PROJECT RE-ENVISION

UNIVERSITY OF FLORIDA

Three R3s:

Three Rapid Research Reviews (R3) of Research Literature

pertaining to

Immersive Simulation Technologies,

Effectiveness Assessment Tools, and

Residential Adaptations/Repurposing Studies

for People with Disabilities and Functional Limitations

Prepared for:

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CONTENTS

CHAPTER 1: INTRODUCTION

In Spring 2017, the U.S. Department of Housing and Urban Development (HUD) issued Funding Opportunity FR-6000-N-29 (Research and Evaluation, Demonstration, and Data Analysis and Utilization). In part, the Opportunity solicited proposals intended to "demonstrate low-cost, low-effort configurations and technological adaptations that can be made to multiple types of existing homes to make them accessible to persons with disabilities" (p. 2). In response, the University of Florida's (UF) submission proposed an approach to enhancing accessibility by means of spatial and fixture repurposing: that is, replacing or adapting problematic fixtures (i.e. built-in's) or spaces with others that were not originally intended for that purpose (e.g. turning a living room into a bedroom suite). Accordingly, the UF team's project has two primary objectives:

- to research, demonstrate and test — with multiple assessment tools and use of virtual reality (VR) — a series of repurposed interior spaces and fixtures of prototypical small-scale attached housing for accessibility, affordability and aesthetics, and for different occupancy types based on disability and household membership
- to lay the foundation for future dissemination of the study's solutions and findings to different user groups.

One of the required activities stipulated by the Opportunity was producing a literature review of issues relevant to the proposed research and related issues. In assessing the breadth and focus of such a review, the UF team recognized that numerous guidelines, reports, manuals and handbooks for designing housing that enables occupant accessibility[1] have been published and produced since the passage of accessibility legislation adopted in the Architectural Barriers Act, Section 504 of the Rehabilitation Act, Title II of the Americans with Disabilities Act and the Fair Housing Act. Some of the most comprehensive of these guidebooks and manuals for residential structures include:

A Basic Guide to Fair Housing Accessibility: Everything Architects and Builders Need to Know About the Fair Housing Act Accessibility Guidelines (Steven Winter Associates, 2001);
Accessible Housing by Design (Steven Winter Associates, 1997);
Accessible Housing: Quality, Disability and Design (Imrie, 2005);

[1] Other terms used for accessible housing include inclusive housing, barrier-free housing, universal design

Aging in Place Design Guidelines for Independent Living in Multifamily Buildings (Oz Architecture Urban Design Interior Design and Enterprise Green Communities, 2016);
Beautiful Universal Design (Leibrock & Terry, 1999);
Building for a Lifetime: The Design and Construction of Fully Accessible Homes (Wylde, Clark & Baron-Robbins, 1994);
Fair Housing Act Design Manual (Barrier Free Environments and HUD, 1996);
Inclusive Housing: A Pattern Book (Steinfeld, White, & Levine, 2010);
Just Below the Line: Disability, Housing and Equity in the South (Smith, Webb, & Williams, 2010);
Residential Remodeling and Universal Design: Making Homes More Comfortable and Affordable (NAHB Research Center and Barrier Free Environments, 1996);
The Accessible Housing Design File (Barrier Free Environments, 1991);
Universal Design as a Rehabilitation Strategy (Sanford, 2012);
Universal Design: Creating Inclusive Environments (Steinfeld & Maisel, 2012);
Universal Design Handbook (Preiser & Smith, 2010).

There are also architectural and interior design monographs that profile various homes designed to be accessible, including *The Accessible Home* (Pierce, 2012), and *Universal Design for the Home: Great Looking, Great Living Design for All Ages, Abilities and Circumstances* (Jordan, 2008). Also the Office of the Secretary of the Department of Housing and Urban Development has joined with the American Institute of Architect's (AIA) Housing Knowledge Community to establish the annual AIA/HUD Secretary Award. Since 2000, one category in this award program is "Housing Accessibility – Alan J. Rothman Award," given to exemplary residential structures that are affordable, accessible, and well-designed housing. Profiles of the awarded homes and housing are available at https://www.huduser.gov/portal/about/housingCommDesign_2000_1.html.

While these and other handbooks, publications, and exemplary residential developments are valuable in their own right, assessments and critiques of the knowledge base as a whole have noted:

- ***a prominent emphasis on design of new construction compared to renovations of existing homes and housing.*** As noted in the Opportunity, approximately 85% of monthly home sales are for existing housing, making accessible renovation imperative to meet current and impending market demand, particularly as baby boomers age in place and individuals with disabilities strive to live in communities instead of institutions. A 2015 study funded by HUD indicated that approximately one-third of American dwelling units are potentially modifiable for a person with a mobility disability. But more startling is that less than 5% of our current housing stock is accessible for individuals with moderate mobility difficulties, and less than 1% is accessible for wheelchair users (Bo-sher, Chan, Ellen, Karfunkel & Liao, 2015). Focusing on homes of the current 65+ population, the US Census

similarly reports significant deficit of existing accessible homes for our aging population (see Figure 1).

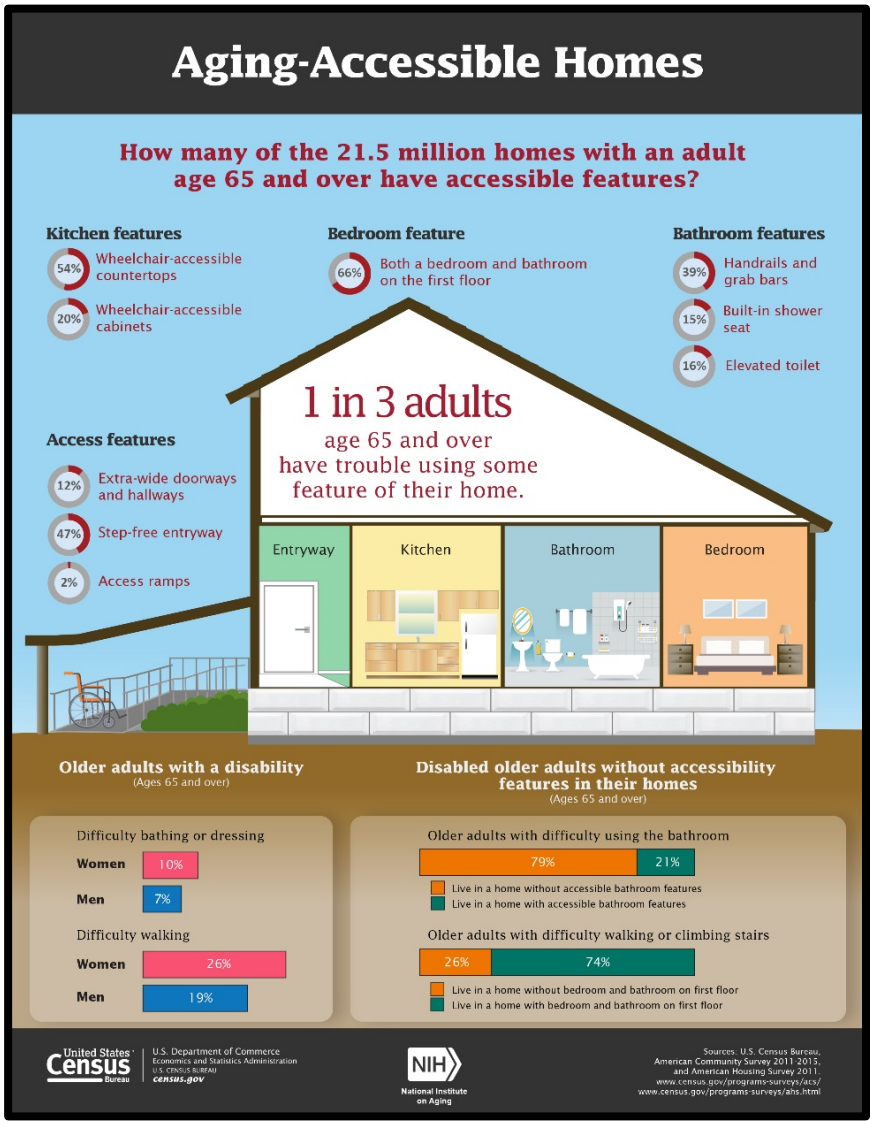

Figure 1. U.S. Census Bureau's assessment of aging-accessible homes, from ACS 2011-2015 and AHS 2011

(Source: https://www.census.gov/library/visualizations/2017/comm/again-accessible-homes.html)

- an ***emphasis on detached, single family homes compared to attached and multi-unit housing.*** The Opportunity's intended focus is on "the design and retrofitting or renovation of non-detached single family homes, semi-detached townhomes, and structures with four (4) or fewer residential units." In comparison to the detached residence, renovating this

designated housing stock for improved accessibility is specifically challenged by: common walls and sometimes ceilings/floors shared between neighboring units; windows typically on only two (and opposing) solar orientations, reducing opportunity to daylight all rooms and spaces fully; and often small and compact floor plans, particularly in the affordable housing stock. According to the 2017 American Housing Survey (AHS), the median square footage of a single family detached home is 1800; of single-family attached, 1332; and of 2-4 unit structures, 900 square feet per unit. Taking into account household occupancy, this translates to 800 square feet (sf) per person of the single family detached home; 675 sf per person of the single family attached; and 500 sf per person in homes within the 2-4 unit structure.

- research attention primarily focused on performance in terms of occupant accessibility, with ***few concomitant assessments of accessibility in relationship to cost*** (e.g. initial construction/renovation cost; longer-term occupant and care provider cost; home value assessment; etc.) ***and aesthetics***

- ***prevailing attention on requirements of wheelchair users compared to users of other assistive devices or individuals with non-mobility impairments.*** Yet noticeably, demographic data reveals that the number of individuals using other assistive devices is larger than those using a wheelchair. Of a total of 6.8 million community-living Americans (i.e. not living in institutions) who use assistive devices, 1.7 million use wheelchairs or scooters, and 6.1 million use other mobility devices such as canes, crutches or walkers (Kaye, Kang & LaPlant, 2000). Figure 2 displays the US Census's most recent estimates of persons with specific disability impairments. The extent to which design and building features can enhance accessibility – including movement – of residents with visual and other sensory impairments is minimally covered in many accessibility manuals. While universal design is considered the aspirational design approach for addressing the needs and conditions of as inclusive range of individuals as possible, certain impairments may need specialized design features that cannot be easily meshed into a universal design strategy. For these, research on design needs and parameters for people with rather complex or challenging impairments is evident though small in number; for example, that for people with cerebral palsy (Hobson & Molenbroek, 1990). While attention to accessibility needs of persons with cognitive or neurological impairments is growing in both research and design practice, this information has rarely been incorporated in the many handbooks and manuals. Such publications include: *At Home with Autism: Designing Housing for the Spectrum* (Steele & Ahrentzen, 2016); *Design for Dementia: Planning Environments for the Elderly and the Confused* (Calkins, 1988); *Holding Onto Home: Designing Environments for People with Dementia* (Cohen & Weisman, 1991). Partly due to the association of dementia with older adults, public attention often characterizes cognitive impairment as the domain of aging. Nonetheless, statistics show that the number of adults between ages 18 and 64 with cognitive difficulty or any disability is actually higher than the number of adults ages 65+ with these conditions (Houser, Fox-Grage & Ujvari, 2018)

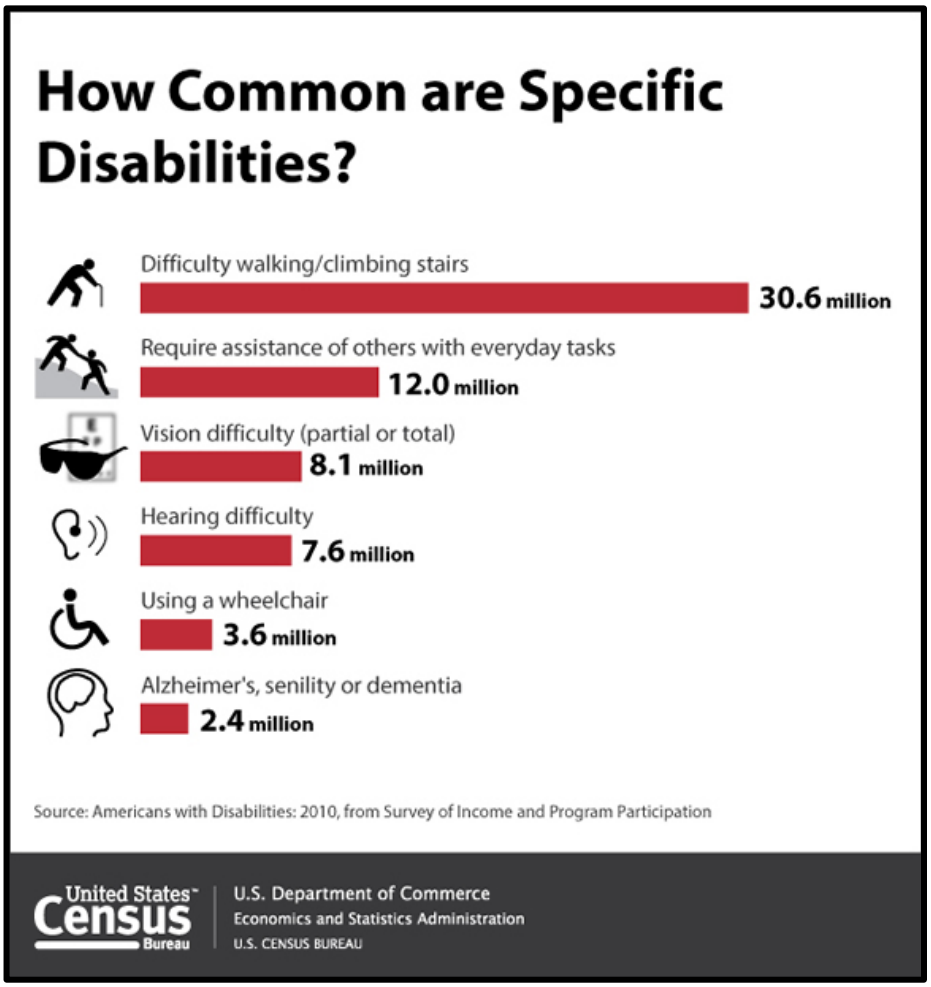

Figure 2. U.S. Census estimates of persons with specific disabilities

(Source: https://www.census.gov/newsroom/facts-for-features/2013/cb13-ff15.html)

- A further issue — voiced by Steinfeld and Danford (1999) nearly twenty years ago — is that most accessibility research has focused on fulfilling **existing standards,** which may be problematic for two reasons. First, standards generally focus solely on built environment characteristics, to the neglect of the interaction between the physical environment and occupant. Research deriving from occupational therapy models, on the other hand, emphasize person-environment-activity transactions (Helle, Brandt, Slaug & Iwarsson, 2011) and accordingly lend insight into the ways the physical environment can support or obstruct individuals' ability to perform everyday activities, such as move from bedroom to bathroom, turn on the stove, and the like. The second issue is the research foundation (or evidence base) for informing existing accessibility standards such as ICC/ANSI A117.1, the

Uniform Federal Accessibility Guidelines (UFAG) and the ADA Accessibility Guidelines (ADAAG). In many circumstances, medical and technological advances outpace anthropometric and user-based research, making some standards eventually obsolete or too narrowly defined, such as that with wheeled mobility devices in the 1990s (Steinfeld, D'Souza & White, 2014). Also, as noted previously, some standards can be skewed more towards one particular disabling condition (e.g. ambulatory/mobility impairment) than another (e.g. cognitive); or to a sub-segment of the population with an impairment needing design solutions or assistive technologies. For example, ADAAG establishes guidelines for grab bar placement in the bathroom, which is primarily based on research of removing barriers to independent transfer by wheelchair users who have the upper body strength to pull themselves onto a toilet or seat (Sanford, 2012). Yet a survey of toilet and tub transfers of over 700 older adults with mobility impairments challenged the assumptions embedded in those guidelines. Over half of the sample with mobility impairments who needed grab bar assistance did not use wheelchairs. And older users reported significantly greater difficulty using the standard grab bar configuration based on the ADAAG than three other configuration options (Sanford, 2012).

- Finally, the widespread acknowledgement of **universal design in the architectural/design community as the sole aspirational design approach has been challenged** by researchers of critical disability studies and other disability rights advocates (e.g. Boys, 2014; Hamraie, 2017). In describing the role of DeafSpace as an emergent architectural paradigm, Edwards and Harold (2014), for example, critique universal design for negating the particularities of the human form and condition, and question how the unique needs of particular groups can be met through universal design principles. These advocates' and designers' calls for a greater user-centered design process stand in stark contrast to existing building and construction paradigms in the production housing market, wherein end users (i.e. occupants) have little role to play except as renters or purchasers. Further, given that our buildings generally are serially occupied by a continuing wave of residents over time, this user-centered design paradigm needs to address not simply initial design strategies but adaptation and rehabilitation strategies as well.

In addition to the manuals and books mentioned above, in the last five years a number of systematic and scoping literature reviews pertaining to home modifications to enhance accessibility for people with various health and disabling conditions. Some of the most relevant ones include:

- *A Scoping Review of Home Modification Interventions – Mapping the Evidence Base* (Carnemolla & Bridge, 2018)
- *Accessible Home Environments for People with Functional Limitations: A Systematic Review* (Cho, MacLachlan, Clarke & Mannan, 2016)
- *Design of Residential Environments for People with Dementia and Sight Loss: A Structured Literature Review* (Bowes, Dawson, Greasley-Adams & McCabe, 2016)

- *Effect of Home Modification Interventions on the Participation of Community-Dwelling Adults with Health Conditions: A Systematic Review* (Stark, Keglovits, Arbesman & Lieberman, 2017)
- *Home Modifications for People with Alzheimer's Disease: A Scoping Review* (Struckmeyer & Pickens, 2016)
- *Systematic Review of the Effect of Home Modification and Fall Prevention Programs on Falls and the Performance of Community-Dwelling Older Adults* (Chase, Mann, Wasek & Arbesman, 2012)

Notably, with the fast development of sensors and smart home devices that can foster accessibility, research literature reviews of this issue are slowly appearing. Notable reviews in this regards is:

- *Exploring the Potential of Virtal Reality for the Elderly and People with Disabilities* (Kamieth, Dähne, Wichert, Villalar, Jimenez-Mixco, Arca & Arredondo, 2010)
- *Usability, Accessibility and Ambient-Assisted Living: A Systematic Literature Review* (Queirós, Silva, Alvarelhão, Rocha & Teixeira, 2015)

UF Team Focus

As a consequence of the abundance of guidebooks and comprehensive literature reviews – and in light of some of the concerns previously identified with the existing knowledge base – the UF team directed its efforts on searching and reviewing empirical research studies that specifically contributed to the aims of our project stated earlier, that is:

- to research, demonstrate and test —with multiple assessment tools and use of virtual reality (VR) —a series of repurposed interior spaces and fixtures of prototypical small-scale attached housing for accessibility, affordability and aesthetics, and for different occupancy types based on disability and household membership
- to lay the foundation for future dissemination of the study's solutions and findings to different user groups

Accordingly, the UF team crafted 3 separate literature reviews, each addressing research questions pertinent to these aims of the project:

1. What adapted, converted or repurposed spaces and fixtures have been made to existing (attached) homes to increase accessibility, and how effective have they been in terms of: access; use or usability; activities (functional activities, ADLs); comfort and

satisfaction; and aesthetics? What targeted occupant (i.e. disability) is examined in the research to date in examining adaptive, converted and repurposed spaces?[2]

2. What data collection scales, instruments and procedures have been used to assess home modifications, adaptations or interior designs for people with disabilities in terms of: access; use or usability; activities (functional activities, ADLs); comfort and satisfaction; and aesthetics? To which specific disabilities are these scales or instruments targeted?

3. What immersive technologies (augmented reality, virtual reality, haptic augmentation, 360o, CAVE or case automatic virtual environment, etc.) have been used in research with disabled persons to assess their perception or use of physical environment, particularly but not exclusively residential environment? What are the strengths, limitations, and exemplary methods of this research?

For these literature reviews, the UF team followed the approach of **Rapid Research Reviews**[3] instead of the more comprehensive Systematic Literature Review. (We refer to the former as "R3.") The increasing interest in evidence-based practice and evidence-based policy coincides with the development of systematic literature reviews. The Cochrane Collaboration claims that "a systematic review uses systematic and explicit methods to identify, select, critically appraise, and extract and analyze data from relevant research" (Higgins & Green, 2011). In their analysis of fourteen different types of research literature reviews, Grant and Booth (2009, 102) characterize the intent and process of systematic reviews as to "systematically search for, appraise and synthesis research evidence, often adhering to the guidelines on the conduct of a review provided by the Cochrane Collaboration or the NHS Centre for Reviews and Dissemination." Each step of the process is conducted independently by at least 2 reviewers. While notable and becoming a standard practice for literature reviews within the medical and health research fields, systematic reviews take an average of 1100+ hours to complete, and a budget of at least $100,000 (Tricco, Antony & Straus, 2015).

Given the resource-intensity that such systematic reviews require, the UF team selected to pursue the R3 approach. According to Grant and Booth (2009, 100), rapid reviews and rapid evidence assessments seek to be 'Quick but Not Dirty.' The protocol for conducting these is explicit and systematic, but unlike the systematic review, the R3 does not entail the breadth of topic or electronic database sources, nor are the screening and evaluation of each research study scrutinized and quantitatively evaluated by multiple, independent reviewers.

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[2] For this question, we also searched for images posted in social media and popular press profiles, that specifically demonstrated examples of "hacked" or repurposed fixtures and spaces made by individuals with disabilities or therapists/care providers. This latter image search is not included in this report.

[3] a.k.a. Rapid Reviews. Since our focus included empirical research only, we changed this to Rapid Research Review, or R3 for short

The UF team carefully structured the R3 process by: focusing the research questions; using the most relevant electronic databases but not a comprehensive use of all electronic databases in the search process; restricting the amount of grey literature searched and examined; and performing a relatively simple assessment of research integrity/quality of each study. To make the process transparent, a protocol was initially established and subsequently followed; and a matrix annotating key characteristics of each of the studies in the review was created. In contrast to the systematic review, R3s may be more susceptible to bias as a consequence of not examining all electronic databases; not having independent reviewers for assessing research quality; excluding articles not written in English; and other concerns. However, for the intent of this particular project, the Rapid Research Review was an appropriate foundation on which to build the remaining activities of the project.

The steps in the protocol (Table 1) that were established and followed for each review were as follows:

Table 1. Protocol Followed in Rapid Research Reviews

1. POSE RESEARCH QUESTIONS
a. What immersive technologies (augmented reality, virtual reality, haptic augmentation, 360o, CAVE or case automatic virtual environment, etc.) have been used in research with disabled persons to assess their perception or use of physical environment, particularly but not exclusively residential environment? What are strengths, limitations, and exemplary methods?
b. What data collection scales, instruments and procedures have been used to assess home modifications, adaptations or interior designs for people with disabilities in terms of: access; use or usability; activities (functional activities, ADLs); comfort and satisfaction; and aesthetics? To which specific disabilities are these scales or instruments targeted?
c. What adapted, converted or repurposed spaces and fixtures have been made to existing (attached) homes to increase accessibility, and how effective have they been in terms of: access; use or usability; activities (functional activities, ADLs); comfort and satisfaction; and aesthetics? What targeted occupant (i.e. disability) is examined in the research to date in examining adaptive, converted and repurposed spaces?
2. SEARCH
a. Select most relevant and Identify electronic databases searched
b. Create and Identify sets and combinations of search terms used
c. Identify inclusion/exclusion factors for search

3. SCREEN
a. 1ST STEP: read title and abstract. Reject if:
1) not a research article or research review
2) a duplicate
3) does not include disability **4) other obvious excluding criteria (e.g. pertains to animals)**
b. 2nd STEP: read abstract and scan article. Reject if:
1) does not include physical/design factors that may pertain to user/resident accessibility/usability or comfort or aesthetics
2) does not include other characteristics relevant to the particular research question
4. IF REMAINDER > 50 ARTICLES: discuss with task lead and PI how to reduce to manageable number
5. CREATE FUNNEL DIAGRAM TO DOCUMENT PROCESS
6. MATRIX ANNOTATING STUDIES
7. NARRATIVE OF SPECIFIC PROTOCOL, AND MAJOR FINDINGS, GAPS, AND IMPLICATIONS FOR THE UF PROJECT
8. ASSEMBLE IN SINGLE REPORT ENCOMPASSING PROTOCOL, MATRICES, AND NARRATIVE OF THE 3Rs

Each of the R3s was led by a faculty co-PI, assisted by a doctoral student. To enhance accountability, the first completed version of the R3 matrix and narrative was reviewed by three to five others individuals who were either co-PIs, advisory council members, or graduate students. Their feedback was provided to the lead co-PI of the R3 either in separate written feedback or in group discussion. Subsequent changes were then made.

Organization of the Report

This report is divided into 4 chapters with a bibliography and appendices. This introductory chapter — which includes the background and justification behind the development of the research questions directing our literature reviews, and the overall protocol of the R3s — is followed by each Rapid Research Review. Chapters 2 through 4 follow a format similar to the

protocol identified above. The bibliography is organized by chapter. Appendices include the matrix of each R3.

CHAPTER 2: RAPID RESEARCH REVIEW OF EMPIRICAL STUDIES OF RESIDENTIAL ADAPTATIONS/REPURPOSING FOR SENIORS AND PEOPLE WITH DISABILITIES

Research Questions

What adapted or repurposed spaces and fixtures have been made to existing (attached) homes to increase accessibility, and how effective have they been in terms of:

- Usability, access, comfort, satisfaction
- Cost
- Aesthetics, attractiveness
- Targeted occupant (i.e. what disability is examined in the research)

Protocol

The goal of the literature search was to identify and review current research evidence published from 2000 to 2018 and specific to this study's research question (above). As such, the R3 protocol included:

- Project team developing a research question
- Project team, with reference librarian assistance, harvesting search terms
- Project team discussing and drawing consensus on search terms, databases to explore, and specific protocol steps for the literature search
- Co-PI and research assistant completing a methodical search and a supplemental hand search.

Search Strategy and Process of Peer-Reviewed Journal Articles: The methodological search used a targeted strategy involving all key points addressed in the research question. More specifically, this means the articles found relevant through the methodical search were those addressing home modifications in residential contexts intended to improve accessibility for persons with functional limitations, as well as examining the effectiveness of those home modifications in terms of usability, access, comfort satisfaction, aesthetics, and/or cost. For this study's purposes, *home modifications were defined* as space alterations (i.e. reallocating rooms or reconfiguring floor plans to use areas for purposes other than what was originally intended) as well as changing or adapting permanent fixtures (i.e. cabinetry, plumbing fixtures, etc.) to more fully support users' needs and capabilities.

Using this search approach, the articles identified as appropriate met all predetermined criteria indicating relevance to this study's research question. Details regarding search terms and databases are explained later in this chapter.

This strictly focused, methodical search presented three challenges. First, despite concentrating the search strategy on only the key factors identified in the research question, initially the search process still produced a substantial number of unrelated articles. The second challenge with this approach was that following the pre-established search guidelines in full resulted in only a small number (5) of useful articles meeting all criteria. This was likely due to the tight focus of the search. Consequently, this meant articles possibly still relevant to the topic but not including all four categories of search terms within the article abstract might be missed. For comparison, several databases were test-searched using only three rather than all four search categories. These test searches returned far too many hits to be able to sift through all the article titles, which was the second step in this R3 search protocol to methodically identify relevant articles. Subsequently, the search continued to adhere to the original, more stringent protocol.

Similar to the structured process followed by Stark, Keglovits, Arbesman, and Lieberman (2017) in their more expansive systematic review of the role of various home modifications in improving participation for community-living adults and older adults, this study's methodical search was supplemented by a hand search also. For this R3, the hand search included searching reference lists of useful articles already identified to uncover other titles that might be relevant as well. Also the hand search entailed looking within a limited number of specific, related journals but using fewer than four categories of search terms. Likewise, other articles were gathered by using fewer search terms but in combination with names of authors known to write on related topics. Together, these hand search strategies provided a way of loosening the four search category strategy yet producing a manageable number of articles to review.

Search Databases Chosen and Justification: The R3 literature search was performed in the following databases: Academic Search Premiere, Avery, Web of Science, Cinahl, Applied Social Science Index and Abstracts, PsycNet (APA), Medline (via Proquest), and Pubmed (Central). By including a substantial number of databases covering a range of areas of study, the methodical search was able to account for the multi-disciplinary nature of the study of modifying home environments for supporting independent living. This methodical search produced 5 unique articles meeting all search criteria. With this, the accompanying hand search uncovered 13 unique results.

Search Term Sets: The search terms were organized into four categories: Place, Access, Change, and Effectiveness. Within those categories, the search terms (bolded) included:

Place category: **hous***, **home*, residential***
Access category: **disab***, **access***
Change category: **adapt*, modif*, repurpose***
Effectiveness category: **attract*, comfort*, cost***

Combination of Term Sets for Searching: The primary strategy for the methodical literature search was to search the eight databases for article abstracts that included at least one of the

search terms from each of the four categories. More specifically, the exact terms used within each category and how these were combined during searches is shown below:

Place category: **hous*** OR **home*** OR **residential***
Access category: AND **disab*** OR **access***
Change category: AND **adapt*** OR **modif*** OR **repurpose***
Effectiveness category: AND **attract*** OR **comfort*** OR **cost***

Criteria Established for Database Searching: Beyond the specific databases and search terms used, the literature search also required selections to be published in a peer-reviewed journal, have a publication date of 2000-2018, be published in the English language, and pertain to adults, aged 18 years and older.

From the first search, 1,085 articles were identified.

Screening Protocol of Peer-Reviewed Journal Articles:

First Screen: In the first screen, the titles of the 1,085 articles initially identified were examined one-by-one. When sifting through the titles, articles were rejected if these did not suggest the article's content included home modifications, accessibility, usability, comfort, aesthetics of the renovation, cost, or other characteristics relevant to this study's research question. After screening the 1,085 article titles, 50 articles remained. Once duplicates were removed there were 33 potentially relevant articles.

In the hand search, only articles with titles meeting the first screen criteria were considered.

Second Screen: In the second screen, the full abstract of each article was read. Articles were rejected if the abstract's content did not incorporate user accessibility, comfort, aesthetics of the renovation, ost, usability, nor other characteristics relevant to the research question. From the second screen of the 33 articles, 5 relevant articles were identified, read, then key contents were organized in the Literature Review Matrix (Appendix A).

Similarly, for articles identified as potentially applicable in the hand search, those abstracts were reviewed and subjected to the same exclusion criteria as the methodical search. Once the abstracts of this article set were screened, 13 unique, applicable articles were identified. These too were read and cataloged in the Literature Review Matrix.

Flow Diagram of Protocol and Number of Articles: The methodical literature search required at least one of the selected search terms from each of the four categories (place, access, change, effectiveness) to appear within the article abstracts. This search was conducted electronically in each of the 8 databases selected for this purpose. The protocol for the methodical literature search is depicted in Figure 3.

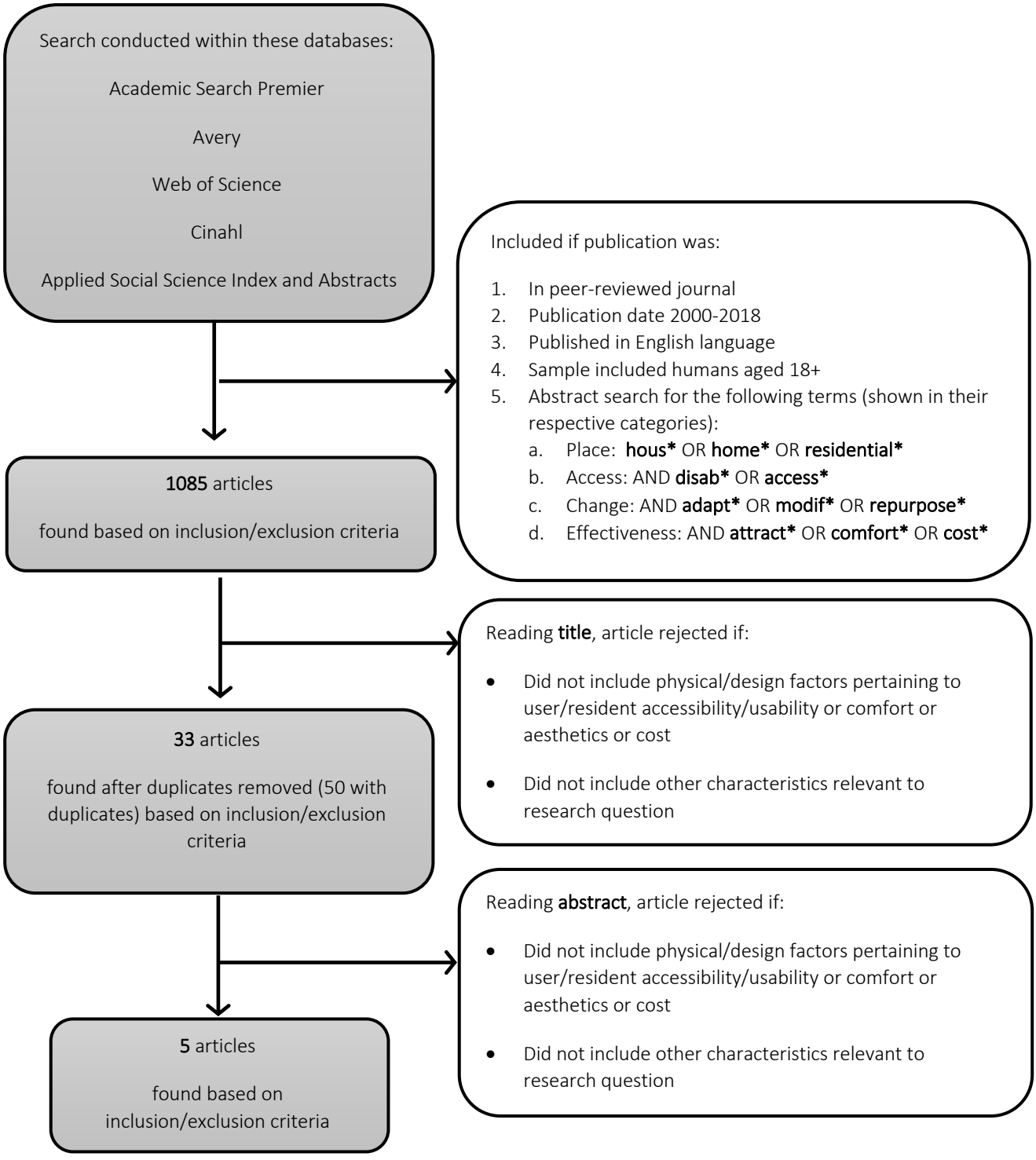

Figure 3. Flow Diagram of Decision-Making Process for Inclusion of Articles in Methodical Search

Ultimately, the Methodical Search articles came from three of the eight databases searched (see Table 2), with more than half of those found in the Web of Science database.

Table 2. Methodical and Hand Search Results per Database

Databases Searched	***Methodical Search Results***	***Hand Search Results***	***TOTAL Search Results***
Academic Search Premiere	1	-	-
Avery	0	-	-
Web of Science	3	-	-
Cinahl	0	-	-
Applied Social Sciences Index and Abstracts	0	-	-
PsycNET (APA)	0	-	-
Medline (via Proquest)	0	-	-
Pubmed (Central)	1	-	-
SUBTOTAL	5	13	18

Once the final 18 articles were identified, a full text review was completed and documented through use of a matrix designed for annotating the study details (Appendix A).

Major Findings

The studies identified as relevant addressed numerous perspectives including those of the occupational therapist, client, the client's caregiver, and other household inhabitants. Further, these articles addressed a **range of functionally limited groups.** Some of these focused on very specific functional limitations such as spinal cord injury or motor neuron disease. Other articles looked at capability limitations more broadly by including various physical limitations but narrowing their scope by including only older adults, low-income persons, minorities,

wheelchair-users, or similar. By contrast, other articles included all adult age groups without distinguishing by more specific demographic parameters.

For the various functionally limited groups listed above, the articles reviewed discussed home modifications intended to increase accessibility in a residential context. Answering the first part of the research question regarding what types of home modifications have been made to existing housing, these articles addressed numerous home modifications related to maneuvering within and between spaces as well as kitchen and bathroom adaptations. These are discussed in greater detail later.

In terms of the effectiveness of the home modifications assessed, **aesthetics** was addressed to a small degree but only secondary to the functional benefits of home modifications. For instance, Granbom, Taei, and Estam (2017) examined experiences of home modifications regarding perceptions of home. Before the home modifications were made, participants expressed concern about how renovations might negatively impact their home's resale value. Granbom et al. found that once completed, the changes did not negatively impact how "homey" participants felt their houses were. While it is important to understand how home modifications influence perceptions of home, that study's scope did not address how visually appealing users found home modifications. This suggests there is a need for further research to understand how accessibility-related renovations and their aesthetic appeal.

Home modifications and their influence on **comfort** was discussed by Szanton, Thorpe, Boyd, Tanner, Leff, Agree, Xue, Allen, Seplaki, Weiss, and Guralnik (2011) in terms of the adaptations making it easier to complete tasks like Activities of Daily Living (ADLs) and Instrumental Activities of Daily Living (IADLs), which in turn reduced stress levels for participants. The direct benefit of improved ease and more independent task completion also provided other emotional pay-offs such as greater self-confidence and life quality (Carnemolla and Bridge, 2016). More specifically, Carnemolla and Bridge found home modifications correlated with a 40% increase in health-related quality of life levels. As research and practice progress in understanding the benefits related to implementing needed home modifications to support living independently, it is critical to investigate both the direct and indirect benefits that provide value to consumers. Consequently examining the role comfort – both physical and emotional - plays in home modifications is a fundamental aspect of home modification research.

In comparison to comfort and aesthetics, **cost** was more frequently discussed. In particular, several studies made a point of explaining the cost of home modifications to support independence was much lower than residential care costs. For instance, Lansley, McCreadie, Tinker, Flanagan, Goodacre, and Turner-Smith (2004, 14) explained, "Except for extreme cases, the provision of (housing) adaptations and AT (Assistive Technology) combined with formal care to older people in their own homes is much less costly than residential care, and for many other reasons distinctly preferable." Lansley et al. further indicated mobility needs are the primary factor influencing the extent and, correspondingly, the cost of the adaptations needed to provide adequate support. Considered in the context of Project Re-Envision, this further emphasizes the importance of addressing mobility concerns as these apply in safely

moving between bedroom and bath to perform bathing, grooming, and toileting tasks as well as maneuvering in the bathroom as well as the kitchen to complete tasks essential to independent living.

Findings Pertaining to Repurposed Spaces and Fixtures

Repurposing spaces to improve a home's functionality was rarely addressed in the literature. The exception to this was found in Sakellariou (2015). In the context of considering a client and the client's partner's needs, there was discussion of how to address the couple's desire to continue sharing a sleeping space when reallocating space to better meet the client's physical needs. The very limited amount of discussion on the topic of repurposing space suggests there is a need for more exploration of this topic.

By contrast, discussion of altering fixtures (i.e. cabinets, plumbing fixtures, etc.) within homes was common. In one study by Callaway, Vredenburgh, Williams and Clark (2016) findings indicated access and mobility both improved when travel paths within the home, such as from the bedroom to the bathroom, were linear rather than circuitous. Also focusing on improving access to maneuver within the home, Carnemolla and Bridge (2016) recommended widening doorways and altering stepped entrances with ramps. Going beyond these more general recommendations, Vredenburgh et al. (2010) tested specific clearances and layouts. For instance, in a bathroom context Vredenburgh et al. found for wheelchair users it was easier to exit rooms offering 58.5" and 59.5" distances between front and back walls compared to other distances tested. When reconfiguring space during a renovation, these specific guidelines are vital to understand.

Regarding specific bathroom fixture locations, Carnemolla and Bridge (2016) as well as he Murphy, Nyquist, Strasburg and Alexander (2006) recommended removing sliding shower doors for improvements in bath transfer safety. Further Canemolla and Bridge found positive outcomes such as improved mobility, increased independence, social participation, and caregiver support occurred when hand-held shower units, grab-bars near shower/bath/toilet were installed, and bathroom layouts were reconfigured. This aligned with the Vredenburgh et al. (2010) research which produced specific guidelines for these types of changes to bathroom layouts, particularly as these apply for wheelchair users. For instance, that study recommended distances between the front and back wall in bathrooms needed to be greater than 55.5 inches to be easily navigated by someone in a standard wheelchair. Also in terms of usability, the sink's height was found to be much more important than the sink's distance from the wall. Vredenburgh et, al. recommended 32" bathroom countertop heights. To meet motorized-wheelchair user needs, that same study indicated the optimal distance between the tub and toilet was 16.5 inches.

Beyond providing evidence for design guidelines, several studies recommended intervention strategies to better support home modification outcomes. For instance Vredenburgh et, al. (2010) recommended supplementing bathroom modifications with greater client education such as teaching clients how to safely transfer to and from the bath. Similarly, focusing on

strategies to enhance the benefits of home modifications, Meucci et al. (2016) suggested increasing the client's role in decision-making during the remodeling project to provide better end results.

In a kitchen context, Vredenburgh et, al. (2010) found a kitchen's size did not significantly affect the ease of entering it; however, the space available for turning was very important for navigating within the space. With that, the study reported the standard 60 inch turning radius as well as a 57" turning radius were sufficient while smaller turning radii were substantially more difficult to maneuver. Further that study's findings indicated the distance from the refrigerator's front to the dishwasher's front did not influence perceived ease of use nor did the distance from the sink's center to the wall.

Findings Pertaining to Sample Characteristics

In the literature reviewed, older adults with functional limitations were considered to a large degree. Although not always the exclusive focus, the following studies specifically addressed the needs of older adult users: Granbom, Taei, and Ekstam (2017), Granbom, Iwarsson, Kylberg, Pettersson, and Slaug (2016); Meucci et al. (2016); Carnemolla and Bridge (2016); Aplin, Jonge, and Gustafsson (2015); Renaut, Ogg, Petite and Chamahian (2015); Helle, Iwarsson, and Brandt (2014); Kim, Ahn, Steinhoff, and Lee (2014); Szanton et al. (2011); Murphy et al. (2006); and Lansley et al. (2004). While these studies represent a large portion of the articles reviewed here, it is important to understand that studying older adults with functional limitations is a useful way to identify solutions for functional limitations for almost any aged user. That is because reduced muscle mass and the accompanying reductions in strength that are common in later life means solutions supporting older adults with functional limitations will likely work for younger, stronger users as well. Conversely, younger persons generally have greater stamina, strength, and other capabilities compared to older adults; therefore, a design that works for younger individuals may not be suitable for older adults as well.

Other studies, such as Aplin et al. (2015), addressed functionally-limited clients and their families more broadly by not restricting participant ages. Similarly Heywood (2004) focused on a variety of disability types and ages. Since Ekstam et al. (2014) addressed the viewpoint of occupational therapy professionals, the range of client types discussed represented the varying client types of these practitioners. While Vredenburgh et al. (2010) and Reid, Angus, McKeever, and Miller (2003) focused on a wide age range of people who were also wheelchair users; although, Reid et al. focused exclusively on female wheelchair users. Callaway et, al. (2016) concentrated on varied aged persons living with neurotrauma.

Findings Pertaining to Effectiveness (use, access, comfort, satisfaction, cost, aesthetics)

Among the articles reviewed, there was much discussion of benefits reaped from implementing needed home modifications. To support independent living, some articles addressed the direct

benefits of home adaptations. For instance, Ekstam et al. (2014) found improved safety and usability were associated with employing needed modifications. Further, Chiatti, et al. as well as Lansley et al. (2004) identified direct cost savings - in terms of the cost of the modifications compared to the substantially greater expense of institutionalization – as another direct benefit of improving home accessibility. Szanton et al. (2011) found coordinating multi-disciplinary interventions more successfully reduced difficulty with Activities of Daily Living (ADLs) and Instrumental Activities of Daily Living (IADLs), ultimately reducing the amount of stress clients experienced.

In addition to identifying direct benefits such as increased usability, Norin, Slaug, Haak, Jörgensen, Lexell, and Iwarsson (2017) reported other valuable but more indirect benefits such as increased independence and social participation resulting from the more user-friendly home modifications which improved the ease of use and mobility within a client's home. Similiarly, Ekstam et al (2014), Carnemolla and Bridge (2016), and Szanton et al. (2011) found quality of life improved when home modifications supported health, safety and usability within the home. Additionally, Carnemolla and Bridge (2016) also reported self-confidence improved as well.

Beyond functional and emotional benefits, Granbom et al. (2017) examined the impact of home modifications on client perceptions of home. More specifically, while participants indicated concern about prospective changes possibly diminishing the visual appeal and with that the monetary value of their homes, findings suggested participant concerns substantially diminished once the adaptations were completed.

Gaps and Limitations in the Existing Research to Date

The literature predominantly examines industry-standard approaches to home modifications for increasing accessibility. When drawing cost into the discussion, studies generally remark on home modification costs relative to the considerably greater expense of premature institutionalization. While that comparison is an important one, the literature stops short of offering solutions to reduce the cost of standard home modification solutions. As Reid et al. (2003) indicated some participants reported lacking the resources to make needed home modifications, this implies there is a need for research regarding less-expensive home modification alternatives.

In addition, the literature addressed home modification aesthetics minimally. Granbom et al. (2017) discussed how implementing home modifications influenced perceptions of how 'homey' participant houses were considered. Despite the importance of understanding how renovations affect perceptions of home, that study's scope did not examine visual appeal of accessibility modifications further. Particularly as research indicates functionally-limited individuals do express concern about home modifications altering the attractiveness and value of their homes, it follows logic that there is a need to understand how to create home modifications that users find visually appealing.

Implications for Project Re-envision

Two of the most important implications from the literature follow directly from the gaps identified above. First, while numerous researchers remarked on the comparatively lower cost of home modifications compared to institutionalization, this is not the only important financial consideration regarding remodeling costs. This does not take into account people with functional limitations may need home modifications yet be unable to afford needed changes. With this, related research does not explore more home modification alternatives to make home needed alterations more affordable. This gap in the literature underscores the need for research that examines lower-cost alternatives to standard home modification solutions. Consequently, this is one of the primary goals of Project Re-envision.

While one study acknowledged participant concerns about home modifications having a negative influence on their home's appearance, that research did not provide guidance on what types of home modification solutions visually appeal to users. This insinuates a need for further study on that topic. With that, Project Re-envision seeks to understand what types of home modifications are most aesthetically appealing as well as functional for persons with functional limitations.

In the context of kitchens, bathrooms, and the transition space between bedrooms and bathrooms, Project Re-envision seeks to address those critical gaps in the literature as these relate to persons mobility and vision impairments.

CHAPTER 3: RAPID RESEARCH REVIEW OF EFFECTIVENESS ASSESSMENT TOOLS FOR STUDIES OF HOME MODIFICATIONS

Research Questions

What data collection scales, instruments and procedures have been used to assess home modifications, adaptations, or interior designs for people with disabilities in terms of:

- Access
- Use, usability
- Activities (functional activities, ADL's)
- Comfort, satisfaction
- Aesthetics?

Moreover, for which specific disabilities are these scales/instruments targeted to?

Protocol

Search: The search process involved: 1) the development of the research question with the project team, 2) term harvesting with a reference librarian and the project team, 3) a team meeting to discuss search terms, databases, and protocol details.

A reference librarian conducted the literature search. The searching process was closely informed by the rapid review methodological recommendations of Harker and Kleijnen (2012), Khangura et al. (2012), Rodgers et al. (2016), and Tricco et al. (2015). Preliminary database searching occurred through *CINAHL* and *PubMed*. The databases used during the final search were: EBSCO Host's *Academic Search Premier, AgeLine, Art and Architecture Source, CINAHL, PsycINFO*; ProQuest's *Avery Index to Architectural Periodicals*; *PubMed* (NCBI), and *Web of Science*. The team selected these databases due to their comprehensive topic coverage of architecture, art, and health sciences. The search strategy was developed through the PICO framework and adapted for each database: **P**opulation: Young adults, adults, and older people with disabilities; **I**nterventions: Accessibility, usability, and aesthetics, in relation to the design and modification of residential housing; **C**omparators: Not applicable; **O**utcomes: Aging in place, comfort, functional independence, health, quality of life, safety, satisfaction, wellbeing, wellness, and wellbeing.

Keyword searching occurred in the title field only, using truncation and phrase-searching functionalities where possible. Relevant subject headings (*CINAHL Headings, MeSH*) were applied, alongside language (English) and publication date (2000 – 2017) limits. Preliminary searching indicated that keywords and subject headings pertaining to measurement and assessment narrowed the search too far, by removing potentially relevant literature. Following team agreement, such terms were omitted from the final database searches. The team included grey literature throughout the search such as book chapters, dissertations, and reports during the screening process.

The database searches were conducted between December 22 -26, 2017. The total number of records retrieved was 281. Following de-duplication using RefWorks, the number of unique results was 229 (Table 3). The full *PubMed* search strategy is provided in Table 4 search strategies for the other databases are available from the reference librarian.

Table 3. Search Results

Database name	# of results
PubMed	53
CINAHL	95
PsycINFO	41
AgeLine	4
Academic Search Premier	75
Web of Science	3
Avery Index to Architectural Periodicals	10
Art and Architecture Source	0
Total results from all searches	281
Total results de-duplicated	229

Table 4: *PubMed* Search Strategy: Search Terms and Combinations

PubMed Search Strategy: (((((("Adult"[Mesh] OR "Aged"[Mesh] OR "Aged, 80 and over"[Mesh] OR "Frail Elderly"[Mesh] OR "Young Adult"[Mesh] OR "Middle Aged"[Mesh] OR adult[ti] OR adults[ti] OR "middle aged person"[ti] OR "middle aged persons"[ti] OR "middle aged people"[ti] OR "old people"[ti] OR "older people"[ti] OR "old person"[ti] OR "old persons"[ti] OR "older person"[ti] OR "older persons"[ti] OR "senior people"[ti] OR "senior persons"[ti] OR "elderly people"[ti] OR "elderly person"[ti] OR "elderly persons"[ti]))) AND (("ADL"[ti] OR "IADL"[ti] OR "activities of daily living"[ti] OR "activity limitation"[ti] OR "activity limitations"[ti] OR "ambulatory limitation"[ti] OR "ambulatory limitations"[ti] OR "assistive device"[ti] OR "assistive devices"[ti] OR "blindness"[ti] OR "cognition disorder"[ti] OR "cognition disorders"[ti] OR "cognitive decline"[ti] OR "cognitive disorder"[ti] OR "cognitive disorders"[ti] OR "cognitive dysfunction"[ti] OR "cognitive dysfunctions"[ti] OR "communication disorder"[ti] OR "communication disorders"[ti] OR "coordination disorder"[ti] OR "coordination disorders"[ti] OR "developmental disorder"[ti] OR "developmental disorders"[ti] OR "functional limitation"[ti] OR "functional limitations"[ti] OR "hearing disorder"[ti] OR "hearing disorders"[ti] OR "impaired executive function"[ti] OR

"impaired executive functioning"[ti] OR "language disorder"[ti] OR "language disorders"[ti] OR "limitation of activity"[ti] OR "mobility limitation"[ti] OR "mobility limitations"[ti] OR "motor skills disorder"[ti] OR "motor skills disorders"[ti] OR "participation limitation"[ti] OR "participation limitations"[ti] OR "participation restriction"[ti] OR "special care needs"[ti] OR "special health care needs"[ti] OR "special needs"[ti] OR "speech disorder"[ti] OR "TBI"[ti] OR "vision disorder"[ti] OR "vision disorders"[ti] OR alzheimer[ti] OR alzheimer's[ti] OR alzheimers[ti] OR arthritis[ti] OR autism[ti] OR autistic[ti] OR deafness[ti] OR dementia[ti] OR dementias[ti] OR disability[ti] OR disabilities[ti] OR disabled[ti] OR handicapped[ti] OR wheelchair[ti] OR wheelchairs[ti] OR "Disabled Persons"[Mesh:noexp] OR "Mentally Disabled Persons"[Mesh] OR "Mentally Ill Persons"[Mesh] OR "Persons With Hearing Impairments"[Mesh] OR "Visually Impaired Persons"[Mesh] OR "Deafness"[Mesh:noexp] OR "Deaf Blind Disorders"[Mesh:noexp] OR "Communication Disorders"[Mesh:noexp] OR "Language Disorders"[Mesh] OR "Mental Disorders"[Mesh:noexp] OR "Developmental Disabilities"[Mesh] OR "Self Help Devices"[Mesh:noexp] OR "Intellectual Disability"[Mesh:noexp] OR "Wheelchairs"[Mesh] OR "Dependent Ambulation"[Mesh] OR "Vision Disorders"[Mesh:noexp] OR "Brain Injuries, Traumatic"[Mesh:noexp] OR "Walkers"[Mesh] OR "Cognition Disorders"[Mesh:noexp] OR "Mobility Limitation"[Mesh] OR "Cognitive Dysfunction"[Mesh] OR "Neurocognitive Disorders"[Mesh:noexp] OR "Spinal Cord Injuries"[Mesh:noexp] OR "Alzheimer Disease"[Mesh] OR "Motor Skills Disorders"[Mesh] OR "Dementia"[Mesh:noexp] OR "Arthritis"[Mesh:noexp] OR "Autism Spectrum Disorder"[Mesh] OR "Blindness"[Mesh:noexp])))) AND (("aging in place"[ti] OR "domestic environment"[ti] OR "domestic environments"[ti] OR "indoor environment"[ti] OR "indoor environments"[ti] OR "living environment"[ti] OR "living environments"[ti] OR "micro scale environment"[ti] OR "private residence"[ti] OR "private residences"[ti] OR "built environment"[ti] OR "built environments"[ti] OR "home environment"[ti] OR "home environments"[ti] OR "house environment"[ti] OR "house environments"[ti] OR "housing environment"[ti] OR "housing environments"[ti] OR "Independent Living"[Mesh] OR "Housing for the Elderly"[Mesh] OR "Housing"[Mesh:noexp])))) AND ((("environmental facilitators"[ti] OR "environment facilitators"[ti] OR "environmental enablers"[ti] OR "assistive device"[ti] OR "assistive devices"[ti] OR entrance[ti] OR entrances[ti] OR entranceway[ti] OR "environmental design"[ti] OR "environmental adaptation"[ti] OR "environmental adaptations"[ti] OR "environmental intervention"[ti] OR "environmental interventions"[ti] OR "environmental modification"[ti] OR "built environment"[ti] OR "built environments"[ti] OR "environmental modifications"[ti] OR "environmental safety"[ti] OR "floor level"[ti] OR "home design"[ti] OR "house design"[ti] OR "housing design"[ti] OR "home adaptation"[ti] OR "home adaptations"[ti] OR "housing adaptation"[ti] OR "housing adaptations"[ti] OR "home modification"[ti] OR "home modifications"[ti] OR "home safety"[ti] OR sound[ti] OR "space layout"[ti] OR "spatial design"[ti] OR "spatial layout"[ti] OR "spatial layouts"[ti] OR "wheelchair access"[ti] OR "wheelchair accessible"[ti] OR "wheelchair accessibility"[ti] OR "barrier free"[ti] OR "barrier free"[ti] OR "interior design"[ti] OR universal[ti] OR universality[ti] OR environmentally[ti] OR lighting[ti] OR retrofit[ti] OR retrofitting[ti] OR retrofitted[ti] OR sensory[ti] OR visitability[ti] OR visitable[ti] OR acoustic[ti] OR acoustics[ti] OR stair[ti] OR

stairs[ti] OR stairway[ti] OR stairways[ti] OR illumination[ti] OR smell[ti] OR olfactory[ti] OR "visual navigation"[ti] OR feeling[ti] OR color[ti] OR colors[ti] OR desire[ti] OR desirable[ti] OR desirability[ti] OR privacy[ti] OR "thermal comfort"[ti] OR textiles[ti] OR comfort[ti]) OR (("interior design and furnishings"[Mesh:noexp] OR "floors and floorcoverings"[Mesh:noexp] OR "household articles"[Mesh:noexp] OR "facility design and construction"[Mesh:noexp] OR "privacy"[Mesh:noexp] OR "textiles"[Mesh:noexp]) AND (accessible[ti] OR accessibility[ti] OR aesthetic[ti] OR aesthetics[ti] OR enabler[ti] OR enablers[ti] OR facilitator[ti] OR facilitators[ti]))))) Filters: Publication date from 2000/01/01; English

Screening. The first step of the screening protocol was to remove duplicates. Following that were titles and abstract review of the 229 articles. Articles were rejected if they were not a research article or research review, did not include a disability population, did not include a measurement/evaluation tool, focused on the outdoor environment, or included only children. After the initial screening, 74 articles remained.

The second screening step was a more detailed reading of the abstract with a scanning of the full text.

The team rejected articles if they did not answer the research question (above). After this screening 40 articles remained. Several were questionable, and this researcher met with the principal investigator and team members from the other two literature review teams to discuss these. An example of a questionable article was a study that measured how much room was needed for scooters (Dutta, T., King, E., Holliday, P. Gorski, S., & Fernie, G. 2011). The team determined this manuscript described specific dimensions for five specific scooters; hence, it did not meet the criteria for this research question and was excluded. Four articles were deemed not to fit the inclusion criteria and were excluded resulting in 36 articles after the second step in the screening protocol.

The third screening step followed completion of a full text review. Articles were rejected if not directly related to the research question. This resulted in the final 26 articles included. During this step full text of articles were read and data relevant to the research questions was extracted. The team then met to review the matrix and make edits for clarity. Literature reviews were also removed at this time. A final matrix annotating the studies (see Appendix B) was developed and compiled to synthesize the findings. Figure 4 illustrates the full search and screen process.

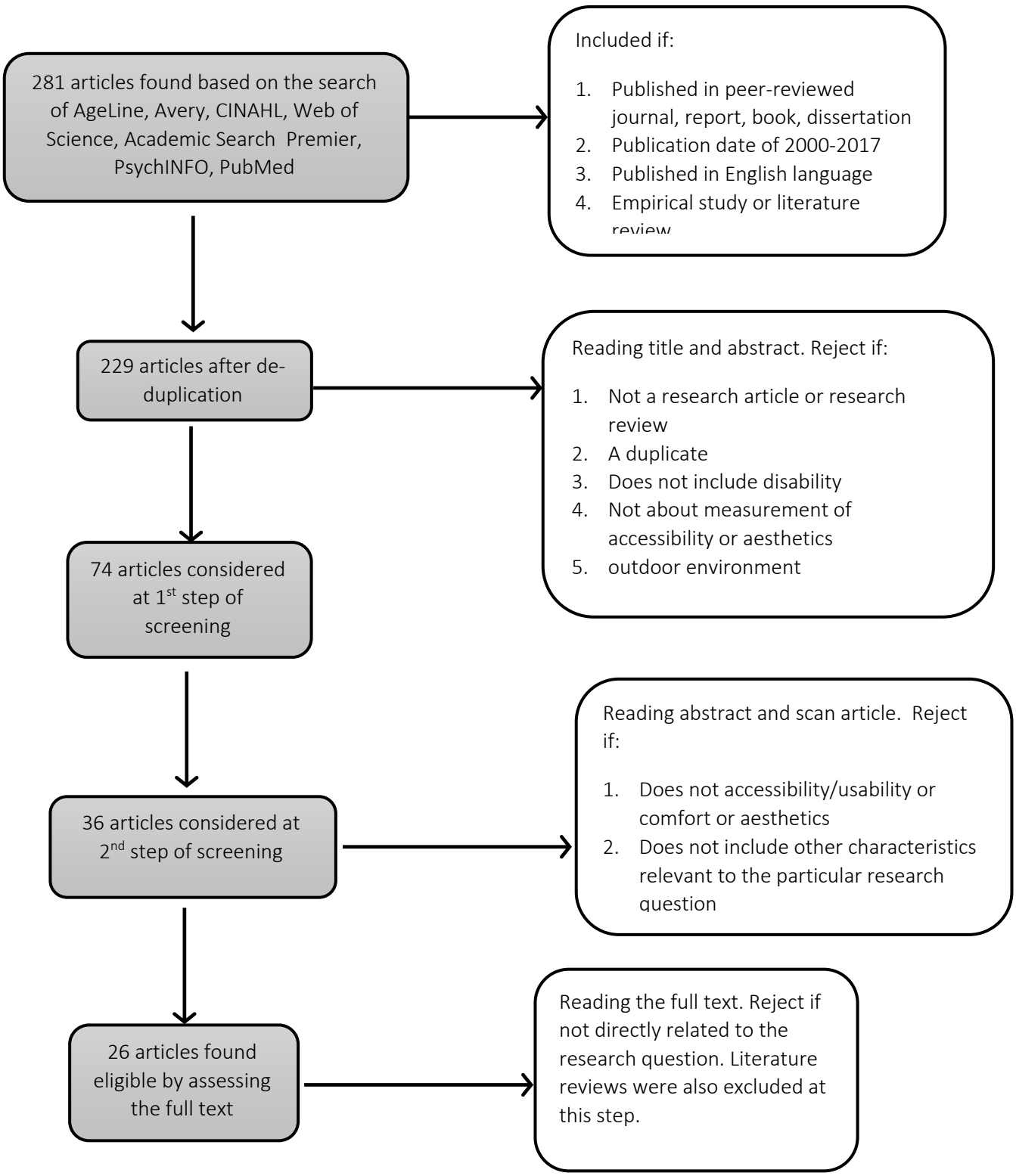
281 articles found based on the search of AgeLine, Avery, CINAHL, Web of Science, Academic Search Premier, PsychINFO, PubMed
Included if:
1. Published in peer-reviewed journal, report, book, dissertation
2. Publication date of 2000-2017
3. Published in English language
4. Empirical study or literature review
229 articles after de-duplication
Reading title and abstract. Reject if:
1. Not a research article or research review
2. A duplicate
3. Does not include disability
4. Not about measurement of accessibility or aesthetics
5. outdoor environment
74 articles considered at 1st step of screening
36 articles considered at 2nd step of screening
Reading abstract and scan article. Reject if:
1. Does not accessibility/usability or comfort or aesthetics
2. Does not include other characteristics relevant to the particular research question
26 articles found eligible by assessing the full text
Reading the full text. Reject if not directly related to the research question. Literature reviews were also excluded at this step.

Figure 4. Flow Diagram of Decision-Making Process for Inclusion of Articles

Major Findings

The research aim was to identify tools that assessed accessibility, usability, functional activities, comfort, or aesthetics of home modifications, adaptations, or interior designs for persons with disabilities. Many of the instruments spanned multiple categories. From the final 26 articles a total of 43 data collection scales, instruments and procedures were identified. Nine of these were specific to client factors such as balance, cognitive level, coordination, or depression. This resulted in 34 tools that met criteria to answer this research question. These were crossed checked by a graduate research assistant to ensure inclusion criteria and accuracy of categorization.

To answer the first part of the research question "What data collection scales, instruments and procedures have been used to assess home modification, adaptations, or interior designs for people with disabilities regarding **access**?" The review identified 19 tools. Twelve were standardized instruments:

- Craig Hospital Inventory of Environmental Factors (CHIEF)
- Client-Clinician Assessment Protocol (C-CAP)
- Enviro-FIM
- Home Assessment of Environmental Interaction (HoPE)
- Home Safety Self-Assessment Tool (HSSAT)
- Housing Enabler
- In-home Occupational Performance Evaluation (I-Hope)
- Measure of Quality of Environment (MQE)
- Safety Assessment of Function and the Environment for Rehabilitation (SAFER)
- The Sign Test
- Usability in My Home
- Westmead

Several of these instruments were used in multiple studies (see Table 5). Seven non-standardized scales and procedures were identified:

- Five-question Behavioral Risk Factor (visitability) telephone survey (Bouldin, 2015)
- Digital photos
- Facilitators and Barriers Survey of Environmental Influences on Participation Among People with Lower Limb Mobility Impairments and Limitations (FABS/M)
- Home Identity Likert Scale
- interview
- Observation (in-home visit)
- Video recordings

Table 5. Standardized Instruments Identified Multiple Times in Literature

Instrument	Brief description (not from review)	Reference of Where to Obtain Instrument if available
Housing Enabler (8) Nordic version(2)	Four rating forms: housing standard, functional limitations and dependence on mobility devices, environmental barriers, and a screening tool	http://www.enabler.nu/download.html Order manual from Slaug Enabling Development: bjorn.slaug@telia.com
Usability in my Home (7)	Self-perception/self-administered tool to assess accessibility and usability in a client's home 31 questions, 7 point rating scale	Fänge, A., & Iwarsson, S. (1999).Physical housing environment: Development of a self-assessment instrument. Canadian Journal of Occupational Therapy, 66, 250-260.
ADL Staircase (5)	Assesses ADL skills (functional activities) on 3 point scale	https://www.ncbi.nlm.nih.gov/pubmed/18277210
SAFER (2)	Assesses both the environment and ability to manage functional activities in the home	https://www.vha.ca/publications-for-sale
EQ-5D-5L (2)	Measure of health status Quality of Life	https://euroqol.org/wp-content/uploads/2016/09/EQ-5D-5L_UserGuide_2015.pdf
HoPE (2)	Home Assessment of the Person-Environment Interaction (HoPE) Assesses issues related to home adaptation	*https://www.ncbi.nlm.nih.gov/pubmed/24102587*

Note. References in this table are provided as a resource and are an addition to the findings of this study.

The total results of data collection tools/instruments for assessing access was 19. However, without the manuals and full procedural details, other tools (such as the Short falls Efficacy Scale or the question about housing satisfaction) identified may encompass access.

To answer the second part of the research question "What data collection scales, instruments and procedures have been used to assess home modification, adaptations, or interior designs f

or people with disabilities in terms of **usability**?" Four tools for measuring usability were identifi ed from the literature. These tools were:

- Self-report
- Short Falls efficacy scale
- The Sign Test
- Usability in My Home questionnaire

Other instruments identified may potentially address use or usability. If not specifically addressed in the manuscript, we were unable to accurately determine if additional instruments that focused on other issues such as access or function also included usability.

To answer the third part of the research question "What data collection scales, instruments and procedures have been used to assess home modification, adaptations, or interior designs for people with disabilities in terms of **activities (functional activities, ADL's**)," fourteen instruments or procedures specifically addressed activities of daily living (ADL's) or functional activities. These were:

- 12 kitchen items
- ADL Staircase
- Canadian Occupational Performance Measure (COPM)
- Functional Autonomy Measurement Scale
- Functional Independence Measure (FIM)
- In-Home Occupational Performance Evaluation (I-HOPE)
- International Classification of Function (ICF), 7 items
- Interview/self-report
- IADL Scale
- Mobility scale
- Observation of functional skills/ADL's
- Perceived severity of physical limitations questions
- Short Falls Efficacy Scale
- Transfer test

Other instruments in these articles may potentially address this issue, but we were unable to ac curately determine this without the entire instrument if not specifically addressed in the article.

To answer the fourth part of the research question "What data collection scales, instruments and procedures have been used to assess home modification, adaptations, or interior designs for people with disabilities in terms of **comfort and/or satisfaction**," four tools were identified:

- EQ-5D-5L, a quality of life measure
- Life Satisfaction Scale, developed specific to the study (Ewen, 2004)
- Positive and Negative Affect Scale (Oswald 2007)
- Self-report (Ekstam, 2014)

Without the manuals and full procedure details, other measures identified may include items on comfort or satisfaction.

The answer to the fifth part of the research question "What data collection scales, instruments and procedures have been used to assess home modification, adaptations, or interior designs for people with disabilities in terms of **aesthetics, attractiveness, meaning**?" resulted in no instruments being identified.

To answer the last part of this research question "For which specific disabilities are these scales/instruments targeted to," none of the instruments were not specific to any one diagnosis. Some studies did target specific diagnosis or populations, such as low vision (Barstow, 2011), stroke (Reid, 2004; Schultz, 2012), liver disease (Somerville, 2016) and wheelchair users (Rousseau, 2013; Vredenburgh, 2010). Five studies included participants from multiple disabilities groups in the same study. Five studies targeted participants with functional or motor physical disabilities. There were thirteen studies that targeted older adults.

In addition to addressing the specific research questions, **additional themes** emerged on spaces commonly assessed and on the importance of using standardized method of assessments. In many of the article studies the bathroom was addressed in terms of accessibility or function. In two articles (Naik, 2005; Sim 2015) the bathroom space was the focus of the study. The kitchen was also frequently assessed and was the focus on one study (Helle, 2014). Still another study focused exclusively on both the bathroom and kitchen (Vredenburgh (2010). The importance of using standardized method of assessment was a frequently reoccurring theme. The Housing Enabler was most commonly identified assessment from the 26 articles having been identified ten times. Other assessments identified multiple times were the Usability in My Home (7), ADL Staircase (5), SAFER (2), Quality of Life EQ-5D-5L (2), HoPE (2). Commonly identified assessments all had published reliability and validity. Table 2 briefly describes these instruments and where available, a reference for obtaining each.

Limitations

The method for classification of the assessments into each subsection of this research question had potential limitations. While the total results identified from the manuscripts for assessing access were 19, function/ ADL's was 14, usability and satisfaction were four tools each, there may be more overlap than identified. Without the instruments, manuals, and full procedural details some of the tools identified may encompass more categories. Another potential limitation is the frequency of occurrence for some instruments may be due to many different researchers and/or research institutes using the instruments; the same team of researchers were prolific in researching and publishing, and they tended to use the same instrument in all their studies.

Gaps in Literature

Several gaps were identified through this literature review. The most notable gap was the lack of assessments to address the aesthetics or attractiveness of the home modification or adaptations, or interior designs for people with disabilities. Other gaps included that

assessments were not specific to a specific diagnosis or population. Studies identified broad groups of persons such as older adults or adults with mobility impairments, or adults who qualified for housing adaptations making it difficult to answer the last part of our research question “Moreover, for which specific disabilities are these scales/instruments targeted to?”. Limited assessments were identified that examined usability (4), comfort and/or satisfaction (4); most of those that were did not have published reliability or validly, or were developed for the study in which they were used. There was no gold standard assessment identified.

Implications for Project Re-envision

This literature review resulted in several key implications for Project Re-Envison. First, the research team may need to adapt current standardized assessment to answer our research questions, especially related to aesthetics. The first step would be reviewing the most commonly identified assessments as listed in Table 2. In addition, the team will need to obtain copies of instruments, manuals, forms, and procedures to further evaluate potential tools for the next phase of this project. The team may also need to identify and hand search additional assessments not identified in this study as we move forward collecting the full scales, instruments, and procedure details and manuals. For aesthetics the team may need to consult with marketing, product research, or housing/real estate experts who measure consumer views on aesthetics to locate an assessment tool. Hand searching may also result in additional findings for measuring aesthetics.

Another implication identified was that the bathroom is almost always assessed and twice was the singular focus of the study, followed closely by kitchen. These are also key areas where persons with disabilities in vision or mobility need accessiblity to particpate in ADL’s and IADL’s to remain or return home. With the exception of outcome measures for aesthetics these areas were identified to have been previously studied with standardized data collection instruments. The Project Re-Envison team can be confidient that we can apply or adapt instruments identified in this study for use in the next phases of Project Re-Envision.

CHAPTER 4: RAPID RESEARCH REVIEW OF IMMERSIVE SIMULATION TECHNOLOGIES FOR PERSONS WITH DISABILITIES

Research Questions

What immersive technologies have been used in research with disabled process to assess their perception or use of physical environment, particularly but not exclusively residential environment? What are strengths, limitations, and exemplary methods?

Protocol

The literature study for targeted peer-reviewed journal articles based on 3 key points: virtual reality technology, accessibility and disabilities.

Search Strategy: Disabilities included general disability, mental disability, movement disability and visual impairment. The relevant articles were to meet certain criteria set forth in each of these categories and the search terms were identified accordingly.

Six sets of searching terms were used during the searching process. They included:

- from the perspective of virtual reality technology: augmented reality, virtual reality, and haptic interaction
- relevant with accessibility: access, ease, use, usability, available, and comfort
- described the general disability: disable*
- described the mental disability: mental disability, mental impairment, cognitive disability, cognitive impairment, Alzheimer, dementia, and autism
- described movement disability: ambulatory, handicap, arthritis, and frailty
- described the movement disability: ambulatory, handicap, arthritis, and frailty

To categorize the application of virtual reality technologies on different disability types, *combinations of searching terms* were used:

S1: virtual reality technology, accessibility, and general disability;

S2: virtual reality technology, accessibility, and mental disability; and

S3: virtual reality technology, accessibility, and movement disability.

S4: virtual reality technology, accessibility, and visual impairment

The details regarding these search terms and the results are explained in a later section.

Search Databases: A comprehensive search was performed on two databases: “Web of Science” and “Google Scholar.” Six sets of searching terms were used during the searching process. Although PubMed was also initially considered, on further discussion with the

librarian, it was understood to have significant overlap with Web of Science and hence it was decided not to consider it for now.

Criteria Established for Database Searching: Beyond the specific databases and search terms used, the literature searches also required selections to be published in a peer-reviewed journal, have a publication date of 2000-2018, be published in the English language, and pertain to elderly adults. It was observed during the literature study that the hardware used for VR and interfaces has significantly changed over the years. The newer published studies have been using VR hardware with significantly improved immersion capabilities than the older ones. Hence, the articles prior to 2000 are not expected to provide more information relevant to this study. Any relevant earlier studies cited by any of the authors in the selected papers was considered, if necessary.

A total of 728 results were obtained based on the first online search.

Screening Protocol of Peer-Reviewed Journal Articles

First Screen: In the first screen, the titles of 728 articles initially identified were examined for relevance to the study and the articles which did not include the content that were relevant to the study were excluded. This examination checked for the use of any form of augmented or virtual reality with participants having the types of disabilities that will be studied. Once the articles were shortlisted, duplicates were eliminated. Based on this screening, 84 articles were selected for second screening.

Second Screen: In the second screen, the full abstract for each article were read. The articles were rejected if the content did not include the topics required for this study. Some of the reasons to reject were: not having a virtual reality hardware (the definition is vague and even non-responsive cues like picture slideshows and audio cues have been called as VR); Participants have no relevant disabilities or are under 30; Study objectives are irrelevant, e.g., purely medical in nature. Based on the second screening, 23 papers were shortlisted.

Flow Diagram of Protocol and Number of Articles

The literature search was carried out electronically in the two databases based on the search criteria explained in the previous sections. Twenty-three articles were shortlisted finally after all the exclusion criteria. These articles are profiled in Appendix C. The search and screen protocol is shown in Figure 5.

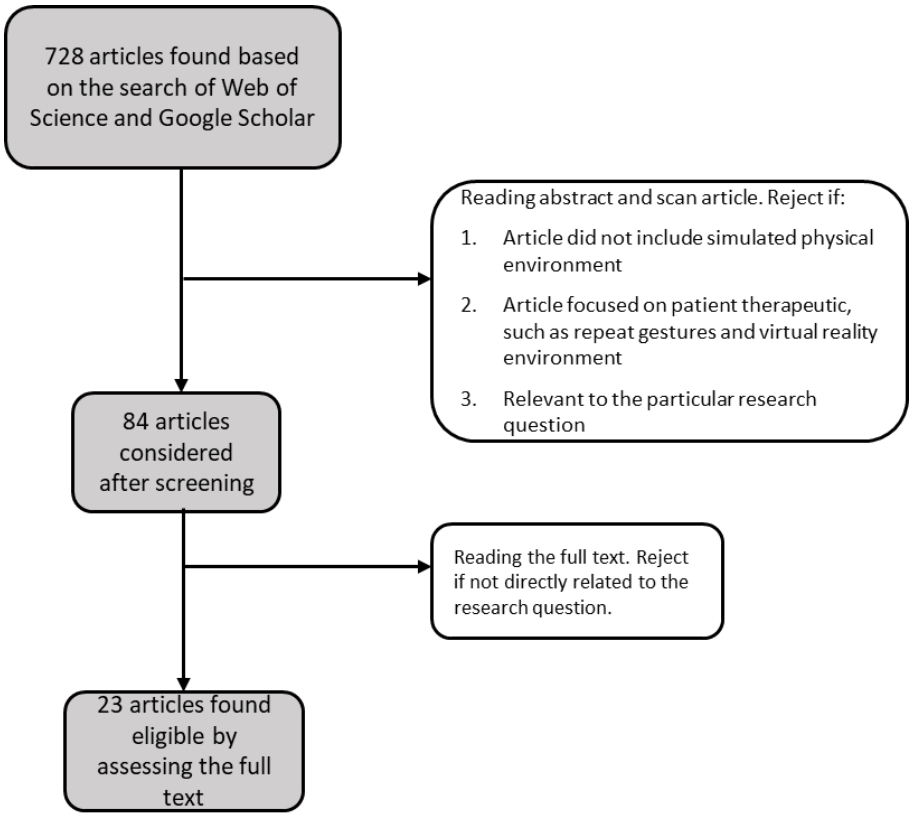

Figure 5. Flow Diagram of Decision-Making Process for Inclusion of Articles in Immersive Technologies Search

Major Findings

Correlation between real life tasks and tasks in VR: Significant correlation were found between real life tasks and tasks in virtual reality for the validation studies. Some example validation studies include: Edmans (2016) evaluated a VE developed for the rehabilitation of the task of making a hot drink; Cushman (2008) compared navigation test in real life and VE. Allain (2014) compared VR with real world for coffee making task; and Besnard (2016) found similar results for coffee making task with participants undergoing rehabilitation for traumatic brain injury.

Slowing in performance in tasks in VR environment with age and disabilities: Studies show that there is a significant slowing in performance in tasks with age and disabilities, further affecting the performance. This was seen in Cushman (2008). This article compared healthy young adults with healthy older adults, older adults with mild cognitive impairment and early Alzheimer's disease. A number of tasks that examined route learning, self-orientation, route drawing, photo recognition, photo location, video location, free recall and object recall were given to them and it was seen that the young adults outperformed all the other groups significantly in almost all the cases.

Application of VR for workspace redesign: Budziszewski (2016) used an immersive virtual reality system to help modify the work environments for persons with upper body disability

without building a physical prototype. It was found to be an efficient and time-saving method to improve design quickly. The study required the creation of avatars that would represent the participants in the virtual world. For the study, in order to be representative, sizes for the avatars were picked up based on the sizes of median male and female.

VR as a tool for navigation study: A number of studies including Faria (2016) and White (2106) showed improvement of navigation skills for participants using VR. These findings primarily deal with memory stimulus and how reflective the VR is of the real world. Harrison (2010) used VR with wheelchair users to check wheelchair accessibility of buildings and concluded that it may be possible to score buildings on ease of access and propose changes in the built environment to ease navigation and accessibility by simulating the design in VR. Harrison also used dynamic force feedback on the wheels to further improve the experience of the user in the VE.

Virtual cues as effective as real world in triggering Freezing of Gate (FoG) in Parkinson's Disease (PD) patients: Georgiades (2016) and Matar (2013) showed that cues in VR are equally capable of as real-life cues to stimulate the freeze of gait in participants with PD. Therefore, testing for the design elements in a built environment with PD participants can help in overcoming design deficiencies during design and improve the comfort in navigating the house.

Sample size diversity among studies is high: There is a large spread in the number of participants used in the studies. Some studies have as few as 1 while the highest was 87. It was also noted that 13 out of the 23 used control subjects in the study. The ideal number of participants and controls are determined by a number of conditions, including availability, statistical power, level of testing, and the like.

Gaps and Limitations

Accessing indoor building systems in VR: There are no assessments identified for accessing indoor building systems (e.g., cabinets – opening / closing of cabinet doors; drawers, cupboards, doors, windows, etc.). The current closest studies are the kitchen training tasks used for rehabilitation. This could either be because VR has not been used as a tool to study this or because such studies are not part of the databases considered.

Use of hand-glove systems in VR: Only one study showed the use of glove systems. This study did not include a fully immersive Head-Mounted Device (HMD) to complement the glove and did not provide any haptic feedback. Hence, the glove was effectively a tracker. Using a glove with haptic feedback systems in a fully immersive HMD based VE could provide the participant with a more realistic experience.

Use of VR hardware with high immersion capabilities: Most studies used VR setups with low immersion capabilities to study the performance of participants This can make the task unrealistic and can feel rather different from the real task. Higher immersion capabilities of HMD can give a better platform for the participants to experience the virtual environment. Of the 23 articles considered, only 5 used a high immersive VR system with HMD. Fifteen used

monitors with joysticks, keyboards and touchscreens, two used projector screens and one article did not mention the VR system used. Therefore, the relevance of some of the results to our study will have to be checked in detail.

HMD based VR systems for design improvement: Only one study (Budziszewski, 2016) used an HMD based VR to study human interaction with design spaces to improve the design environment. This study was performed to improve an industrial workbench and was not used for indoor space improvement. Therefore, there are no available articles with comparable VR systems that explore human interaction with design spaces.

Application of gait mats to study leg movement: Only one study (Guo, 2015) used a gait mat to analyze the gait or foot response of participants during the study. A detailed analysis of the gait can provide detailed information about what part of navigating an interior space is problematic for the participants and thereby allow for the design of better spaces.

Implications for Project Re-envision

Virtual Reality: Higher immersion capabilities illicit better place illusion and embodiment illusion for the users (Alshaer, 2017). HTC Vive has capabilities of 6 DoF tracking along with wide field of view and coupled with the high-performance computer is able to track and render imagery with minimal latency. This will provide a more realistic experience for the user and also reduce chances of cybersickness.

Familiarization tasks: Although none of the HMD based studies explicitly mentioned the need for or effect of familiarization based on the experience of users, it is suggested that the new participants be given a set of tasks to familiarize themselves with the virtual world and the HMD before the study is carried out. Tasks mentioned in the literature like virtual coffee making task, chemistry lab, etc. with a few number of steps are ideal for this purpose. The structure of these tests can be designed based on the literature if needed.

Assessment Instruments: The papers name a few assessment tests which are given to participants with disabilities. These include standardized tests, structured questionnaires and unstructured questionnaires. When analyzing the performance of interior spaces, tasks can be designed and timed to see how well the participant is able to perform in the adapted space. This can include simple and complex multi-tasking tests (Titov, 2005), tasks with increasing complexity levels, Virtual daily living test (Seo, 2017), movement hesitation measure, and gait analysis (Guo, 2015). A few sample tasks in the literature are: coffee making task, cooking task, navigational task, grocery store, parking simulation, chemistry lab tasks, and wheelchair navigation. Some instruments used specifically to study the feelings of participant's feeling about experiencing the virtual world are Witmer–Singer Presence Questionnaire 7 and the Slater–Usoh–Steed Questionnaire 8 (Guo, 2015)

BIBLIOGRAPHY

CHAPTER 1

Barrier Free Environments. (1991). *The Accessible Housing Design File* (1st ed.): Wiley.

Bowes, A., Dawson, A., Greasley-Adams, C., & McCabe, L. (2016). Design of residential environments for people with dementia and sight loss: A structured literature review. *British Journal of Visual Impairment, 34*(3), 225-237. doi:https://doi.org/10.1177/0264619616653991

Boys, J. (2014). *Doing Disability Differently: An alternative handbook on architecture, dis/ability and designing for everyday life*: Routledge.

Bo'sher, L., Chan, S., Ellen, I. G., Karfunkel, B., & Liao, H.-L. (2015). *Accessibility of America's Housing Stock: Analysis of the 2011 American Housing Survey (AHS)*. Retrieved from

https://www.huduser.gov/portal/sites/default/files/pdf/accessibility-america-housingStock.pdf

Calkins, M. P. (1988). *Design for Dementia: Planning Environments for the Elderly and the Confused*: Natl Health Pub.

Carnemolla, P., & Bridge, C. (2018). A scoping review of home modification interventions – Mapping the evidence base. *Indoor and Built Environment*, 12. doi:https://doi.org/10.1177/1420326X18761112

Chase, C. A., Mann, K., Wasek, S., & Arbesman, M. (2012). Systematic review of the effect of home modification and fall prevention programs on falls and the performance of community-dwelling older adults. *Am J Occup Ther, 66*(3), 284-291. doi:10.5014/ajot.2012.005017

Cho, H. Y., MacLachlan, M., Clarke, M., & Mannan, H. (2016). Accessible Home Environments for People with Functional Limitations: A Systematic Review. *International Journal of Environmental Research and Public Health, 13*(8). doi:10.3390/ijerph13080826

Cohen, U., & Weisman, G. D. (1991). *Holding Onto Home: Designing Environments for People with Dementia* (1 ed.): The Johns Hopkins University Press.

Edwards, C., & Harold, G. (2014). DeafSpace and the principles of universal design. *Disabil Rehabil, 36*(16), 1350-1359. doi:10.3109/09638288.2014.913710

Grant, M. J., & Booth, A. (2009). A typology of reviews: an analysis of 14 review types and associated methodologies. *Health Info Libr J, 26*(2), 91-108. doi:10.1111/j.1471-1842.2009.00848.x

Hamraie, A. (2017). *Building Access: Universal Design and the Politics of Disability*: Univ Of Minnesota Press.

Helle, T., Brandt, A., Slaug, B., & Iwarsson, S. (2011). Lack of research-based standards for accessible housing: problematization and exemplification of consequences. *International Journal of Public Health, 56*(6), 635-644. doi:10.1007/s00038-011-0290-4

Higgins, J., & Green, S. (2011). *Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 [updated March 2011]*: The Cochrane Collaboration.

Hobson, D. A., & Molenbroek, J. F. (1990). Anthropometry and design for the disabled: experiences with seating design for the cerebral palsy population. *Appl Ergon, 21*(1), 43-54.

Houser, A., Fox-Grage, W., & Ujvari, K. (2018). *Across the States: Profiles of Long-Term Services and Supports*. Washington, D.C.:Retrieved from https://www.aarp.org/content/dam/aarp/ppi/2018/08/across-the-states-profiles-of-long-term-services-and-supports-full-report.pdf

Fair Housing Act Design Manual: A Manual to Assist Designers and Builders in Meeting the Accessibility Requirements of the Fair Housing Act, (1996).

Imrie, R. (2005). *Accessible Housing: Quality, Disability and Design* (1st ed.): Routledge.

Jordan, W. A. (2008). *Universal Design for the Home: Great Looking, Great Living Design for All Ages, Abilities and Circumstances* (1st ed.): Quarry Books.

Kamieth, F., Dähne, P., Wichert, R., Villalar, J. L., Jimenez-Mixco, V., Arca, A., & Arredondo, M. T. (2010). Exploring the Potential of Virtual Reality for the Elderly and People with Disabilities. In J.-J. Kim (Ed.), *Virtual Reality*: InTech.

Kaye, H. S., Kang, T., & LaPlant, M. P. (2000). *Mobility Device Use in the United States*. Retrieved from Washington, D.C.:

Leibrock, C. A., & Terry, J. E. (1999). *Beautiful Universal Design: A Visual Guide* (2nd ed.): John Wiley & Sons, Inc.

NAHB Research Center & Barrier Free Environments. (1996). *Residential Remodeling and Universal Design: Making Homes More Comfortable and Affordable*. Retrieved from Raleigh, NC: https://www.huduser.gov/publications/pdf/remodel.pdf

OZ Architecture Urban Design Interior Design & Enterprise Green Communities. (2016). *Aging in Place Design Guidelines for Independent Living in Multifamily Buildings* Enterprise Community Partners.

Pierce, D. (2012). *The Accessible Home: Designing for All Ages and Abilities* (P. Chapman Ed.): The Taunton Press.

Preiser, W. F. E., & Smith, K. H. (2010). *Universal Design Handbook*. New York: McGraw Hill Education.

Queirós, A., Silva, A., Alvarelhão, J., Rocha, N. P., & Teixeira, A. (2015). Usability, accessibility and ambient-assisted living: a systematic literature review. *Universal Access in the Information Society, 14*(1), 57-66. doi:10.1007/s10209-013-0328-x

Sanford, J. A. (2012). *Universal design as a rehabilitation strategy: design for ages*. New York, NY: Springer Publishing Company, LLC.

Smith, K., H., Webb, J., & Williams, B., T. (2010). *Just Below the Line Disability, Housing, and Equity in the South*. Fayetteville, AR: The University of Arkansas Press.

Stark, S., Keglovits, M., Arbesman, M., & Lieberman, D. (2017). Effect of Home Modification Interventions on the Participation of Community-Dwelling Adults With Health Conditions: A Systematic Review. *Am J Occup Ther, 71*(2), 7102290010p7102290011-7102290010p7102290011. doi:10.5014/ajot.2017.018887

Steele, K., & Ahrentzen, S. (2016). *At Home With Autism Designing Housing For The Spectrum*. Great Britain: Policy Press.

Steinfeld, E., D'Souza, C., & White, J. (2014). Developing Evidence-Based Standards: A Case Study in Knowledge Translation In H. Caltenco (Ed.), *Universal Design 2014: Three Days of Creativity and Diversity* (Vol. 35, pp. 89-98): IOS Press.

Steinfeld, E., & Danford, G. S. (1999). *Enabling Environments: Measuring the Impact of Environment on Disability and Rehabilitation*: Springer.

Steinfeld, E., & Maisel, J. (2012). *Universal Design: Creating Inclusive Environments*: John Wiley & Sons.

Steinfeld, E., White, J. R., & Levine, D. R. (2010). *Inclusive Housing: A Pattern Book Design for Diversity and Equality* (1st ed.). New York: W. W. Norton & Company, Inc.

Steven Winter Associates, Inc. (1997). *Accessible Housing By Design Universal Design Principles In Practice*: McGraw-Hill.

Steven Winter Associates, Inc. (2001). *A Basic Guide to Fair Housing Accessibility : Everything Architects and Builders Need to Know About the Fair Housing Act Accessibility Guidelines* (1st ed.): Wiely.

Struckmeyer, L. R., & Pickens, N. D. (2016). Home Modifications for People With Alzheimer's Disease: A Scoping Review. *Am J Occup Ther, 70*(1), 7001270020p7001270021-7001270029. doi:10.5014/ajot.2015.016089

Tricco, A. C., Antony, J., Zarin, W., Strifler, L., Ghassemi, M., Ivory, J., . . . Straus, S. E. (2015). A scoping review of rapid review methods. *BMC Med, 13*, 224. doi:10.1186/s12916-015-0465-6

Wylde, M., Clark, S., & Baron-Robbins, A. (1994). *Building for a Lifetime: The Design and Construction of Fully Accessible Ho* (1st ed.): Taunton Press.

CHAPTER 2

Aplin, T., Jonge, D. D., & Gustafsson, L. (2014). Understanding home modifications impact on clients and their familys experience of home: A qualitative study. *Australian Occupational Therapy Journal, 62*(2), 123-131. doi:10.1111/1440-1630.12156

Callaway, L., Tregloan, K., Williams, G., & Clark, R. (2016). Evaluating Access and Mobility within a New Model of Supported Housing for People with Neurotrauma: A Pilot Study. *Brain Impairment, 17*(01), 64-76. doi:10.1017/brimp.2016.7

Carnemolla, P., & Bridge, C. (2016). Accessible Housing And Health-Related Quality Of Life: Measurements Of Wellbeing Outcomes Following Home Modifications. *International Journal of Architectural Research: ArchNet-IJAR, 10*(2), 38. doi:10.26687/archnet-ijar.v10i2.977

Carnemolla, P., & Bridge, C. (2018). A scoping review of home modification interventions – Mapping the evidence base. *Indoor and Built Environment*. doi:10.1177/1420326x18761112

Ekstam, L., Carlsson, G., Chiatti, C., Nilsson, M. H., & Fänge, A. M. (2014). A research-based strategy for managing housing adaptations: Study protocol for a quasi-experimental trial. *BMC Health Services Research, 14*(1). doi:10.1186/s12913-014-0602-5

Granbom, M., Iwarsson, S., Kylberg, M., Pettersson, C., & Slaug, B. (2016). A public health perspective to environmental barriers and accessibility problems for senior citizens living in ordinary housing. *BMC Public Health, 16*(1). doi:10.1186/s12889-016-3369-2

Granbom, M., Taei, A., & Ekstam, L. (2017). Cohabitants' perspective on housing adaptations: A piece of the puzzle. *Scandinavian Journal of Caring Sciences, 31*(4), 805-813. doi:10.1111/scs.12400

Helle, T., Iwarsson, S., & Brandt, Å. (2013). Validation of Housing Standards Addressing Accessibility. *Journal of Applied Gerontology, 33*(7), 848-869. doi:10.1177/0733464813503042

Heywood. (2004). The health outcomes of housing adaptations. *Disability & Society, 19*(2), 129-143. doi:10.1080/0968759042000181767

Kim, H., Ahn, Y. H., Steinhoff, A., & Lee, K. H. (2014). Home modification by older adults and their informal caregivers. *Archives of Gerontology and Geriatrics, 59*(3), 648-656. doi:10.1016/j.archger.2014.07.012

Lansley, P., Mccreadie, C., Tinker, A., Flanagan, S., Goodacre, K., & Turner-Smith, A. (2004). Adapting the homes of older people: A case study of costs and savings. *Building Research & Information, 32*(6), 468-483. doi:10.1080/0961321042000269429

Meucci, M. R., Gozalo, P., Dosa, D., & Allen, S. M. (2016). Variation in the Presence of Simple Home Modifications of Older Americans: Findings from the National Health and Aging Trends Study. *Journal of the American Geriatrics Society, 64*(10), 2081-2087. doi:10.1111/jgs.14252

Murphy, S. L., Nyquist, L. V., Strasburg, D. M., & Alexander, N. B. (2006). Bath Transfers in Older Adult Congregate Housing Residents: Assessing the Personâ"Environment Interaction. *Journal of the American Geriatrics Society, 54*(8), 1265-1270. doi:10.1111/j.1532-5415.2006.00814.x

Norin, L., Slaug, B., Haak, M., Jörgensen, S., Lexell, J., & Iwarsson, S. (2016). Housing accessibility and its associations with participation among older adults living with long-standing spinal cord injury. *The Journal of Spinal Cord Medicine, 40*(2), 230-240. doi:10.1080/10790268.2016.1224541

Reid, D., Angus, J., McKeever, P.,& Miller, K.L. (2003). Home is where their wheels are: Experiences of women wheelchair users. *American Journal of Occupational Therapy, 57*(2), 186-195.

Renaut, S., Ogg, J., Petite, S., & Chamahian, A. (2014). Home environments and adaptations in the context of ageing. *Ageing and Society, 35*(06), 1278-1303. doi:10.1017/s0144686x14000221

Sakellariou, D. (2015). Home Modifications and Ways of Living Well. *Medical Anthropology, 34*(5), 456-469. doi:10.1080/01459740.2015.1012614

Stark, S., Keglovits, M., Arbesman, M., & Lieberman, D. (2017). Effect of Home Modification Interventions on the Participation of Community-Dwelling Adults With Health Conditions: A Systematic Review. *American Journal of Occupational Therapy, 71*(2). doi:10.5014/ajot.2017.018887

Szanton, S. L., Thorpe, R. J., Boyd, C., Tanner, E. K., Leff, B., Agree, E., & Gitlin, L. N. (2011). Community Aging in Place, Advancing Better Living for Elders: A Bio-Behavioral-Environmental Intervention to Improve Function and Health-Related Quality of Life in

Disabled Older Adults. *Journal of the American Geriatrics Society, 59*(12), 2314-2320. doi:10.1111/j.1532-5415.2011.03698.x

Vrendenburgh, A.G., Williams, K., Zackowitz, I.B., & Welner, J. (2010). Evaluation of wheelchair users' perceived kitchen and bathroom usability: Effort and accessibility. *Journal of Architecture and Planning Research*, *27*(3), 219-236.

CHAPTER 3

References marked with an asterisk (*) indicate studies included in this literature review.

Aromataris E., Munn, Z. (Editors).(2017). *Joanna Briggs Institute Reviewers Manual.* The Joanna Briggs Institute. Available from https://reviewersmanual.joannabriggs.org

*Barstow, B. A., Bennett, D. K., & Vogtle, L. K. (2011). Perspectives on home safety: Do home safety assessments address the concerns of clients with vision loss?. *American Journal of Occupational Therapy*, *65*(6), 635-642.

*Bouldin, E. D., Andresen, E. M., Bauer, S. E., Whitney, C., Tamayo, C. C., Schumacher, J. R., & Hall, A. G. (2015). Visitability surveillance, prevalence, and correlates in Florida. *8*(1), 140-145.

Chase, C. A., Mann, K., Wasek, S., & Arbesman, M. (2012). Systematic review of the effect of home modification and fall prevention programs on falls and the performance of community-dwelling older adults. *American Journal of Occupational Therapy*, *66*(3), 284-291.

Dutta, T., King, E., Holliday, P. Gorski, S., & Fernie, G. (2011). Design of built environments to accommodate mobility scooter users: Part I. *Disability & Rehabilitation: Assistive Technology, 6,* 67-76. doi:10.3109/17483107.2010.509885Ekstam, L., Carlsson, G., Chiatti, C., Nilsson, M. H., & Fänge, A. M. (2014). A research-based strategy for managing housing adaptations: study protocol for a quasi-experimental trial. *BMC health services research*, *14*(1), 602.

*Ekstam, L. Carlsson, G., Chiatti, C., Nilsson, M., & Fange, A. (2014). A research-based stragety for managing housing adaptations: study protocol for a quasi-experimental trial. *BMC Health Services Research,* 14:602. doi 10.1186/s12913-014-0602-5

*Ewen, H. H., Hahn, S. J., Erickson, M. A., & Krout, J. A. (2014). Aging in place or relocation? Plans of community-dwelling older adults. *Journal of Housing for the Elderly*, *28*(3), 288-309.

*Fänge, A., & Iwarsson, S. (2003). Accessibility and usability in housing: construct validity and implications for research and practice. *Disability and Rehabilitation*, *25*(23), 1316-1325.

*Fänge, A., & Iwarsson, S. (2005). Changes in accessibility and usability in housing: an exploration of the housing adaptation process. *Occupational Therapy International*, *12*(1), 44-59.

*Fänge, A., & Iwarsson, S. (2005). Changes in ADL dependence and aspects of usability following housing adaptation—a longitudinal perspective. *American Journal of Occupational Therapy*, *59*(3), 296-304.

*Fänge, A., & Iwarsson, S. (2007). Challenges in the development of strategies for housing adaptation evaluations. *Scandinavian journal of occupational therapy*, *14*(3), 140-149.

*Gray, D. B., Hollingsworth, H. H., Stark, S., & Morgan, K. A. (2008). A subjective measure of environmental facilitators and barriers to participation for people with mobility limitations. *Disability and rehabilitation*, *30*(6), 434-457.

Harker, J., & Kleijnen, J. (2012). What is a rapid review? A methodological exploration of rapid reviews in health technology assessments. *International Journal of Evidence-Based Healthcare, 10*, 397-410.

*Helle, T., Iwarsson, S., & Brandt, Å. (2014). Validation of housing standards addressing accessibility: exploration of an activity-based approach. *Journal of Applied Gerontology*, *33*(7), 848-869.

*Helle, T., Nygren, C., Slaug, B., Brandt, A., Pikkarainen, A., Hansen, A. G., & Iwarsson, S. (2010). The Nordic Housing Enabler: Inter-rater reliability in cross-Nordic occupational therapy practice. *Scandinavian Journal of Occupational Therapy*, *17*(4), 258-266.

*Horowitz, B. P., Nochajski, S. M., & Schweitzer, J. A. (2013). Occupational therapy community practice and home assessments: Use of the Home Safety Self-Assessment Tool (HSSAT) to support aging in place. *Occupational therapy in health care*, *27*(3), 216-227.

*Iwarsson, S., & Wilson, G. (2006). Environmental barriers, functional limitations, and housing satisfaction among older people in Sweden: A longitudinal perspective on housing accessibility. *Technology and Disability*, *18*(2), 57-66.

Khangura, S., Konnyu, K., Cushman, R., Grimshaw, J., & Moher, D. (2012). Evidence summaries: the evolution of a rapid review approach. *Systematic Reviews, 1*(10), 1-9.

*Morales, E., & Rousseau, J. (2010). Which areas of the home pose most difficulties for adults with motor disabilities?. *Physical & Occupational Therapy in Geriatrics*, *28*(2), 103-116.

*Naik, A. D., & Gill, T. M. (2005). Underutilization of environmental adaptations for bathing in community-living older persons. *Journal of the American Geriatrics Society*, *53*(9), 1497-1503.

*Oswald, F., Wahl, H. W., Schilling, O., Nygren, C., Fänge, A., Sixsmith, A., ... & Iwarsson, S. (2007). Relationships between housing and healthy aging in very old age. *The Gerontologist*, *47*(1), 96-107.

*Petersson, I., Fisher, A. G., Hemmingsson, H., & Lilja, M. (2007). The Client-Clinician Assessment Protocol (C-CAP): Evaluation of its psychometric properties for use with people aging with disabilities in need of home modifications. *OTJR: Occupation, Participation and Health*, *27*(4), 140-148.

*Reid, D. (2004). Accessibility and usability of the physical housing environment of seniors with stroke. *International Journal of Rehabilitation Research*, *27*(3), 203-208.

Rodgers, M., Thomas, S., Harden, M., Parker, G., Street, A., & Eastwood, A. (2016). Developing a methodological framework for organisational case studies: a rapid review and consensus development process. *Health Services and Delivery Research, 4*(1).

*Rousseau, J., Potvin, L., Dutil, É., & Falta, P. (2013). Home assessment of person-environment Interaction (HoPE): Content validation process. *Occupational therapy in health care*, *27*(4), 289-307.

*Schulz, C. H., Hersch, G. I., Foust, J. L., Wyatt, A. L., Godwin, K. M., Virani, S., & Ostwald, S. K. (2012). Identifying occupational performance barriers of stroke survivors: Utilization of a home assessment. *Physical & occupational therapy in geriatrics*, *30*(2), 109-123.

*Sim, S., Barr, C. J., & George, S. (2015). Comparison of equipment prescriptions in the toilet/bathroom by occupational therapists using home visits and digital photos, for patients in rehabilitation. *Australian occupational therapy journal*, *62*(2), 132-140.

*Slaug, B., Schilling, O., Iwarsson, S., & Carlsson, G. (2015). Typology of person-environment fit constellations: a platform addressing accessibility problems in the built environment for people with functional limitations. *BMC public health*, *15*(1), 834.

*Somerville, E., Smallfield, S., Stark, S., Seibert, C., Arbesman, M., & Lieberman, D. (2016). Occupational therapy home modification assessment and intervention. *American journal of occupational therapy*, *70*(5), 7005395010p1-7005395010p3.

*Stark, S. (2004). Removing environmental barriers in the homes of older adults with disabilities improves occupational performance. *OTJR: Occupation, Participation and Health*, *24*(1), 32-40.

*Tongsiri, S., Ploylearmsang, C., Hawsutisima, K., Riewpaiboon, W., & Tangcharoensathien, V. (2017). Modifying homes for persons with physical disabilities in Thailand. *Bulletin of the World Health Organization*, *95*(2), 140.

Tricco, A. C., Antony, J., Zarin, W., Strifler, L., Ghassemi, M., Ivory, J., Perrier, L., Hutton, B., Moher, D., & Straus, S. E. (2015). A scoping review of rapid review methods. *BMC Medicine, 13*(224).

*Vredenburgh, A. G., Williams, K., Zackowitz, I. B., & Welner, J. M. (2010). Evaluation of wheelchair user's perceived kitchen and bathroom usability: effort and accessibility. *Journal of Architectural and Planning Research*, 219-236.

CHAPTER 4

Allain, P., Foloppe, D. A., Besnard, J., Yamaguchi, T., Etcharry-Bouyx, F., Le Gall, D., . . . Richard, P. (2014). Detecting Everyday Action Deficits in Alzheimer's Disease Using a Nonimmersive Virtual Reality Kitchen. *Journal of the International Neuropsychological Society, 20*(5), 468-477. doi:10.1017/s1355617714000344

Alshaer, A., Regenbrecht, H., & O'Hare, D. (2017). Immersion factors affecting perception and behaviour in a virtual reality power wheelchair simulator. *Applied Ergonomics, 58*, 1-12. doi:10.1016/j.apergo.2016.05.003

Besnard, J., Richard, P., Banville, F., Nolin, P., Aubin, G., Le Gall, D., . . . Allain, P. (2016). Virtual reality and neuropsychological assessment: The reliability of a virtual kitchen to assess daily-life activities in victims of traumatic brain injury. *Applied Neuropsychology-Adult, 23*(3), 223-235. doi:10.1080/23279095.2015.1048514

Budziszewski, P., Grabowski, A., Milanowicz, M., & Jankowski, J. (2016). Workstations for people with disabilities: an example of a virtual reality approach. *International Journal of Occupational Safety and Ergonomics, 22*(3), 367-373. doi:10.1080/10803548.2015.1131069

Cushman, L. A., Stein, K., & Duffy, C. J. (2008). Detecting navigational deficits in cognitive aging and Alzheimer disease using virtual reality. *Neurology, 71*(12), 888-895. doi:10.1212/01.wnl.0000326262.67613.fe

Edmans, J. A., Gladman, J. R. F., Cobb, S., Sunderland, A., Pridmore, T., Hilton, D., & Walker, M. F. (2006). Validity of a virtual environment for stroke rehabilitation. *Stroke, 37*(11), 2770-2775. doi:10.1161/01.str.0000245133.50935.65

Faria, A. L., Andrade, A., Soares, L., & Badia, S. B. I. (2016). Benefits of virtual reality based cognitive rehabilitation through simulated activities of daily living: a randomized controlled trial with stroke patients. *Journal of Neuroengineering and Rehabilitation, 13*. doi:10.1186/s12984-016-0204-z

Georgiades, M. J., Gilat, M., Martens, K. A. E., Walton, C. C., Bissett, P. G., Shine, J. M., & Lewis, S. J. G. (2016). Investigating Motor Initiation and Inhibition Deficits in Patients with Parkinson's Disease and Freezing of Gait Using a Virtual Reality Paradigm. *Neuroscience, 337*, 153-162. doi:10.1016/j.neuroscience.2016.09.019

Guo, R. K., Samaraweera, G., & Quarles, J. (2015). Mobility impaired users respond differently than healthy users in virtual environments. *Computer Animation and Virtual Worlds, 26*(5), 509-526. doi:10.1002/cav.1610

Harrison, C. S., Grant, P. M., & Conway, B. A. (2010). Enhancement of a Virtual Reality Wheelchair Simulator to Include Qualitative and Quantitative Performance Metrics. *Assistive Technology, 22*(1), 20-31. doi:10.1080/10400430903520223

Matar, E., Shine, J. M., Naismith, S. L., & Lewis, S. J. G. (2013). Using virtual reality to explore the role of conflict resolution and environmental salience in Freezing of Gait in Parkinson's disease. *Parkinsonism & Related Disorders, 19*(11), 937-942. doi:10.1016/j.parkreldis.2013.06.002

Seo, K., Kim, J. K., Oh, D. H., Ryu, H., & Choi, H. (2017). Virtual daily living test to screen for mild cognitive impairment using kinematic movement analysis. *Plos One, 12*(7). doi:10.1371/journal.pone.0181883

Titov, N., & Knight, R. G. (2005). A computer-based procedure for assessing functional cognitive skills in patients with neurological injuries: The virtual street. *Brain Injury, 19*(5), 315-322. doi:10.1080/02699050400013725

White, P. J. F., & Moussavi, Z. (2016). Neurocognitive Treatment for a Patient with Alzheimer's Disease Using a Virtual Reality Navigational Environment. *Journal of Experimental Neuroscience, 10*, 129-135. doi:10.4137/jen.s40827