for home care workers. Within the home, the bathroom is a challenging workplace where many of the heavy lifting and transferring of clients take place; these high physical workloads limit the sustainability of the home care workforce. Bathroom design, including assistive devices, layout and available space, can play an important role for home care workers to facilitate work tasks and enable the clients to help themselves, but it is not clear to what extent.

Aim: The overall aim of this thesis was to investigate, using a human-centered lens, how the home bathroom design affects work and bathroom activities for home care workers and clients. To address this aim, two studies were conducted.

Methods: The first study was a qualitative interview study consisting of 21 interviews with participants from the perspective of a client, health care worker, or care organization. The interviews aimed to gather information and identify challenges, needs, and gaps for home care bathroom tasks. The second study was experimental, comparing three bathroom designs: a standard nursing home bathroom and two apartment-like bathrooms; one equipped with common assistive devices and one unequipped. Trunk and arm posture and movement data were collected using IMU-sensors from 18 care workers conducting bathroom tasks in the three bathrooms. Further, the frequency and duration of contact with assistive devices was documented via video recording,

and interviews were conducted with the participating care workers about their experience of usability and suitability when assisting a client.

Findings: The findings from study 1 identified important factors for enabling both independent living for clients and a sustainable work environment for health care workers. These factors included an adequate amount of space, access to assistive devices, and regular risk assessments to recognize changing needs. In study 2, the nursing home bathroom showed significantly higher 50th & 90th percentile left upper arm angular velocity than the equipped bathroom. Contacts with assistive devices were consistently longer and more frequent in the equipped bathroom than in the nursing home bathroom, which was in turn higher than the unequipped bathroom.

Conclusions: Workers, administrators, and users reported that the biggest challenges are lack of adequate space, lack of assistive devices, and lack of regular assessments to match needs. Assistive devices alone cannot replace space; worker postural and movement exposures are not improved by additional space and provision of assistive devices as anticipated. In both studies care workers reported considerable stress in small spaces regardless of the presence of assistive devices.

Keywords

Home care, Ergonomics, Assistive devices, Injury prevention, Ageing in place

Sammanfattning

Introduktion: Demografin för världens befolkning förändras i snabb takt. Det leder till att många äldre kommer att behöva åldras och få vård i sina egna hem, och hemmen kommer i större utsträckning än idag att bli arbetsmiljöer för hemtjänstpersonal. Badrummet i det egna hemmet är en utmanande plats där många av de tunga lyften och förflyttningarna av hemtjänsttagare sker. Hög fysisk arbetsbelastning leder till en mindre hållbar arbetsmiljö för hemtjänstpersonal. Badrummets layout, tillgängligt utrymme och hjälpmedel, spelar en viktig roll för hemtjänstpersonal för att underlätta arbetsuppgifter och göra det möjligt för vårdtagare att hjälpa sig själva. Det är inte klart i vilken utsträckning.

Syfte: Det övergripande syftet med denna avhandling var att undersöka, med hjälp av ett människocentrerat perspektiv, hur badrumsdesignen i hemmet påverkar arbete och badrumsaktiviteter för hemtjänstpersonal och vårdtagare. För att uppnå detta syfte genomfördes två studier.

Metod: Den första studien var en kvalitativ intervjustudie bestående av 21 intervjuer med deltagare som har ett vårdtagar-, vårdpersonal- eller vårdorganisationsperspektiv. Intervjuerna syftade till att identifiera utmaningar, behov och brister för arbete och aktiviteter i badrum i det egna hemmet. Den andra studien var experimentell och jämförde tre badrumsdesign: ett standardbadrum på ett vård- och omsorgshem samt två mindre badrum, ett utrustat med vanliga hjälpmedel och ett utan hjälpmedel. Både kvantitativa och kvalitativa data samlades in från 18 vårdpersonal när de utförde arbete och badrumsaktiviteter tillsammans med en vårdtagare i

badrummen. Kroppsställningar för bål och överarm registrerades med hjälp av IMU-sensorer. Vidare dokumenterades frekvens och varaktighet av kontakter med hjälpmedel via videoinspelning. Slutligen genomfördes intervjuer med vårdpersonalen om deras upplevelse av att hjälpa vårdtagaren i badrummen.

Resultat: Resultaten från studie 1 identifierade viktiga faktorer för att möjliggöra både självständighet i badrummet för vårdtagare och en hållbar arbetsmiljö för hemtjänstpersonalen. Dessa faktorer inkluderade tillräckligt med utrymme, tillgång till hjälpmedel och regelbundna riskbedömningar för att identifiera förändrade behov. I studie 2 var hastigheten för vänster överarm signifikant högre i vård- och omsorgsbadrummet jämfört med det utrustade badrummet. Det gällde för såväl den 50:e percentilen som den 90:e percentilen. Kontakter med hjälpmedel var genomgående längre och mer frekventa i det utrustade badrummet än i vård- och omsorgsbadrummet, vilket i sin tur var mer frekventa än i det icke-utrustade badrummet.

Slutsatser: Enligt vårdpersonal, administratörer och vårdtagare är de största utmaningarna för arbete i badrum bristen på utrymme och hjälpmedel samt kontinuerliga behovsbedömningar.

Hjälpmedel kan inte ersätta utrymme, personalens arbetsställningar förbättras inte av utrymme och hjälpmedel som förväntat. I båda studierna rapporterade vårdpersonal avsevärd stress i små utrymmen oavsett närvaron av hjälpmedel.

Nyckelord:

Hemtjänst, Ergonomi, Hjälpmedel, Skadeprevention, Åldras i det egna hemmet

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Over the course of my licentiate, I have had the pleasure of having two different main supervisors, Catherine Trask and Linda Rose. From the bottom of my heart, a warm thank you for all the knowledge, encouragement, support, and enthusiasm that you have given me. I also want to thank my co-supervisors, Mikael Forsman and Jörgen Eklund, for your expertise and support as well as your time to review my different manuscripts.

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Appended papers

Two papers are included in this licentiate thesis:

Paper I:

Gleisner, A. S., Rose, L., & Trask, C. (2022). Towards safety and autonomy in the home bathroom: Identifying challenges, needs and gaps. *Applied Ergonomics*, 105, 103865–103865.

<https://doi.org/10.1016/j.apergo.2022.103865>

Paper II:

Gleisner, A.S., Papahristodoulou, N., Wu, K. & Trask, C. (Submitted manuscript). Bathroom design and home care: work posture, assistive product contacts and worker experience in three different designs.

Author contributions

Paper I: Towards safety and autonomy in the home bathroom: Identifying challenges, needs and gaps.

Gleisner and Rose conceptualized and designed the study. Gleisner conducted the interviews, transcribed the collected data. Trask contributed to the design of the qualitative methods and Gleisner and Trask conducted the qualitative analysis. Gleisner drafted the manuscript. Rose and Trask critically reviewed the manuscript. Gleisner was the corresponding author.

Paper II: Bathroom design and home care: work posture, assistive product contacts and worker experience in three different designs.

Gleisner and Trask conceptualized and designed the study. Gleisner, Trask and Papahristodoulou contributed with data collection and analysis of data. Wu contributed with analysis of data. The synthesis of qualitative results and multi-method results were performed by Gleisner. Gleisner drafted the manuscript, and Trask critically reviewed the manuscript. Gleisner was the corresponding author.

In both paper 1 and 2, multidisciplinary research team members have been engaged planning the qualitative research design, reviewing and refining the interview protocols, analyzing the data as well as co-creating the two figures “ageing in place” and “safe task completion”.

List of abbreviations & definitions

ADL	Activities in daily living
Ageing in place	To live safely at home in your community as you age
Assistive devices / products / equipment	Devices or equipment that help people with disabilities to perform their daily activities
Care worker / home care worker	A person, employed to support people with their daily activities in a nursing home or in home care, respectively
HCD	Human-centered design
Health care worker (HCW)	A collective name for a variety of professions and occupations who provide some type of healthcare service, e.g. home care worker, assistant nurse, or occupational therapist
HTO	Human, technology and organization
MSD	Musculoskeletal disorder
SP	Standardized patient
UCD	User-centered design
Usability	Characteristics by which a work system that is utilized and operated by workers can be assessed

WHO

World Health Organization

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1 Introduction

Older adults, defined by National Institute of Health as people age 65 or older (NIH, 2025), are expected to 'age in place' in most EU states, meaning ageing independently and safely in one's own home and in the community (Sturge et al., 2025). This means many homes will become work environments for care workers. For this work force, assisting with personal care tasks in a home can be challenging, especially in the bathroom where many work tasks include heavy lifting and moving clients in adverse work postures (Jepsen et al., 2025; Kim et al., 2010; Lang et al., 2014). Assistance with bathroom activities is defined in this thesis as help with personal hygiene e.g. toileting, washing, bathing/showering, dental care; this assistance could be given by, for example, a family member or a care worker. An often aggravating factor is the limited space available (King et al., 2018; Pati et al., 2017) and research on bathrooms in general has traditionally focused on the physical characteristics of the bathroom space (Feldman & Chaudhury, 2008; Mullick, 2001; Murphy et al., 2006; Pati et al., 2017). Literature on bathroom design has investigated size to some degree (Hignett & Evans, 2006; Hignett & Keen, 2005), although this was in a hospital rather than a home care setting. In contrast to home bathrooms, the bathrooms in Swedish hospitals and nursing homes are large. They are designed according to work environment regulations to enable sustainable work postures for one or two nursing assistants along with a client and her assistive devices for mobility, for example a wheelchair, or a walker. Research on assistive devices (e.g. toilet seat raiser, toilet armrests, wall grab bars, grab bars incorporated in the sink, shower grab bar and shower chair) in personal care often focus the usability perspective on the client's usage (Dekker et al., 2005; Guitard et al., 2013; King & Novak, 2017; Petersson et al., 2012; I.

Petersson et al., 2008) and not the care workers. There are also other organizational challenges for home care workers, such as time limits and high patient loads (Strandell, 2020), as well as balancing the emotional needs (and sometimes states of distress) of their clients (Ahnlund et al., 2023; Kober & Chang, 2024; Ruotsalainen et al., 2020).

Considering trends toward 'aging in place', the design of the home bathroom has implications for society. With a fast-growing older population, the need for help and personal care at home will increase (United Nations. UN75). This leads to a present and future challenge in the availability of labor in the home care workforce. Employers in home care services are already struggling to find enough competent staff (European Commission Directorate-General for Employment, 2021), and there is thus a critical need to ensure a healthy and sustainable work environment for home care workers. Equally important is maintaining clients' autonomy and enabling healthy ageing. A safe home environment for both clients and workers can contribute to sustainability in the welfare system.

An improved understanding of how bathroom design affects work and bathroom activities for home care workers and clients is needed to create sustainable home bathroom solutions in the future. The research presented in this thesis addresses the important gap between the regulated institutional bathroom work environment and the home bathroom. The thesis integrates perspectives from several user groups, *both* professionals and clients within the context of home care, to obtain their experiences on challenges and needs of care work and care assistance in the bathroom.

1.1 Thesis aim

The overall aim of this thesis was to investigate, using a human-centered lens, how home bathroom design affects work and bathroom activities for home care workers and clients.

The sub-aims were:

Study 1:

1. to identify challenges, needs and gaps for bathroom activities in a private home, both for home care workers and clients.
2. to gather information that will allow for user-centered and sustainable solutions for bathroom activities in private homes.

Study 2:

3. to compare three bathrooms designs (which differ in space, layout, and assistive devices) in terms of care workers': 1) trunk and arm postures and movements; 2) frequency and duration of contacts with assistive devices; 3) experience of usability and suitability when assisting a client.

1.1.1 Delimitations

This licentiate thesis has focused on the physical work environment for care workers and clients conducting care tasks in the bathroom. Due to the Covid-19 pandemic, it was not feasible to conduct interviews or experiments in clients' own homes. The interviews in study 1 were conducted via telephone and the bathroom experiments and interviews in study 2 were conducted in a controlled test environment. It was not possible to bring home care workers to the nursing home test location to conduct experiments due to infection risks.

2 Background

2.1 The demographic shift and older adult care

A global demographic shift is increasing the number of older adults people in the population. The 'over-65' age group is currently the fastest growing (United Nations. UN75). In Europe, this age group is estimated to increase by 41% by the year 2055. An even larger increase in life expectancy is anticipated in the over-80 age group, which is estimated to increase by 88% by the same year (European Commission Directorate-General for Employment, 2021).

Throughout Europe there are challenges in providing care and support to older adults residents (United Nations. UN75). Due to limited nursing home spaces, more older adults EU residents will be 'ageing in place' and receiving care at home, provided by care workers or family members (European Commission Directorate-General for Employment, 2021). Sweden is no exception; by the year 2042, 25% of Sweden's population will be over 65, with most staying in their own home (Fröst, 2017). This means private residences are also working environments. However, there are challenges associated with this; if home care (assistance with daily living activities and personal care) should be given in people's own homes, it is required that the homes are adapted to this type of work (Fröst, 2017).

In Sweden, home care is tax-financed and is available to all citizens based on individual needs. This generally applies to the other Nordic countries as well (Rostgaard & Szebehely, 2012). However, home care has different meanings and purposes across countries, in that it is more or less institutionalized due to, for example, financial conditions, regulatory mechanisms, and policy differences (Genet et al., 2012). For the purpose of this thesis, home care is

defined as care workers helping and supporting a person with ADL (Activities of Daily Living).

Today, people live longer due to improved living conditions, public health initiatives, and access to medicine and treatments. However, living longer does not necessarily mean maintaining good health. On the contrary, old age generally brings a decline in physical and mental capacity that brings with it the need for care and help (Oxley, 2009). See figure 1 illustrating a care worker assisting a client with undressing.

As a result of these demographic shifts, the EU and other jurisdictions around the world are focusing on how to provide for, manage and enable “healthy ageing”. The term is defined by WHO as “the process of developing and maintaining the functional ability that enables wellbeing in older age” (Rudnicka et al., 2020). One important part of “healthy ageing” is maintaining autonomy for the older adults by enabling self-care. This can mean, for example, fall prevention, continually assessing care needs and eliminating risks in the older adult’s accommodation (Oxley, 2009).



Figure 1: Care worker assisting a client to undress, pencil by AnnaKlara Stenberg Gleisner.

2.2 Work environment challenges in home care

2.2.1 Home care tasks and workload

Home care workers provide care to clients in their own home. This line of work involves physically demanding personal care tasks (Jepsen et al., 2025; King et al., 2018), for example lifting, moving and transferring clients, with often limited space to perform these tasks. See figure 2 illustrating a client transfer. In psychosocial terms, home care work is considered to be a high strain and low control work (Grasmo et al., 2021; Ruotsalainen et al., 2020; Suarez et al., 2017; Szebehely et al., 2017). This means care workers have a high workload at the same time as they experience low influence over their work (Ekstedt et al., 2022; Szebehely et al., 2017). Home care workers often work alone and lack both peer and leader support (Kaihlanen et al., 2023; Strandell, 2020; Westerberg & Tafvelin, 2014). Taken together, all these demands translate into higher injury risk than other healthcare professions; non-fatal time loss incidence is higher among home care workers compared to registered nurses or assistant nurses (Czuba et al., 2012).



Figure 2: Care worker assisting a client to transfer to the toilet, watercolor and pencil by AnnaKlara Stenberg Gleisner.

2.2.2 Injury statistics among home care workers

Statistics from 2023 show that 44% of care workers in Sweden experience ill health caused by conditions at work (Arbetsmiljöverket, 2023). The occupation has the highest rates of sick-leave on the Swedish labor market; the sick-leave rate is double that of other occupations in Sweden (Socialstyrelsen, 2025). According to the labor union for municipal care workers, the majority of the sick-leave is caused by high levels of stress and high strain (Kommunal, 2022). Such risks threaten the sustainability of the workforce directly due to illness and injury, but also in terms of recruiting and retaining workers in such a challenging work environment. Home care workers are predominantly women, and women show systematically higher risk of MSDs (musculoskeletal disorders) than men (Wijnhoven et al., 2006). According to Mathiassen et al. (2020), this is hypothesized to be due to a combination of gender differences in task behaviors and biological differences in capacity and physiological responses to loading. For example, in healthcare, women and men may be assigned different patient mixes and case workloads. They also may experience different workloads although performing the same work tasks. This can be due to the design of the workplace and work tools, as well as differences in body dimensions and physical capacity that affect their physiological response (Mathiassen et al., 2020). Thus, there is a clear need for solutions to help reduce the physical loads and sick leave due to MSD, which are now disproportionately higher in women.

2.2.3 Home care work and the home care work force in Sweden

Working in home care in Sweden, it is common to be either a care assistant (in Swedish *vårdbiträde*) or an assistant nurse (in Swedish *undersköterska*). There are different education options for these professions, for example to study a health and care program or an education program delivered by the employer (Kommunal, 2025a, 2025b). However, to be a care assistant it is not mandatory to have that formal training. Although several different educational options exist, many care assistants lack formal post-secondary education. The municipal union “Kommunal” representing care workers has identified this as a potential source of risk to client safety, care quality and work environment (Kommunal, 2025b).

In contrast to a care assistant, an assistant nurse has a higher level of education and is a protected and certified professional title, received through formal education and training. However, a care worker with many years of

work experience can apply to be validated to become an assistant nurse (Kommunal, 2025a). Education level and competence vary among care workers in general, and only 64% of the home care workforce are certified assistant nurses.

Working as a care worker in elder care is the most common occupation in Sweden, with women making up 82% of the workforce (SCB, 2024). Although it is a large workforce, only half of the workers work full-time. In the private elder care sector, the proportion of workers that lack health care education is larger than in the municipal sector (Socialstyrelsen, 2025). Of the monthly employed care workers, 22% are foreign-born, a proportion that has grown over the last years. Of the hourly-paid care workers, 42% are foreign-born (SKR, 2025). The proportion that lacks health care education and foreign-born workers in the work force are much higher in the larger cities than in the rural parts of Sweden (Socialstyrelsen, 2025).

2.2.4 The home bathroom as a work environment

The home bathroom is, for most people, their own private space for themselves. However, it can also be a workplace for care workers who perform physically demanding tasks, such as moving and transferring clients (Grønseth Grasmo et al., 2021; Hignett et al., 2016; Jepsen et al., 2025; Suarez et al., 2017). Yet, home bathrooms are typically not physically adapted to care (Ekstedt et al., 2022). Lack of space in the bathroom is one of the most significant causes of high workload and work environment risks among home care workers according to reports from interviews with care workers, occupational therapists, physiotherapists and clients. Problems with cluttered and cramped bathrooms, where there is little space to maneuver mobility aids and equipment, limits the approaches and methods that can be used to assist a client (Darragh et al., 2015; King et al., 2018; Lang et al., 2014). Figure 3 illustrates a home care worker assisting a client with ADL. The lack of space also leads to poorer quality care, as well as stress and uncomfortable working positions that can increase the risk of injuries for both workers and clients (King et al., 2018; Lang et al., 2014; Suarez et al., 2017).

The Swedish work environment policy (Arbetsmiljöverket, AFS 2023:12) states that there should be 'enough space' for challenging bathroom care tasks like showering and toileting. There is a minimum dimension of 0.8 m 'free space' listed as a guideline, for example on both sides of the toilet. The policy also states that interpreting how much space is 'enough' needs to consider the

patient's needs, the amount and frequency of lifting force, presence of assistance/equipment, as well as sufficient time and knowledge for safe work procedures. This guideline is legally binding, for example in hospitals and nursing homes, but does not apply in private bathrooms. This is a conflict – residential bathrooms are often built to the minimum dimensions that can accommodate a single, fully-independent user and not designed to accommodate a client, a wheelchair or walker, and one or two home care workers.

Aside from the physically demanding work tasks in the bathroom, such as lifting and moving clients, there are also work tasks of more delicate nature. The provision of intimate care is emotionally challenging for both the worker and the client (Ahnlund et al., 2023; Andersson & Kalman, 2017). There are different levels of intimate care, for example brushing teeth, helping with showering, and perineal care. There are emotional aspects of these work tasks, which include holding space for clients' integrity, dependency and vulnerability. For care workers performing these care tasks in someone's home and personal sphere, the work involves being fully present in order to be able to navigate to the clients' social, relational and emotional life (Ahnlund et al., 2023). This can be stressful for both client and worker. Andersson & Kalman (2017) describe a tension between the client being an active consumer of care and the strategies that both client and worker engage in when intimacy and integrity is most at stake, such as objectification and diverting attention to move focus elsewhere.



Figure 3: Care worker assisting client with toileting, pencil by AnnaKlara Stenberg Gleisner.

2.3 Home bathroom design features relevant to the work environment

In the context of this thesis, “bathroom design” refers to the size of bathroom entrance, size and layout of the bathroom (i.e. space), placement of toilet, sink, bathtub/shower, and other bathroom furniture. Further, it also includes the presence of assistive devices such as toilet raisers, toilet armrests, grab bars, and a shower chair.

2.3.1 Size and layout of the home bathroom

Throughout the years, the size and layout recommendations for Swedish bathrooms have evolved from detailed descriptions with floorplans to functional requirements and recommendations with less detail.

The first Swedish building codes and regulations for bathrooms were released in 1947 and quantified the minimum permitted floor area of a bathroom (*BABS Anvisningar till byggnadsstadgan*, 1950). As shown in figure 4, the placement of the toilet, the sink and the bathtub leaves very little space left, just about the space needed for a single average-size, non-disabled person to stand. The minimum area for a bathroom was 1.6 * 1.5 meters.

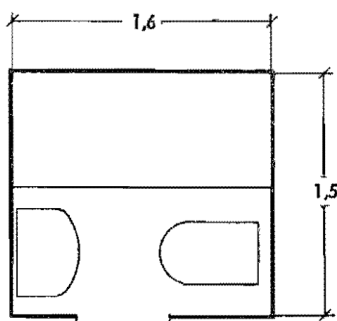


Fig. 28.

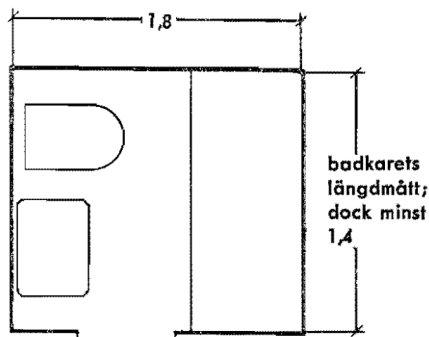


Fig. 29.

Figure 4: Guidelines to building code for bathroom BABS (1950) (text in Swedish translates to: “Minimum length of the bathtub 1.4 meters”). Measurements specified in meters. (*BABS Anvisningar till byggnadsstadgan*, 1950).

In 1968, building regulations and recommendations from the National board of urban planning replaced the national codes (*Svensk Byggnorm 67*, 1968). The regulations and recommendations were developed in more detail with

focus on functional requirements as well as measurements, including wheelchair accessibility. A selection of examples from the building recommendations for wheelchair accessibility are shown in figure 5. The suggested layouts have more floor space to accommodate the turning radius of a wheelchair than earlier building recommendations. However, the space on the sides of the toilet and the sink are largely the same. The recommended total area was 1.7 * 2.4 metres for toilet, sink and bathtub/shower. Note the drawn handles beside the toilet.

63:4

4: INSTALLATIONSENHETER I WC-RUM, BADRUM OCH DUSCHRUM FÖR RULLSTOLSBUNDNA PERSONER

För wc-stol och badkar gäller under 2 angivna mått. Rullstolens mått och svängradie bestämmer erforderliga friytor.

41 Tvättställ, stor modell, med kombinationer

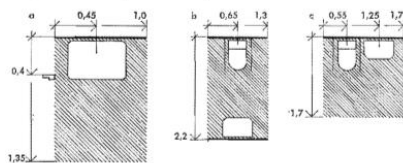


Fig 63:41a Tvättställ 0,70 x 0,50 m. Fig b, c Tvättställ och wc-stol.

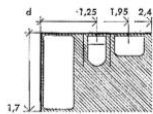


Fig 63:41 d Tvättställ, wc-stol och badkar.

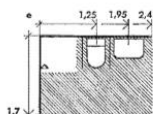


Fig 63:41 e Tvättställ, wc-stol och duschplats.

Figure 5: Chapter 63, section 4 in Svensk byggnorm 67 (1967) illustrating different combinations of placements of toilet, sink and bathtub in bathrooms for people in a wheelchair. Measurements specified in meters. (Text in Swedish translates to: Units for installation in bathrooms for person with wheelchair. The turning radius and size of the wheelchair decides the size of the free space).

One decade later, new recommendations (*Svensk Byggnorm 75, 1976*) were released and came with a few updates regarding measurements. The new building recommendations refer to differences in ability (e.g. low mobility in wheelchair or outdoor wheelchair) and the potential need of help with toileting. See figure 6 for one recommended floorplan with a toilet installed

with 0.3 meter from the wall behind to make it easier for the care worker to reach the client. The floorplan was designed for people with low mobility in wheelchair.

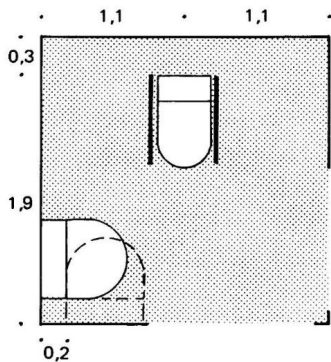


Figure 6: Chapter 63, section 2 in Svensk byggnorm 75 (1976) (text in Swedish) illustrating placements of toilet, for people with low mobility in wheelchair, to facilitate help from care worker.

Examples of recommended total area for toilet, sink and shower are illustrated in figure 7. These floorplans were designed for people with high mobility in wheelchair.

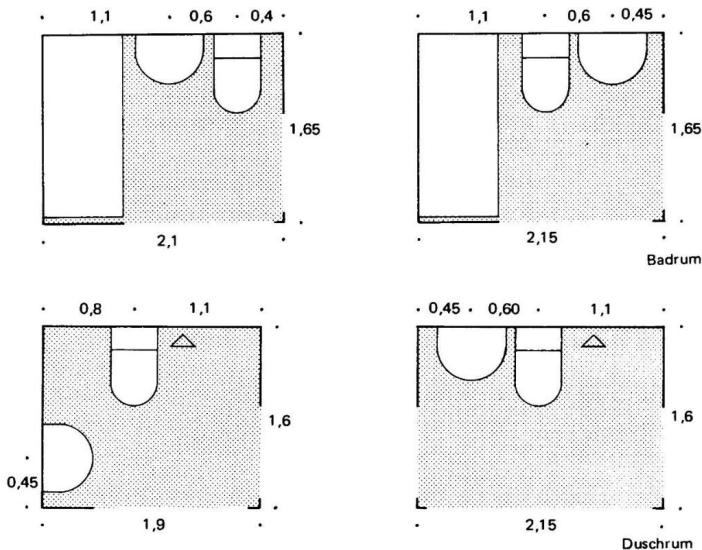


Figure 7: Chapter 63, section 2 in Svensk byggnorm 75 (1976) (text in Swedish) illustrating two recommended floorplans for people with high mobility in wheelchair.

Upcoming publications came with very few updates. In late 1980's and up until 1993, the building codes were released in a much simpler format; they were functional measurements rather than the layout of total bathroom space drawings with measurements seen in previous publications. This edition contained recommended measurements, for example for space requirements around the toilet and sink. The measurements were divided into *normal* and *minimum*, suggesting two levels of accessibility. The *normal* measurements apply to accessibility for a wheelchair user. Recommended normal space requirements were suggested to be expanded in cases where the wheelchair was large and one or two care assistants (*Boverkets Byggregler: föreskrifter och allmänna råd*, 1993).

In 2006 (the current standard), a third level of accessibility was added, *extended accessibility*, which apply to a larger group of disabilities (Standards, 2006). This update came with multiple proposals for bathroom layout the different levels of accessibility, especially in the extended accessibility level. Examples of functional measurements are shown below in figure 8 (Standards, 2006). The current recommended minimum size of bathroom in the home is 1.9 * 1.7 meters and is illustrated in figure 9 (Boverket, 2011). The bathroom should have space for the turning radius of a small wheelchair.

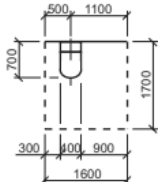
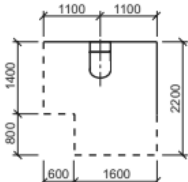
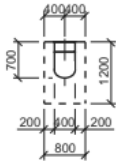
	Normalnivå	Höjd nivå	Sänkt nivå
	Grundläggande tillgänglighet	Utökad tillgänglighet	Utan krav på tillgänglighet
WC-stol med funktionsmått	 <p>Figuren visar vilka mått som skall vara möjliga att anordna efter ändring som t.ex. borttagning av badkar.</p>	 <p>Figuren visar vilka mått som skall vara möjliga att anordna efter ändring som t.ex. borttagning av badkar eller flyttning av handfat.</p>	

Figure 8: Functional measurements around the toilet for three levels of accessibility. (Text in Swedish translates to: Toilet with functional measurements that should be possible after for example removing the bathtub, for normal level accessibility, extended level accessibility and low-level accessibility.)(Standards, 2006)

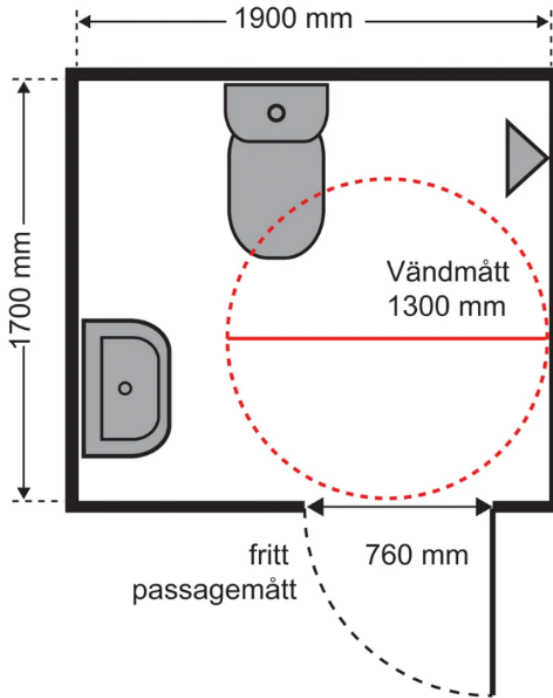


Figure 9: Current recommended minimum size bathroom in the home. (Text in Swedish translates to: Measurement for turning radius 1300 millimeter, measurement for free passage 760 millimeter. Illustration retrieved from Boverkets byggregler – föreskrifter och allmänna råd (2011).

2.3.2 Assistive devices in the bathroom

Several aspects of bathroom design are important for injury prevention and healthy aging in place, in particular appropriate fixtures and equipment. For the purpose of this thesis, the terms ‘equipment’ and ‘assistive devices’ are equivalent and used interchangeably. A common bathroom design is equipped with a shower or a bathtub, a toilet, and a sink with storage. These design features are often made from hard materials, such as ceramics and steel. Walls and flooring are often covered in tiles, a material that is hard and can also get slippery when wet. A study on fall initiation in bathrooms (Pati et al., 2018) identified several physical design elements that can contribute: the door, the toilet, sink hardware, the bathroom spatial configuration and space availability. The unforgiving surfaces motivate the use of fall prevention strategies, with assistive equipment being an important example.

Private homes often lack the equipment and assistive devices that are present in a hospital or nursing home bathroom. Modifications such as installing grab bars and other assistive devices can have a positive impact on clients' performance in their bathroom by reducing the difficulty of personal care tasks and increasing safety (Agree & Freedman, 2000; Burton et al., 2011; De-Rosende-Celeiro et al., 2019; Ingela Petersson et al., 2008). However, for home modifications to be successful, they need to be tailored to the clients' needs (Ainsworth et al., 2023; Petersson et al., 2012).

A recent study on challenges of home care in small residential bathrooms summarized commonly used assistive technology in the home bathroom (Rodrigues Coutinho, 2025). The resulting 'inventory' of equipment was divided into 9 main categories: shower benches, grab bars, toilet raisers, washbasin, shower and sink taps, alarm buttons, contrast fixtures and "others" (e.g. wheelchair shower seat, lifting device); these assistive devices will be described in brief here.

A shower bench *or* shower stool is used to support the client while they sit for a shower. Such benches minimize the risk of falls in the shower and are available in many shapes and sizes. Grab bars or support handles mounted on the wall can offer support when changing positions, for example when sitting and standing or moving in the bathroom. A raised toilet seat comes in different heights to accommodate different user needs; they come with or without safety handles and facilitate moving between sitting and standing.

Assistive washbasins offer free space to accommodate wheelchair users' legs under the sink. Washbasins can also have built-in support handles for safety and balance, as well as height adjustability to match the client's needs. Shower and sink taps can also be designed to facilitate usage for older adults, for example a long handle that reaches over the tap. Alarm button kits can be installed in the bathroom in addition to the personal/individual alarm, to facilitate calling for help in case of a fall or other emergency. Contrasting colors on fixtures in the bathroom can improve visibility and enhance safety, especially for those with impaired vision or cognitive impairment. Other assistive devices can function as lifting and moving devices; for example, a shower chair with wheels can enable a transfer outside the bathroom or could be used as a portable toilet. There are also other technical solutions on the market, such as "smart toilets" that can help with perineal care (washing), and with heart rate monitoring (Wagner & Boiten). However, the availability of these products to a broad public is yet limited due to financial constraints.

Assistive devices in the home are often provided by occupational therapists (hereafter called OT). The OT addresses the client's needs and handles issues related to the client (e.g., balance, difficulties standing), the activity (e.g., toileting, showering) and the environment (e.g., toilet, sink) (Ruest et al., 2017). The use of assistive devices is important to foster the clients' physical and psychological health, but also for the workers' occupational health (Guay et al., 2014). A change in a client's needs can come quickly, and care workers are put at risk when there is a long wait time for an assessment visit from the OT (and then subsequent provision of the equipment needed). This difficulty has been acknowledged in a study by a Canadian research group (Guay et al., 2014). They identified that home care workers are important observers of clients' changing needs, since they typically have daily contact with them. The clinical algorithm *Algo* was thus developed to support non-OTs such as home care workers to select bathing and showering assistive devices for their clients. *Algo* is a visual map with steps, guided by yes and no questions, to help select appropriate bathing assistive devices. It can be used by home care workers for "straightforward" cases, defined as "clients of standard morphology with predictable occupational performance in bath transfer in their standard shower stall or bathtub" (Guay, 2012).

The provision of assistive devices has potential for big impacts on a client's independence and plays an important part for a client coping with everyday life (De-Rosende-Celeiro et al., 2019; King & Novak, 2017; Pettersson & Fahlström, 2010). Assistive devices may also contribute to the reduction of care workers' physical workload, for example to facilitate work tasks and enable the clients to help themselves (Boge et al., 2017; Pettersson & Fahlström, 2010). A systematic review on accessible home environments concluded that installing, for example, grab bars, raised toilet, shower chair, have positive effects for injury and fall prevention (Cho et al., 2016). In addition, they also stated accessible homes lead to better overall health, wellbeing, and ADL (activities in daily living) for the client.

3 Theoretical framework

This chapter presents the theoretical framework. The thesis design was inspired by the concept of human-centered design and the analysis approach by the concept of HTO. The human-centered design approach supports the participatory research methodology and underlines the importance of understanding user needs by evaluating user experience. The concept of HTO was used to analyze and identify factors that can contribute to safety, well-being, and overall system performance in the bathroom work environment.

3.1 Human-centered design

The concept of human-centered design (HCD) has its roots in the fields of Human Factors and Ergonomics (Giacomin, 2014). “HCD is a design practice that takes a holistic systems approach towards human needs” (Melles et al., 2021). It is characterized by its focus to understand the users, their needs, experiences, tasks, and environments (Melles et al., 2021). Importantly, users’ is plural here, HCD is performed by engaging a wide range of users, which includes several target groups, involving them throughout the process and then evaluating the outcomes through their perspectives. A similar design practice is user-centered Design (UCD). In contrast to HCD, UCD typically identifies a specific target group and has a special focus on usability for a specific end-user (Göttgens & Oertelt-Prigione, 2021; Windlinger et al., 2022).

In HCD design practice, it is also considered important to use a multidisciplinary team to contribute multiple perspectives and knowledge (Standards, 2019). The goal is to learn from various users and match the outcome to their needs and preferences (Giacomin, 2014; Steen, 2011). The

methods or tools used in HCD design practice are, to a great extent, qualitative (Melles et al., 2021). Methods such as observation, personas, interviews, surveys, and questionnaires are used to gain both verbal and non-verbal information (Giacomin, 2014).

HCD is frequently used in research projects in healthcare. For example, a recent study on falls prevention in hospital bathrooms (O’Neill et al., 2024) engaged multiple target groups, including both male and female nurses from different institutions, to evaluate multiple design concepts by engaging them in focus groups, having them complete surveys and using storyboards to address the needs of the humans. The participating nurses saw the greatest opportunity with devices which could improve the process of toileting and reduce physical strain, such as mobility and lifting devices. They had concerns with higher-technology tools removing the emotional connection between the patient and the nurse, as well as the potential to lead to further healthcare disparity. The study’s outcome contributed to valuable insights into human needs and limitations. In another recent study investigating a human-centered AI chat-bot in healthcare (Alsalamah et al., 2025), the principles of HCD were used to conduct surveys and interviews to collect both qualitative and quantitative data on user experience from both health care professionals and patients.

HCD has influenced the design of the two studies included in this thesis. This includes methodological choices aimed at interacting, observing, and communicating with the participants to obtain an understanding of their needs, experiences, tasks, and environments.

3.2 HTO – Human, technology and organization

The HTO concept represents a holistic approach to work systems. It was first developed to improve safety outcomes in the *technology* development in the Swedish nuclear industry (Karlton et al., 2017). As the research progressed, the role of the *human* and the role of the *organization* in improving safety was added. Since then, this holistic concept has been shown to be useful in a variety of industries for creating good working conditions. For example, the HTO concept has been applied in the wood working industry, the Swedish postal service and the meat packing industry (Berglund et al., 2020). The HTO concept centers on *work system performance* and builds on the three sub-systems: Human, Technology and Organization. The system components

interact with one another and impact the overall outcome of the work activities.

It is in the overlap between the three sub-systems where the challenges and biggest potential improvements are. The **H** relates to the individual activities in a workplace and can be viewed from different perspectives, for example as “exposed to the system” or “an actor in the system”. The **T** relates to the tools, machinery, and technology used in the work activities. The **O** refers to how the work is structured and organized, which includes both formal (goals, instructions, etc.) and informal (informal work practice, organizational culture) aspects (Karlton et al., 2017).

In this thesis, the HTO concept has been used to analyze the bathroom work environment and the client assistance work activities that occur there. Applying this holistic approach may identify factors that can contribute to safety, well-being, and overall system performance. In addition, the HTO lens also helps identify areas of improvement. In the context of this study of home care, the **H** stands for care workers and the clients. The **T** stands for the physical setting and the tools, namely the bathroom, its design, layout, environmental characteristics, the equipment and assistive devices available. The **T** also contains work methods and procedures for the care workers and their “know how” (Karlton et al., 2017). The **O** refers to the care organization and its documented policies on how the work is structured and instructed, for example lifting and moving techniques and policies regarding double staffing. It also includes the care workers’ written job description and formal responsibilities, for example client follow-ups and risk assessments. These formal aspects can be described as “work as imagined” (Hollnagel & Wears, 2015). However, **O** also contains informal aspects, for example the care workers’ informal work practices on work activities, described as “work-as-done” (Berglund et al., 2020; Hollnagel & Wears, 2015; Karlton et al., 2017). In the context of home care, this could include work strategies or work postures that change due to time pressure or lack of space.

4 Materials and methods

This thesis is comprised of two studies with separate data collections. Throughout this thesis research, the study participants' experiences and actions were investigated in different contexts, including interviews with participants via telephone and in-person, and experiments in test environments. The goal of this was to better understand how the bathroom environment affects work and bathroom activities for both care workers and clients. The methods and approaches chosen for this research were influenced by a pragmatist research philosophy as described by Allemang et al. (2022). The goal of pragmatist research is to build knowledge and understand the world, combined with values of democracy and social justice, through human experience. It is based on the beliefs of using the most suitable methods, allowing for multiple sources of data to answer the research questions. This epistemological position is supported by applying a mixed methods approach. The combination of different qualitative and quantitative methods in this thesis was selected to support a human-centered approach in service of the overarching goal: making home bathrooms safer and more usable and promoting independence for home care.

4.1 Paper 1 – a needs analysis

4.1.1 Study participants

Interviews were held with twenty-one participants, both professionals and clients. The professionals were divided into two categories: "Care organization representatives" and "Health care workers". They were recruited via inquiries made by the author in various municipalities and manufacturing companies in Sweden and invited to participate in the study. Inclusion criteria for the

professionals were that they worked with older adults or handled questions regarding older adult care, accessibility, or assistive devices in their profession. The different occupations of the professionals were chosen to provide a broad perspective. Since receiving home care in Sweden is a government authority decision, a municipal quality developer for older adults has insights on how the home care should function and be performed from an government perspective. Inspectors from the Swedish work environment authority have another perspective; their mission is for everyone to have a health-promoting work environment. The trade union representative, the home care managers and the home care workers were recruited because of their insights into everyday work life for home care workers and what problems they face. The manufacturing company for assistive devices as well as the occupational therapists are experts on assistive devices and therefore bring another perspective on how assistive devices function for both clients and home care workers. The participating clients were recruited via the research team’s network of contacts. Inclusion criteria were that they were seventy years of age or more and living in private residences. Table 1 provides information about occupation, gender, and the number of participants in each category.

Table 1: Composition of participants, sex and occupation.

Occupation/Role	Female	Male	In total
Inspector from the Swedish Work Environment Authority	2	-	2
Quality developer, Older-adult Care, Municipality	1	-	1
Manager manufacturing company (assistive devices)	1	-	1
Physiotherapist manufacturing company (assistive devices)	1	-	1
Head of home care for older adults	1	1	2
Representative from the Swedish trade union Kommunal	1	-	1
Home care worker	3	1	4
Occupational therapist	3	-	3
Clients (community-dwelling older-adult care recipients)	5	1	6
In total	18	3	21

4.1.2 Data collection

Two interview guides were developed, one for the professionals and one for the clients (for detailed description see appendix I) with fifteen and nine main questions, respectively. When interviewing the professionals, the questions were formulated from an organizational point of view and their experience of the bathroom as a work environment. The questions to the clients focused on their individual perspective and experience of how their bathroom was functioning for them and individual needs concerning assistive devices in the bathroom. Due to the outbreak of Covid-19, the interviews were conducted via telephone and were audio-recorded. They lasted between 30 and 60 min and were transcribed verbatim.

4.1.3 Data analysis

The recordings from the interviews were transcribed and imported into NVivo software (QSR International Pty Ltd, 2020) for analysis. The data was analyzed using qualitative content analysis (Elo & Kyngäs, 2008). The interview material was thoroughly read through repeatedly, and an “open coding” strategy was performed (AKSG) to freely generate and organize the data into different categories as they were discovered. In the first iteration, 46 categories were identified. The aim of the second iteration was to group categories describing similar phenomena, resulting in 4 main categories. Interpretive description (Thompson Burdine et al., 2021) was then used to achieve a deeper understanding of the data, to detect patterns, interpret and draw conclusions from the material. A subsequent analysis of the interplay between client and professional perspectives was performed (AKSG & CT) and then illustrated in a figure to show the interconnected system in which the 4 main categories link in different ways to enable *ageing in place*.

4.2 Paper 2 – a comparison of three bathrooms

4.2.1 Study design

In the second study, care workers' trunk and arm posture, contact with assistive devices, as well as their experience, was evaluated when assisting a client in a bathroom test environment. Three different bathroom designs were used in the experiments: one standard nursing home bathroom (size 2.40 m * 2.20 m)(See figure 10, picture A) and two smaller bathrooms sharing the same layout and size (size 2.70 m * 1.54 m), one “unequipped” (See figure 10, picture B) and one “equipped” (See figure 10, picture C).The nursing home bathroom

was designed in accordance with the Swedish work environment regulations (Arbetsmiljöverket, 2024) and ‘equipped-to-standard’ with assistive devices such as grab bars, toilet raiser and toilet armrests. The “equipped” smaller bathroom was equipped with a selection of commercially available assistive devices (i.e. toilet seat raiser, toilet armrests, wall grab bars, grab bars incorporated in the sink, shower grab bar and shower chair), designed and provided by the partners of this study. The smaller, unequipped bathroom was equipped as an ordinary bathroom without assistive devices.

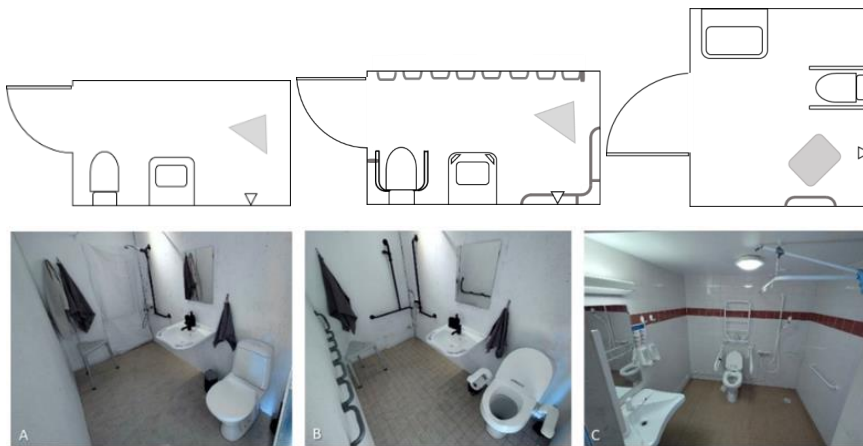


Figure 10: Layout and picture of the three bathrooms. (A) Bathroom one “unequipped”, a standard residential bathroom with a shower stool; (B) Bathroom two “equipped”, an equipped residential bathroom; (C) Bathroom three “nursing home”, a standard, equipped nursing home bathroom.

Each the experiments involved 1-2 care workers conducting pre-determined care tasks. See table 2 for detailed care task guide. Care tasks were performed with an experienced care worker acting as a standardized patient (Barrows, 1993), acting as two different personas. Persona one was semi-mobile and corresponded to level B in the CareThermometer (Knibbe, 2002); this persona used a walker. Persona two was very passive and frail, corresponding to level C in the CareThermometer (Knibbe, 2002); this persona used a wheelchair. Prior the experiments, the participants filled in a short demographic questionnaire and were oriented to the study protocols including role of the standardized patient and the required care tasks. After each test, an interview with semi-structured questions was conducted with the participants.

Table 2: Detailed care tasks steps given to participants prior to each test.

Care tasks

1. Move into the bathroom
 2. Transfer to toilet – provide help with positioning and finding toilet handles.
Provide help sitting down and rising up
 3. Assistance with cleaning – half-stand, needs support
 4. Get to the sink
 5. Hand wash and rinse
 6. Dry hands
 7. Place shower chair where you would place it
 8. Transfer to shower chair
 9. Place the walker where you would place it
 10. Undress (bathrobe and shorts)
 11. Rinse
 12. Soap and clean body
 13. Shampoo hair
 14. Rinse off
 15. Dry off
 16. Dress
 17. Return to wheelchair/walker
 18. Leave bathroom
-

4.2.2 Study participants

Eighteen care workers, fourteen women and four men, participated in the experiments. The participants worked at different wards at Högdalen nursing home and were invited to participate in the study based on schedule, availability and interest. Inclusion criteria were that they were currently employed as care workers for older adults and were free from work-limiting MSDs. The care workers were between the ages of forty and sixty-five and had a median of seventeen years of care worker experience. Median height was 1.60 m for the women and 1.74 m for the men.

4.2.3 Data collection

Inertial Measurement Unit (IMU) (Movesense Oy, Vantaa, Finland) sensors were used to measure the body postures of the care worker's trunk and upper arms. The sensors were mounted in pockets on the upper arms and trunk of a tight and stretchy t-shirt. The IMUs' acceleration and gyroscope signals were used to compute angles and velocities. In comparison to using only accelerometer data, the IMUs give significantly higher validity (Lind et al.,

2023). After the care worker had put on the T-shirt, they were instructed to hold a reference posture for each body part. During a few seconds of data where zero angle was sampled, the angles from all tests were indexed to the individual's zero postures. Trunk movement velocities were computed as a derivation of the trunk inclination angle; while the angular velocities of the upper arms were computed as the generalized angular velocity, i.e. including movements in all three planes (Forsman et al., 2022).

Video-recordings of the tests were made using a camera mounted on the ceiling of each bathroom. Interviews were held with participants after each test (See table 3 for detailed interview guide). The interviews lasted between 3-12 minutes. All interviews were audio recorded and transcribed verbatim.

Table 3: Interview guide performed after each bathroom care trial.

Questions
What is your perception about entering the bathroom together with the client and their walker/wheelchair?
How do you perceive the space in the bathroom?
What is your perception about being in the bathroom and move around together with the client and their walker/wheelchair?
Is there anything you would like to change or add in the bathroom? For example, the placement of bathroom furniture?
Add something that would facilitate or remove anything that is obstructing?
How did you experience the space around the toilet?
How did you experience the space around the sink?
How did you experience the space around and in the shower?

4.2.4 Quantitative data analysis

The distributions of the posture exposure metrics were visually inspected, and the Shapiro-Wilks test was performed to test for normality. Many of the posture and contact variables were not normally distributed, therefore all descriptive statistics are presented as median and interquartile range (IQR). Freidman's test was used (as a non-parametric analogue to repeated measures ANOVA) to identify any significant differences in postural exposures or contact variables among the three bathroom designs. Asymptotic significance <0.05 prompted post hoc testing using pairwise Wilcoxon tests, where significance was determined after Bonferroni adjustment. P-values <0.05 on the pairwise

tests were considered statistically significant. The SPSS v29 statistical software was used for all analyses.

4.2.5 Qualitative data analysis

The interview data were analyzed using qualitative content analysis with an inductive approach (Elo & Kyngäs, 2008). The data was read thoroughly by the author, AKSG. In the first iteration, 24 categories were freely generated, guided by the research questions (AKSG). The categories were discussed by two team members (AKSG & CT). After grouping them into higher orders (AKSG & CT), three overarching main categories remained. The categories were assembled into a visualization of the interconnected categories (AKSG & CT). The interview data were then reviewed to ensure alignment with the results and any needed refinements were made.

4.2.6 Video-recording analysis

The video data was reviewed for each trial. Contacts with assistive devices were divided into “supportive” (i.e. the hand or elbow is in contact with the assistive products in a way that provides support or balance) or “hindering” (i.e. any part of the body that bumps into or presses assistive products without getting support). Instances of contacts were documented for both the care worker and the standardized patient. The duration of each task and each contact was calculated by subtracting the start time from the end time. The frequency of contacts per minute was then computed by dividing the total number of contact instances by the duration of the task.

4.3 Researcher ‘lens’ for qualitative analysis

Both paper 1 and paper 2 involve qualitative analysis of participant interviews; the analysis is by nature conducted via the lens of the analysts. Objectivity is not regarded as a hallmark or requirement of good qualitative research; it is acknowledged that the researcher’s positionality in relation to what is being studied will always influence their work to some degree. Dodgson (2019) suggests that the credibility and trustworthiness (which are regarded as important characteristics for good qualitative research) are increased by the practice of reflexivity, that is, describing the contextual and intersectional relationship between the participants and the researchers themselves. This means stating the researcher’s relationship as an “insider” or an “outsider” in relation to the participants. The quality of the work builds on the researcher’s ability to articulate this relationship. Dodgson(2019) asserts that a reflexive

positionality statement should state the shared experiences, similarities and differences that exist between the researcher and the participants.

The thesis author's educational background is diverse. She is trained as a social worker with a special focus on care for older adults and those living with disabilities. She is also trained in spatial and furniture design. Her work experience as a social worker in care of older adults and a manager in home care, positions her as an insider to the professional participants in study 1 and the participants of study 2. Although considered an outsider in relation to the participating clients in study 1, she has, through her education, a deep understanding and knowledge of the group "older adults and disabled".

Catherine Trask, the other author analyzing the interviews, is trained as an Occupational Hygienist and Ergonomist. She has professional experience as an ergonomics researcher and leads injury prevention projects within healthcare, nursing homes, and home care. Her relationship with the professional group in studies 1 and 2 is as a collaborator, since she is non-clinician without direct care management or professional care experience. Although not an insider in this group, she has acted as an informal caregiver to family members and has some lived experience delivering personal care in a bathroom, as well as advocating for and setting up bathrooms to support care.

Together they contributed to the analysis through the lens of their background and professional training.

4.4 Ethical considerations

The two studies comprising this thesis were reviewed and approved by the Swedish ethical review authority (certificate number 2019-05809).

Throughout the research conducted in study 1 and 2, the research team has been guided by the ethical considerations and guidelines presented in the Principles of Good Research Practice by the Swedish Research Council (*Good research practice*, 2017).

Prior to all data collection, all participants gave oral (study 1 and 2) and written (study 2) consent to participate; they consented to be video-recorded (study 2) and to have their interview audio-recorded (study 1 and 2). They were informed they could, at any time, withdraw their consent.

In study 2, real patients were not recruited to participate in the experiments due to potential health risks and fatigue effects borne by a frail older adult.

Instead, an experienced member of the care staff was trained to act as a standardized patient.

5 Findings

This chapter presents the findings of the two studies, starting with the needs analysis study followed by the experimental comparison of three bathroom designs.

5.1 Study 1 – a needs analysis

Paper 1's aim was to identify challenges, needs and gaps for bathroom activities in a private home for both care workers and older-adult clients. Further, the paper aimed to inform sustainable solutions for bathroom activities in private homes. To present and explain the interview results, a figure was formed to depict a system for enabling *aging in place* (see figure 11). In the figure, home care services constitute the foundation to support community-based independence (stated as a priority of all participating clients); the four main categories *independence, a safe work environment, assistive devices and responsive care* are presented as interplaying to enable ageing in place.

5.1.1 Maintaining independence

Based on the combined perspectives of clients and professionals, it was clear that facilitating independence is seen as key when it comes to enabling ageing in place. Both professional and client interviewees described bathroom layout and design features that can reduce a client's abilities and make them dependent on help from others, e.g. family members or care workers. To support independent living, it is important to adapt the bathroom to individual needs. Yet, according to the professionals, clients commonly underestimate their own need for care, which can in turn produce a poor fit between assistive devices, needs and conditions. According to the professionals, encouraging

self-management to promote independence is sometimes difficult due to time pressure. This in turn can affect the care given. As told by a care worker participant, to maintain clients' abilities, it is important to provide a consistent level of help and care, and in accordance with her needs, to promote independence. This could mean a care worker not providing more assistance than the client minimally needs, for example, encouraging (but not lifting) a client when the client can use a grab bar to pull herself up.

5.1.2 A safe work environment

When a client receives formal care and service in their home, the home becomes a work environment. Interviews with both clients and professionals reveal a tension between the bathroom being a private space and being a work environment. Participating care organization representatives described work-related challenges with the private bathroom. Design features such as size, layout, doorways and thresholds become obstacles to performing bathroom tasks safely. Both clients and professionals described that space in particular causes problems in several ways, especially with moving and lifting clients and difficulties fitting two nursing assistants and the client along with assistive devices. The tension lies in the workers and managers having little to no control over the layout and equipping of this workspace, since the final decision rests with the client.

5.1.3 Assistive devices

Assistive devices play an important role in this system, both for clients by enabling them to help themselves, but also for care workers assisting the client. Professional interviews described that continually assessing client care needs is important to ensure having the right assistive devices and receiving the service and care they need. The participating care staff all described a need for assistive devices that function well in small bathrooms. One care organization representative commented on the importance of connecting the needs of both the care workers and the clients when designing and developing new assistive devices. There were also comments from the same group that access to assistive devices (to most part free of charge for the client) differs depending on where you live. For example, a simple yet very effective assistive product – a shower stool – is not provided in some parts of Sweden.

5.1.4 Responsive care

According to both the organizational representatives and the care staff, assessing care needs is important since client needs change over time.

Assessing care needs is important to make sure the client's care plan is updated with, for example, the right assistive devices. An outdated care plan constitutes a risk for both clients and care workers. However, care workers who help clients with their PADL on a daily basis express that it is not always easy to convince a client to change, add or update assistive devices. One organizational representative described how one needs knowledge of what is on the market, and that knowledge may not always exist among the care workers.

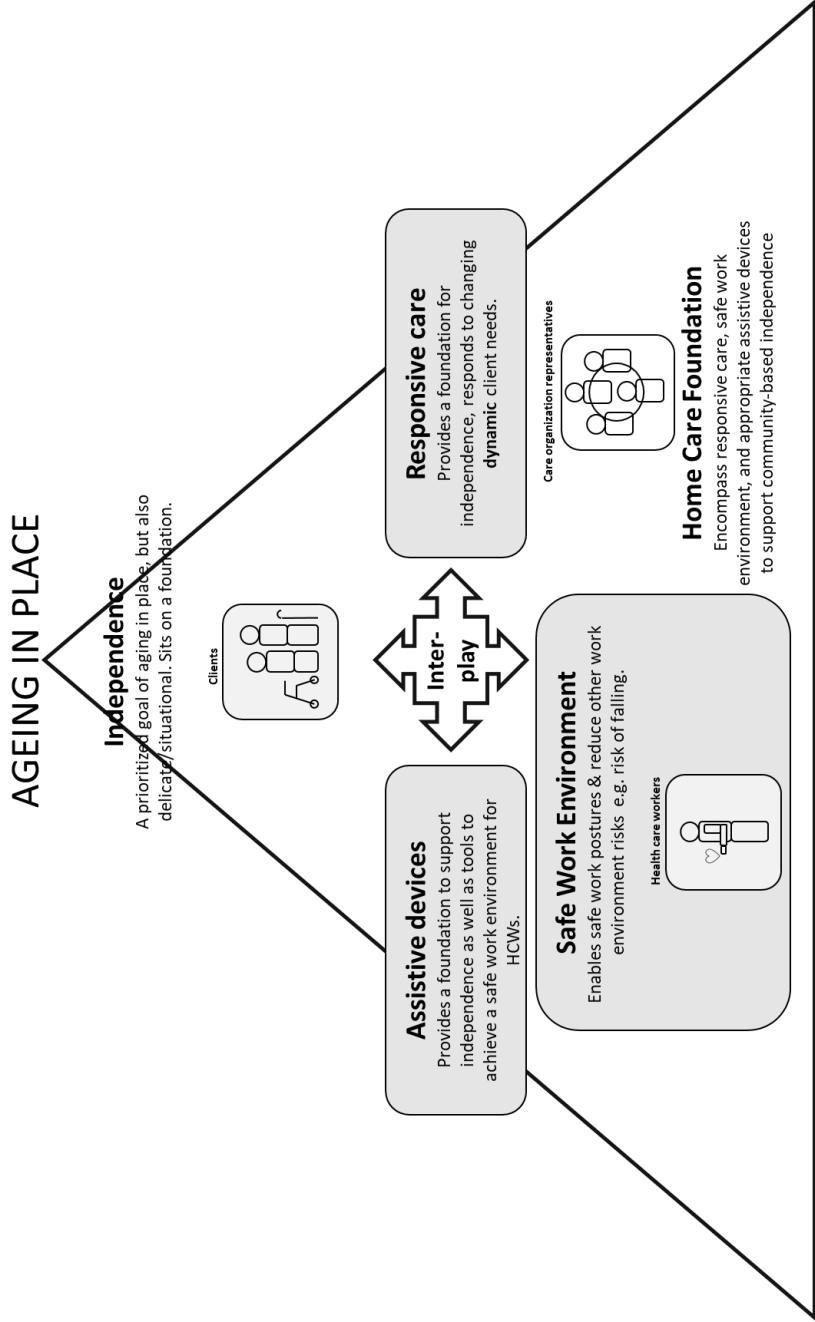


Figure 11: The four main categories formed as a system and how they interplay to enable ageing in place.

5.2 Study 2 – a comparison of three bathrooms

Paper 2's aim was to compare three bathroom designs in terms of care workers': 1) trunk and arm posture and movement; 2) frequency and duration of contacts with assistive devices; and 3) experience of usability and suitability when assisting a client. The findings are presented in the following order: the quantitative results from the postural measurements, contact data from video recordings and the qualitative interview results.

5.2.1 Postural measurements

There were no significant differences in the trunk posture among the three bathroom designs. However, there were significant differences detected in the upper arm angular velocity. Both left and right 50th percentile as well as the left arm 90th percentile angular velocity was higher in the nursing home bathroom than in the equipped bathroom. There were some non-significant trends pointing towards higher postural and movement exposures for the nursing home bathroom, see table 4. For example, the median upper arm angular velocity and inclination angle both trended higher in the nursing home bathroom.

5.2.2 Contacts with assistive devices

The contacts with assistive devices were divided into two categories: supportive and hindering. Across all bathrooms and users, there was a far greater number of supportive contacts than hindering contacts during the trials. The contacts were made mostly by the standardized patient, and they were more frequent and longer in the equipped bathroom than in the nursing home bathroom. Unsurprisingly, the unequipped bathroom recorded minimal contacts. Analysis shows that both frequency and duration of standardized patient contacts were significantly lower in the unequipped bathroom than in the nursing home bathroom. The nursing home was in turn significantly lower than the equipped bathroom. Both frequency and duration of contacts were higher for the standardized patient when using a walker than when using a wheelchair. The most frequently used supportive assistive product was the sink grab bar, whilst the shower rail had the longest supportive duration. Hindering contacts were only recorded in the nursing home bathroom.

Table 4: Median and IQR posture angles and movement angular velocities for the trunk, right arm and left arm during care tasks in the three bathroom designs, n = 18.

		Unequipped	Equipped	Nursing Home
		Median (IQR)	Median (IQR)	Median (IQR)
	Task time (min:s)	6:39 (1:14)	8:03 (1:20)	7:36 (1:07)
Body Part	Postures & Velocities			
Trunk	50 th percentile inclination (°)	15.5 (8.8-21)	14 (7.8-19.3)	18.5 (8.8-23.3)
	90 th percentile inclination (°)	50.5 (36-62.5)	42.5 (34.8-58.1)	48.5 (40-64.8)
Right Arm	50 th percentile inclination (°)	22 (19.8-25.5)	24 (19.8-26.5)	24.5 (20.8-27.3)
	90 th percentile inclination (°)	48.5 (43.8-57.3)	51.5 (44-62.3)	53.5 (46-59.3)
	50 th percentile, velocity (°/s)	30 (27-37.3)	29.5 (25.5-40) ^c	32.5 (26.8-42.5) ^c
	90 th percentile, velocity (°/s)	96.5 (85.3-116.5)	98 (83.3-106.3)	100 (85.3-114.3)
Left Arm	50 th percentile inclination (°)	21 (19.3-23.5)	22(19.1-24.5)	22 (19.8-24.3)
	90 th percentile inclination (°)	51 (45.8-55)	51.5 (44.8-58.3)	51.5 (44.5-58.3)
	50 th percentile, velocity (°/s)	28.5 (24.8-34.5)	28.5 (22.8-33.8) ^c	31 (23.8-35) ^c
	90 th percentile, velocity (°/s)	90.5 (77.8-103.3)	91.5 (76.5-100.8) ^c	95.5 (82-109.3) ^c

^a Significant difference between unequipped and equipped (p<0.05 with Bonferroni adjustment)

^b Significant difference between unequipped and nursing home (p<0.05 with Bonferroni adjustment)

^c Significant difference between equipped and nursing home (p<0.05 with Bonferroni adjustment)

5.2.3 Care worker interviews

Qualitative content analysis of the interview data produced three main categories: space, equipment and responsibility. The categories are all connected to the goal of safe task completion, which is safely assisting a client in the bathroom. Findings indicate these categories can represent either stressors or supports for the care worker. In this case a stressor is defined as a factor negatively influencing the workflow or work task; a support conversely facilitates work performance. Figure 12 illustrates the categories from care workers' experiences in three different bathroom designs.

Safe Task Completion

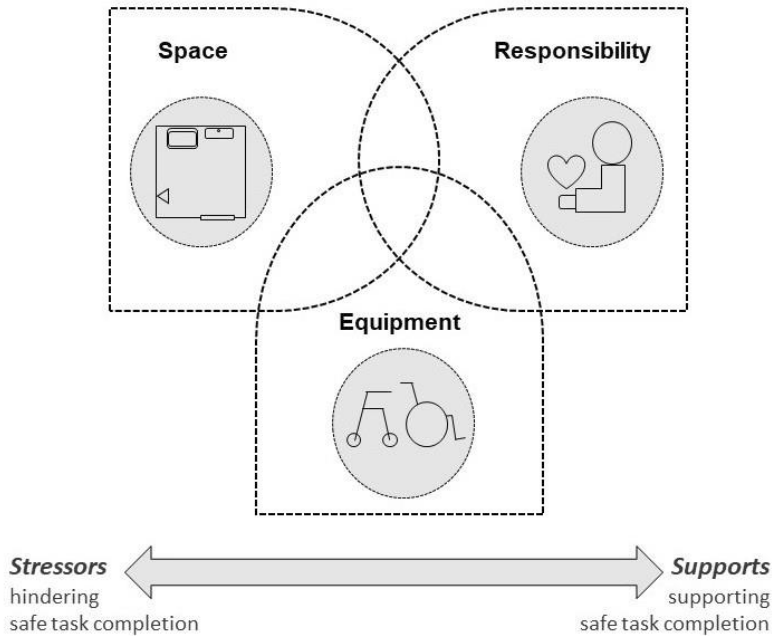


Figure 12: Figure illustrating three interconnected categories from care workers' experiences in three different bathroom designs. Depending on the context, these categories can represent either supports or stressors to the overall goal of safe task completion.

5.2.3.1 Space

All participants expressed there was enough space in the nursing home bathroom to move around and assist the standardized patient, both for a walker and wheelchair. However, they consistently described both the small bathrooms as stressful and difficult to work in during the trials. Especially during the wheelchair trials, care workers described great difficulties in fitting the standardized patient, their wheelchair and two care workers. Difficulties were described not only with the inside space, but also with entering the bathroom due to the narrow (i.e. standard apartment size) doorway. These difficulties were experienced as stressful, and many participants expressed a fear of hurting the patient (indicating a link to responsibility) and themselves.

5.2.3.2 *Equipment*

All participants agreed that having assistive equipment in the bathroom is important. However, equipment must be placed where it is needed. For example, a grab bar that is mounted too high on the wall will never be used if the patient is unable to reach it. All care worker participants expressed that the equipment around the toilet was especially useful and essential when it comes to assisting with hygiene. Still, while all participants agreed equipment is important, some care workers expressed it can in some cases become an obstacle to movement and care by making the accessible bathroom space smaller, demonstrating interplay with the category of 'space'.

5.2.3.3 *Responsibility*

The notion of responsibility for patient safety was raised by care workers throughout the interviews. They all expressed a great sense of responsibility for the clients' safety, as well as concern for their own safety. This provides both motivation and a sense of caution for safe completion of the care tasks, and the care workers considered their (often limited) options for performing bathroom care in a way that minimizes risk. The participating care workers described how assisting a client in a smaller bathroom (as opposed to a larger bathroom) often requires more transfers to complete a task. According to them, more transfers in a smaller space often represents higher risk of injury, both for client and workers; in the absence of adequate space and equipment, the sense of responsibility to keep the patient safe and cared-for becomes a source of stress.

6 Points of perspective

The aim of this thesis was to investigate, using a human-centered lens, how the home bathroom design affects work and bathroom activities for care workers and clients. Evaluating the impact of bathroom design requires broad and inclusive perspectives from multiple target groups and the use of multiple methods; this will be synthesized here.

In this chapter, the findings are discussed in terms of the two primary bathroom design features that were studied: assistive devices and space. Further, methodological considerations that may influence the interpretation of findings and criteria for research quality will be discussed.

6.1 Do assistive devices help?

Findings from both studies 1 and 2 suggest there are great challenges associated with a good fit between the physical environment, the assistive devices, the client, and their needs. In the context of home care, installing assistive devices designed to maintain physical capacity in an older-adult client plays an important role for home care workers to facilitate bathroom activities and enable the clients to help themselves (King et al., 2018). Thus, assistive devices can indeed contribute to greater and longer independence (Agree & Freedman, 2000; De-Rosende-Celeiro et al., 2019; Gates et al., 2008; Hjalmarson & Larsson, 2011; I. Petersson et al., 2008). However, the bathroom design itself can limit the possibility of fitting the assistive devices, such as a walker or a wheelchair, due to lack of space. Another hindrance, addressed by participants in study 1, is that many bathrooms are poorly equipped, for example lacking grab bars and toilet raisers. This demonstrates a

problem that could be addressed by regular assessment of care needs. However, the duration of contact with assistive devices used in study 2 suggests that assistive devices could provide greater benefit when provided at an early stage, as they were used almost exclusively by the client using a walker. Visits from an assistive devices prescriber (i.e. an occupational therapist) at an early stage would therefore seem to be of great value.

A Swedish government report on the future of older adult care states that assistive devices and assistive technology will lead to significant gains in the welfare system, thus contributing to a better work environment for HCWs (Socialstyrelsen, 2020). However, the assistive devices used in the trials of study 2 did not demonstrate significant improvements in work postures for the care workers. In fact, there were comments from the participants that the assistive devices were in the way, for example when entering the equipped bathroom during wheelchair trials. This implies that the assistive devices do not replace adequate space. Neither does time stress seem to be solved with assistive devices, since the results from study 2 show it takes longer for semi-mobile walker users to make use of them, when bathroom tasks are conducted in a way that is optimal to maintain autonomy. For example, duration might well be different if the care worker were to rush through the tasks and apply more force to transfer the client rather than encourage the client to take their time and do as much as they can themselves.

Throughout the trials in study 2, care worker participants reported experiencing considerable stress in the smaller bathrooms. The trial interview results also imply that the assistive devices reduced fear and stress around acute safety (i.e. slip and fall risk). This was especially notable when participants commented on work tasks in the unequipped bathroom that lacked support points. Psychosocial stressors, such as fear of injury and time stress, have been previously acknowledged in home care research (Jepsen et al., 2025; Kaihlanen et al., 2023; Ruotsalainen et al., 2020). Although suggested in scientific literature as contributors to MSDs (Hauke et al., 2011), these kinds of stressors in the psychosocial work environment need further investigation (Jepsen et al., 2025). Jepsen et al. (2025) have suggested that quantitative methods would help contribute to understanding, for example HR could be used in future home care studies. While assistive devices can play a vital role in fostering client autonomy and the ability to age in place, according to the findings from studies 1 and 2 compiled in this thesis, they cannot on

their own solve all the work environment problems facing home care workers in the bathroom.

6.2 The impact of space on home care in the bathroom

There are distinct differences between a private home bathroom and a nursing home bathroom. The latter is designed to accommodate care workers assisting a client along with their assistive devices. Yet the same care tasks are expected to be performed in the home bathroom. Findings from both articles 1 and 2 suggest that too little space is a great stressor for care workers, and more space is generally a support. Although previous research also seems to indicate that too little space is an issue (Grønset Grasmø et al., 2021; Jepsen et al., 2025; King et al., 2018), it is reasonable to wonder whether too much space could have a deleterious effect. This cannot be directly addressed by the results of studies 1 or 2 and has not been scientifically investigated to the author's knowledge. Still, this phenomenon has been suggested in a non-peer-reviewed report (Daram, 2014) about the complexity of the bathroom where large bathrooms are described as potentially introducing a higher risk of fall for the client due to longer distances between support points. In contrast, the posture results of study 2 suggest a large bathroom may enable greater freedom of movement in work posture for the care worker assisting a client.

Regarding what minimum amount of space is actually needed for safe performance in home care, no studies have been conducted to the author's knowledge. The most relevant studies are based on hospital-based performance of patient handling using ceiling lifts (Hignett & Keen, 2005) and assistance in the bathroom (Hignett & Evans, 2006), where tasks were simulated using patient actors in experiments. These studies have provided many valuable insights, but the applicability is limited in a home care environment where hoists are rare, and 2-person transfers are the norm for a wheelchair user. This was commented on by a care worker participant in study 1, explaining that sometimes a manual hoist is used outside of the bathroom due to lack of space, making a transfer to a shower chair. These previous hospital-based space studies (Hignett & Evans, 2006; Hignett & Keen, 2005) also examined only one dimension: how wide the space must be for the work task to be possible. Helping a client from a wheelchair to the toilet or showering and dressing involves several different three-dimensional movements and repositioning that may not be captured by measurement in a single dimension, as exemplified in figure 13.



Figure 13: Illustration of a care worker repositioning during, for example, a client transfer, watercolor and pencil by AnnaKlara Stenberg Gleisner.

6.3 Interpreting the findings through the lens of HTO

Together, the care worker and the client (human), the bathroom design and the assistive devices (technology), and the care organization (organization) form an HTO system. Analyzing our findings through this system perspective enables us to see how these sub-systems interact and to detect the different problems of performance and task efficiency in the system (Karlton et al., 2017).

There are a number of challenges for a care worker working in a home bathroom, and space is the most commonly raised concern throughout the interviews in both study 1 and 2. Space can enable safe task completion, to have enough space to freely move around for care workers and clients along with assistive devices. On the other hand, insufficient space can limit the

possibilities to perform work tasks at all and to have sustainable work postures in the bathroom, a scenario that is common in home care and was described by all care workers and care organization participants in study 1.

A home care worker needs to adapt to different conditions (i.e. bathrooms and assistive devices) and care needs in order to help the clients, often with time constraints (Ekstedt et al., 2022). This can result in the care worker using methods for “work as done”, defaulting to what methods are possible and quickest, instead of using their “work as imagined”, e.g. guidelines and correct lifting- and moving techniques. This conflict between “work as done” and “work as imagined” is troublesome. Notable is the fact that training for moving- and lifting techniques for home care workers is held in large nursing home bathrooms and not where they usually perform work tasks (i.e. in a client’s home bathroom). A “work as done” mentality may lead to stress. As described in the results of study 2, in the smaller bathrooms, stress and fear of falling was experienced by the care workers. Such stress can, in the long term, contribute to developing MSD: s (Hauke et al., 2011) and in the short-term effect safety and the quality of care given (Strandell, 2020).

Findings from study 1 and 2 indicate assistive devices are helpful if there is a clear need for them. If the client can help themselves to a greater extent, and have the assistive devices needed to achieve that, then physical load and time stress can be taken off the care worker. The findings of this thesis underline the importance of having regular assessments of care needs. This is often left to the home care worker herself to pay attention to whether her client’s needs have changed and then take appropriate action. That requires a great deal of knowledge, not only to be updated on available assistive devices but also to be the one that visits the older adult often enough to spot a change in needs. This is complicated in home care, where the turnover of staff is high, and it is more likely to receive help from several different care workers than the same one.

The findings from study 2 show that the assistive devices were used almost exclusively by the SP using a walker. This suggests the use of more complex devices such as wheelchairs seeming to decrease the need (or possibility) for using assistive devices in the bathroom and instead rely on manual help from a care worker. The future scenario for older adult care, not only in Sweden but in all Europe, is ageing in place. Many older adults will live at home for as long as possible and with a greater need of care as age progresses. This trend will increase the acuity in home care, and care workers will be exposed to small bathrooms together with clients that have a greater need for more advanced

care. The question is, should care be given in a bathroom that has not got the space for it, when this puts both the workers' and clients' health and safety at risk?

In Sweden, the home care manager is responsible for the care workers' work environment. However, according to the Swedish Social services act, any changes that may be needed in a client's home can only be decided by the client, and other agencies cannot force changes to the private home ("Social services act 2025:400 "). This conflict between the self-determination of the client and work environment rules and legislation is a fundamental challenge in home care. Although some changes can be made in the physical work environment in a client's home (i.e. widening doors, installing equipment) conjuring more floor space and square meters in a bathroom is close to impossible.

6.4 Methodological considerations – strengths and limitations of the study designs

In this thesis, the aim was to investigate, using a human-centered lens, how the home bathroom design affects work and bathroom activities for home care workers and clients. This has been accomplished using multiple methods, both qualitative and quantitative. In this section, I will discuss methodological considerations of the two studies as well as strengths and limitations of study design.

6.4.1 Qualitative methods

In this section, the qualitative methods are considered in terms of criteria such as *credibility, dependability, confirmability and transferability*, and *authenticity* (Graneheim et al., 2017). In study 1, twenty-one interviews were held with a broad spectrum of people, both professionals and clients. They were from different parts of Sweden, both from larger cities and from rural areas and had experience and knowledge of the bathroom as well as the bathroom being a work environment. This brings high credibility to the study.

Originally, the interviews were planned to be conducted in-person, but due to the Covid-19 pandemic, they were held via telephone. This may have affected the information received. According to Johnson et. al (2021) an in-person interview produce richer descriptions and information, and by that higher quality. Further, taking photographs of the clients' bathrooms would have been

possible as a home visit allows observation and discussion about their bathroom during interviews.

At the time of interviewing, the participating clients did not receive help from home care workers in their bathroom. Currently receiving home care was not an inclusion criterion for participating, as part of our research questions was about what the clients thought of their bathroom *becoming* a work environment in the future and how they perceived the physical environment in their bathroom. Interviewing clients that actively had help from home care in their bathroom could have brought additional perspective on our research questions. Similarly, since the study is based only on data from Sweden, it does not include other countries. The study addresses the specific problems that may exist in Swedish bathroom settings and not necessarily in other countries. The findings from study 1 are in line with previous research which indicates a generalizability of the findings.

Study 2 had a limitation in transferability, e.g. the suitability (Graneheim et al., 2017) of study participants; they were not home care workers but rather currently employed care workers at the nursing home complex where the experiments were performed. A home care worker may have other strategies and solutions for work tasks in small spaces. Further, they may have given different answers on the experience of conducting tests in the 3 bathrooms.

The analysis of the qualitative data in both studies 1 and 2 was analyzed using qualitative content analysis (Elo & Kyngäs, 2008). Categories and themes, as well as the analysis, were reviewed by both AKSG and CT, which contributes to higher dependability of the results. Further, quotes from participants were used to strengthen the analysis which contributes to high credibility and authenticity of the findings. Different analysis methods were discussed but considering the nature of the interview protocol with open ended questions and a focus on the interviewee's experiences of the subject being studied, the inductive qualitative content analysis suited the thesis aim and purpose best.

6.4.2 Critiquing the quantitative methods in study 2

For ethical reasons, we used a standardized patient instead of a real patient. We trained a member of the care staff to simulate two different personae based on based on the CareThermometer scale (Knibbe, 2002). This enabled us to have consistent experimental conditions for comparing results across bathrooms and eliminate bias of fatigue effects, as well as the ethical concerns and health risks of involving a frail older adult. However, using a standardized

patient limits the fidelity of the study. It is likely that the SP responded differently than a real client would. A real-life scenario is by nature not as controlled as the experimental protocol and would present a greater range of challenges and conditions. There is also a possibility of a Hawthorne effect (Schwartz et al., 2013), since both the participating care workers and the standardized patient may have modified their behavior due to their awareness of being watched and recorded. A potential result of that could be, for example, an increase in productivity and speed.

The fact that nursing home care workers were the participants may have influenced how familiar they were with the nursing home bathroom environment relative to the apartment designs. Further, it may have influenced how they performed in the smaller bathroom, given the fact that they were used to working in large nursing home bathrooms. These factors lower the external validity, e.g. the appropriateness of generalizing the findings. However, the internal validity is high given the controlled conditions for the data collection with a protocol for attaching the IMU sensors, sampling zero angle before every trial, as well as the consistent protocol for performing care tasks.

6.5 Applications of the findings

There are several ways the findings could be applied to the home. It is important to provide assistive devices as early as possible. This enables to maintain the older adult's abilities and degree of independence. Equally important is regular assessments of care needs to spot any changes in abilities and needs. Potential solutions could be to for example, link assistive devices, as guidance, to the five care recipient personas in the Care Thermometer scale (Knibbe, 2002). The use of the clinical algorithm *Algo* (previously mentioned in 2:3:2), could provide insights and help care workers that make recommendations of assistive devices to clients.

The findings further suggest that installing assistive devices can be a challenge by impeding space, especially in the smallest bathrooms for a wheelchair user. Therefore, it could be worth considering removing self-help assistive devices in the bathroom after the client starts using a wheelchair, given that there are space constraints. Once at a stage where the client and care worker can't make use of them, it might be better to choose more space to maneuver instead.

6.6 Sustainability goals alignment

The work presented in this thesis contributes to understanding the bathroom as a work environment and how to make it sustainable for both care workers and their ageing clients. This is in line with six of the United Nations Sustainability Development Goals (SDGs) (UN75, 2015).

Good health and well-being for all ages (SDG 3), especially subgoal 3.8 about better health and well-being for all through access to quality and essential health care services. Taking together, the findings of this thesis and related work on this topic seem clear that assistive devices that can be used by both clients and workers could improve quality of care in home care services.

Gender equality (SDG 5), especially subgoal 5.4, to recognize and value unpaid care and domestic work. Unpaid care work (informal carers) as well as paid care work are most often performed by women (Paul et al., 2022). For example, in Sweden, 82% of the care worker workforce are women (SCB, 2024). This workforce also has a large proportion of foreign-born labor. By providing public services and social protection policies that support care work, care work can be valued for its important social contributions. In addition, enabling access to home care services reduces the burden of informal carers. Subgoal 5.4 relates to understanding the complex care work that takes place in the home bathroom. By improving the work environment in the home bathroom, we will improve working conditions for the (mostly women) workers in the home care sector.

Decent Work and Sustainable Economic Growth (SDG 8), especially subgoal 8.8 about safe and secure work environments for all. This relates to findings of the importance of providing the older adult with assistive devices and regular assessment of care needs to enable a sustainable work environment for home care workers. There are challenges related to the home bathroom being a workplace, most home bathrooms are not built and designed to accommodate a client and her assistive devices and one or two care workers.

Inclusive and Sustainable Industrialization (SDG 9), especially subgoal 9.5 about the importance of scientific research and fostering innovation. In this thesis, this relates to the importance of researching and developing assistive devices and ergonomic aids to improve the work environment for home care workers and fostering the autonomy of clients. Product development should also focus on assistive devices, especially adapted for small home bathrooms.

In addition, take a human-centered approach in the design process and be mindful about older age and disabilities.

Inclusive, Safe and Sustainable cities (SDG 11) are relevant, especially subgoal 11.1 about access for all to adequate and safe housing. This thesis adds to the knowledge about creating a safe and accessible home bathroom environment for all, with inclusive designs for older people and those with disabilities. Housing should be accessible to home-based care, and the home environment should support a client to age in place.

Sustainable consumption and production patterns (SDG 12) are addressed in this thesis, especially subgoal 12.2 for efficient use of resources. Studies can identify efficient bathroom layouts that reduce the floor space needed by providing other equipment; therefore, the total building costs and heating/maintenance cost can be reduced. Although the two studies presented in this thesis did not directly produce data about the ideal floor size of a bathroom, even the incremental insights in this area contribute to the overall mission of efficiency.

7 Conclusions

This thesis contributes to the understanding of how home bathroom design affects work and bathroom activities for home care workers and clients. As part of the effort to facilitate more user-centered and sustainable solutions for home bathroom activities in the future, study 1 has identified challenges, needs and gaps faced by home care workers and clients. Specifically, workers, administrators, and clients all report that their biggest challenges in home-based care are space, lack of assistive devices and need for regular assessments to address care needs.

According to the findings of study 2, when comparing the three bathroom designs, care workers' postural and movement exposures were not improved by space and assistive devices as anticipated. In the endeavor of making a "small" home bathroom more usable and suitable for work and bathroom activities, equipping it with assistive devices did not replace the care workers' need for space when assisting a client. During trials, the contacts with assistive devices were mostly made by the SP using a walker and not by the care workers. Reported in both study 1 and 2, care workers experienced considerable stress in small bathrooms, regardless of the presence of assistive devices.

In the case of care workers assisting clients with mobility aids, it is clear that the design and evaluation of bathrooms cannot be reduced to a single variable or a single perspective. Applying HTO system thinking, namely considering the interplay of the **human**, the **technology** and the **organization**, provides valuable insight on opportunities for improvement in the bathroom work environment and the client assistance work activities. Here there is also an

element of inclusion, considering a human centered design approach, including the needs of the many when designing workplaces and work systems. This complexity expands into the social dimension when one recognizes the bathrooms in private homes as work environments.

From these conclusions, it is suggested to further explore and measure care workers' physiological and psychosocial stress when assisting clients with care tasks in the bathroom, for example via self-report, heartrate, and muscle load via EMG. In order to meet the challenges of caring for an increasing number older adults, there is a need to further investigate the usability and safety of small home bathrooms, both for clients and care workers. To be effective in meeting this challenge, future research will need to embrace the complexity of the home bathroom-home care system and consider the range of stakeholders and users in a human-centered approach.

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Appendix I – Interview guides

These are the two interview guides for study 1, one for professionals and one for clients.

Professionals:

What is your perception of the work environment in a bathroom?

What challenges exist in those work environments?

What is needed in order to create a functional work environment, especially in residential bathrooms?

What is your perception about the need of care for the older adults, especially the need of care and help in the bathroom?

What are your thoughts about the future need of care? Ageing in place or in a nursing home?

What is required to meet the future needs regarding the increasing Older adult population?

What is your perception of the current need of assistive devices?

Do you believe users/clients have access to the assistive devices they need in the bathroom? Is there a future prognosis on the need of assistive devices? Do you have the ability to provide input on the possibility to prescribe new innovative assistive devices?

What do you believe is needed to make the users/clients more independent in the bathroom? At home? In a nursing home?

Do you perceive that research and development in the field of Older adult care are used and implemented in the municipalities?

Are companies investing in new and innovative assistive devices?

Clients:

Do you think your bathroom is well planned based on your needs?

Why or why not? Tell me about that.

Do you experience any challenges in your bathroom?

If so, what do you think could be a solution?

Do you consider the fact that your bathroom may be a work environment as well? Why or why not? Tell me about that.

What is your opinion on your need for help and assistance in the bathroom?

Do you think about your future in terms of your need of care and help at home, especially in the bathroom? Why or why not? Tell me about that.

Do you have access to the assistive devices you need in your bathroom?

Is there something that could make you more independent in the bathroom? In your current situation or in the future?