A multidisciplinary examination of walkability: Its concept, assessment and applicability

by

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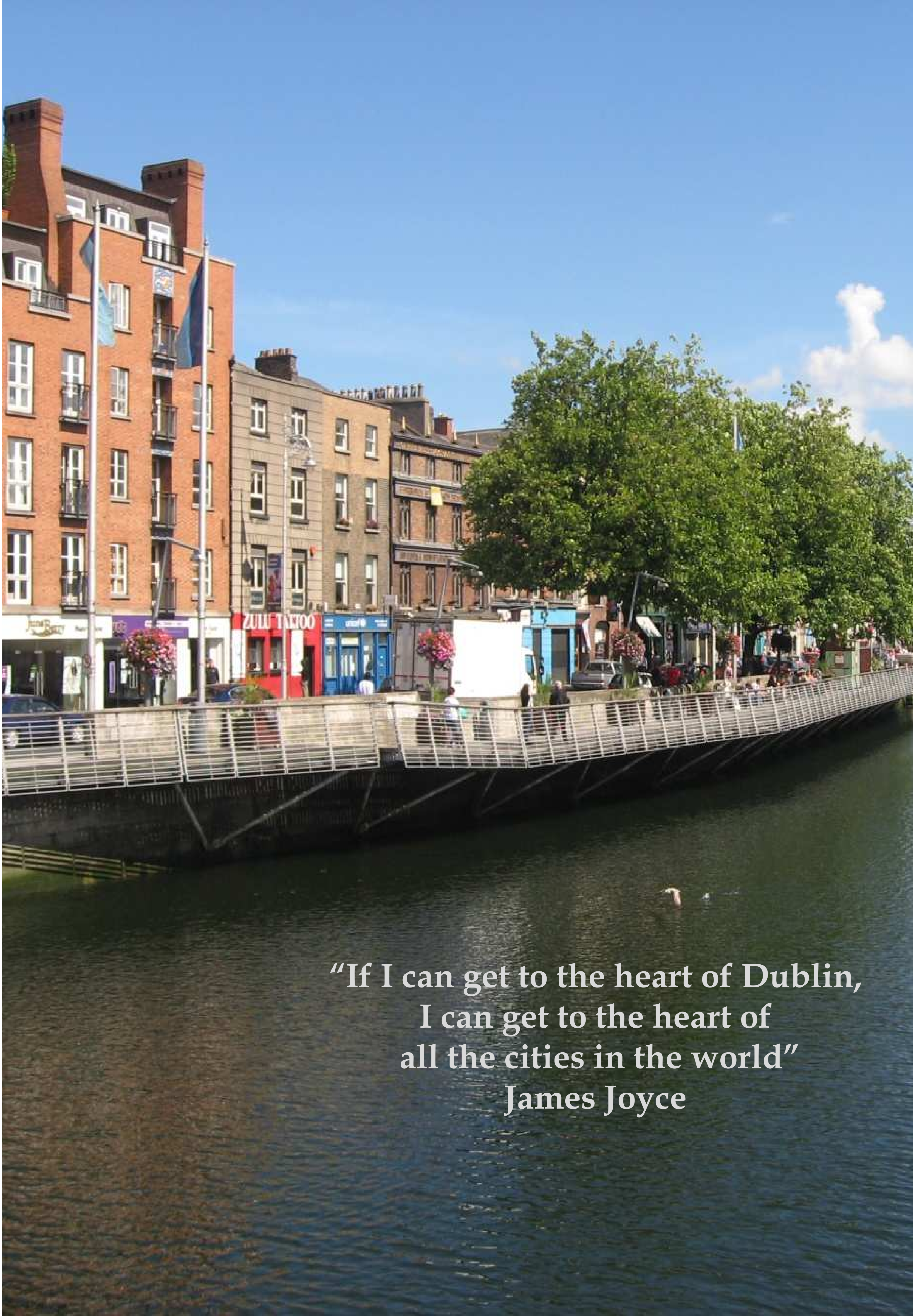

**"If I can get to the heart of Dublin,
I can get to the heart of
all the cities in the world"
James Joyce**

Declaration

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Abstract

This thesis explores the term 'walkability', how it is understood, measured and what role it plays in neighbourhood mobility and physical activity behaviours. Two groups are of interest in this study, the professionals tasked with planning and designing neighbourhoods and the residents who live within these environments.

This thesis outlines a mixed methods project comprising of a literature review and four studies. The literature review analyses the concept of walkability with particular focus on identifying and collating neighbourhood features associated with walking behaviour and how they are measured. An online survey was used to understand level of ambiguity, or agreement, between relevant professions on the elements of walkable environments in study one. Study two further explores walkability using a phenomenological study with a select group from study one. In study three, a novel site selection process, based on the findings of the previous studies, was used to identify high and low walkable areas in the Greater Dublin Area. Study four describes a cross sectional study which was undertaken to investigate the environmental perceptions and behaviours of residents living in identified neighbourhoods. Univariate analyses were carried out on correlates of interest to compare the four area catagories; high walkable deprived, high walkable not deprived, low walkable deprived and low walkable not deprived.

In conclusion, ambiguity exists in both the understanding and measurement of walkability. Neighbourhood walkability is dependent on the physical environment, the social environment, and how both are perceived. They key elements for consideration are: (i) scale, (ii) permeability, (iii) a liveable village centre and (iv) the streetscape with particular emphasis on transparency and no visual disorder. A model was proposed for future multivariate analysis which considers the many influential correlates of walkability.

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Ian, I dedicate this thesis to you. Not least because you deserve a medal for putting up with me through this process, but because without you this PhD would never have happened. Your love, encouragement and support was unfailing. There aren't many couples who spend the first few months of marriage knocking on doors around a city. I'll forever be indebted to you for the transcribing, coding, questionnaire reviewing and cooking. I'm looking forward to making it up to you for the rest of our lives. Jellytots x

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Fitzsimons, L., Nelson, N.M., Leyden, K.M., Wickham, J. and Woods, C.

Walkability means what, to whom? Difficulties and challenges in defining walkability.

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Conference presentations (Peer reviewed abstracts, no papers):

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19th Irish Environmental Researchers Colloquium, Environ 2009, Waterford Institute of Technology, Waterford, Ireland, 18th to 20th February 2009

Other Publications:

Leyden, KM and Fitzsimons D'Arcy, L. 2012. *Heritage, Planning, and Health: the benefits of good planning practice.* The eZine of the Heritage Council. (November).

Co-authored paper and presented launch presentation

The National Heart Alliance '*Building Young Hearts*', launched April 14th 2010, Dublin

1 Introduction

This thesis is an exploration of the term 'walkability' and an account of the method development and preliminarily findings of the Cleaner, Greener, Leaner Study (CGL). A conceptual model illustrating the role of the environment on mobility behaviour is proposed based on the findings of this thesis. The CGL study is an investigation of the influence of neighbourhood walkability on resident's physical activity and transport behaviours in the Greater Dublin Area (GDA). It was funded by the Environmental Protection Agency (EPA) under their STRIVE programme (EPA 2013), a research funding stream supported by Ireland's National Development Plan (NDP) (REF: 2008-PhD-CC-1). A multi-disciplinary team consisting of researchers from public health, exercise science, social cohesion/ political science and transportation/ migration economics obtained funding for the CGL population study on 16 neighbourhoods in the GDA within four categories: high walkability low socio-economic status, low walkable low socio-economic status, high walkable high socio-economic status and low walkable high socio-economic status. The author was recruited to undertake the CGL research study.

1.1 Walkability

Informed by my professional knowledge and my experience of Irish development planning practices alongside a familiarity of physical activity promotion I undertook this project with what I believed was a comprehensive knowledge of walkability. However, as I researched into the concept of 'walkability' I discovered that my own understanding of the term was heavily biased by my academic training as a civil engineer and subsequent work as a transportation planner. What I considered best practice in physical environmental design for walkability was both complemented and contradicted by information obtained from casual conversations about my proposed research with former colleagues, with friends from other relevant professions and from preliminary literature and internet searches. Reflection on this diverse information prompted me to ask two questions i) what is walkability? and ii) How is it understood by different relevant professionals and those involved in physical activity promotion and public health? I believed this information was an essential step before selecting areas of high and low 'walkability' for inclusion in the CGL study. This information would (i) ensure that the process used to assign a walkability status to an area was not biased by a particular research field and encompassed as many neighbourhood design aspects associated with walkability by various disciplines as possible, (ii) contribute to the development of the research field and (iii) ensure the transferability of the information by ensuring its relevance to those who are tasked with considering walkability in their design practices.

To investigate the influence of the environment on walking behaviours, and subsequently health, we need to better understand the meaning of the concept walkability. Studies one and two of this thesis outline multi-disciplinary quantitative and qualitative studies designed to inform a working definition for walkability from an Irish context for use in this project.

1.2 The Role of the Environment on Behaviours

It is hypothesised that the way we plan and design our communities and transport systems matters for sustainable transport behaviours, human health and the natural environment. Ecological models emphasise the role of the intra (personal) and extra-individual (social, physical, contextual) variables on behaviour outcomes (TRB, 2005; Pikora *et al.*, 2003; King *et al.*, 2002; Humpel *et al.*, 2002; Sallis *et al.*, 1998; Stokols, 1992). Five levels of influence of the social ecological model were proposed by McLeroy and colleagues (1988) interpersonal (the individual), interpersonal (between people), institution (e.g. churches, schools or workplaces), community level and policy level. Ecological models not only assume that multiple levels of influence exist but also that these levels are interactive and reinforcing and may have different effects on individual people differently depending on their unique beliefs and practice, thus conceptualising behaviours, and outcomes such as health, as determined by an interplay of environment and individual factors (Golden and Earp, 2012).

Ecological models are considered appropriate for analysing the complex link between environments (social and physical) and physical activity and are frequently used for this purpose (Pikora *et al.*, 2003; King *et al.*, 2002; Sallis *et al.*, 1998). It is believed that the decrease in the number of people meeting the minimum physical activity requirements is exacerbated by the environmental barriers to walking and cycling to fulfil daily transport and recreational needs (Brownson *et al.*, 2009; Saelens and Handy, 2008; TRB, 2005; Sallis *et al.*, 1998). Historically, walking was the primary mode of transport for most humans (Ingold, 2004), however advancements in technology and residential patterns (inter alia home locations, work locations) have resulted in a modal change to motorised modes, predominately in recent years to the car (Frumkin *et al.*, 2004). The increase in motorised transport trips has environmental implications. Increased fuel usage results in greater transport related carbon emission which in turn can impact on the air quality and respiratory health of inhabitants (Younger *et al.*, 2008). An opportunity exists to reverse increasing motorised transport and reducing walking trends by designing and retrofitting neighbourhoods to make them more walkable or pedestrian friendly. It is also hypothesised that the way we design, plan and build our environments can influence the perceptions of the residents of these environments and that these perceptions could have an association with physical activity and mobility behaviours. The behaviours of interest in this thesis are recreational walking and transport behaviours. These transport behaviours include walking, other active travel such as cycling, public transport use and motorised transport behaviour.

1.3 Mixed Method Research

Mixed method research refers to the use of both qualitative and quantitative methods in one study, concurrently or one nested in the other, or sequentially in two or more studies drawing inferences from both approaches (Hesse-Biber and Leavy, 2011; Teddlie and Tashakkori, 2009; Creswell and Plano Clark, 2007). Qualitative research methods are defined as 'the techniques associated with the gathering, analysis, interpretation, and presentation of narrative information' (Teddlie & Tashakkori, 2009, p.343). Qualitative research gives information on individual level lived experiences and is useful to obtain in-depth perspectives and interpretations on a particular concept or phenomenon. However it is not very useful for getting an overall picture and can be costly in terms of time and finance (Hesse-Biber and Leavy, 2011; Creswell and Plano Clark, 2007). Quantitative research methods are defined as 'the techniques associated with the gathering, analysis, interpretation and presentation of numerical information'

(Teddlie & Tashakkori, 2009, p.343). Research hypotheses are tested and results can be generalised for large populations but may be influenced by biased researcher questioning and interpretation (Hesse-Biber and Leavy, 2011; Creswell and Plano Clark, 2007). A synergistic research project can be created using mixed methods as one method can enable another to be more effective by providing a fuller understanding of the research problem (Hesse-Biber and Leavy, 2011).

Mixed method research encourages researchers to combine inductive and deductive thinking to answer questions that cannot be answered by qualitative or quantitative approaches alone (Creswell and Plano Clark, 2007). The combination of methods can assist in tackling highly complex problems involving several layers of understanding (Hesse-Biber and Leavy, 2011). However, mixed method research is not easy as it requires the researcher to be proficient in both forms of inquiry and it takes time to collect the required data (Creswell and Plano Clark, 2007). Reasons why researchers might want to use a mixed method approach include (i) using different theoretical approaches on the same research question to enhance credibility (triangulation), (ii) to give a fuller understanding of a research question or to clarify a result (complementarity), (iii) to use result from one method to develop or inform another method (development), (iv) where a studies results raise questions or contain contradictions which require clarification (initiation) or (v) where a researcher decides to expand into a whole new investigation (expansion) (Hesse-Biber and Leavy, 2011; Greene *et al.*, 1989).

This thesis addresses 'Walkability'. The concept is investigated using a multiple-study mixed method programme of inquiry, or sequential mixed-method studies, where each study is reported separately as a distinct study but overall the programme of inquiry is mixed method (Creswell and Plano Clark, 2007). Figure 1-1 shows how the qualitative

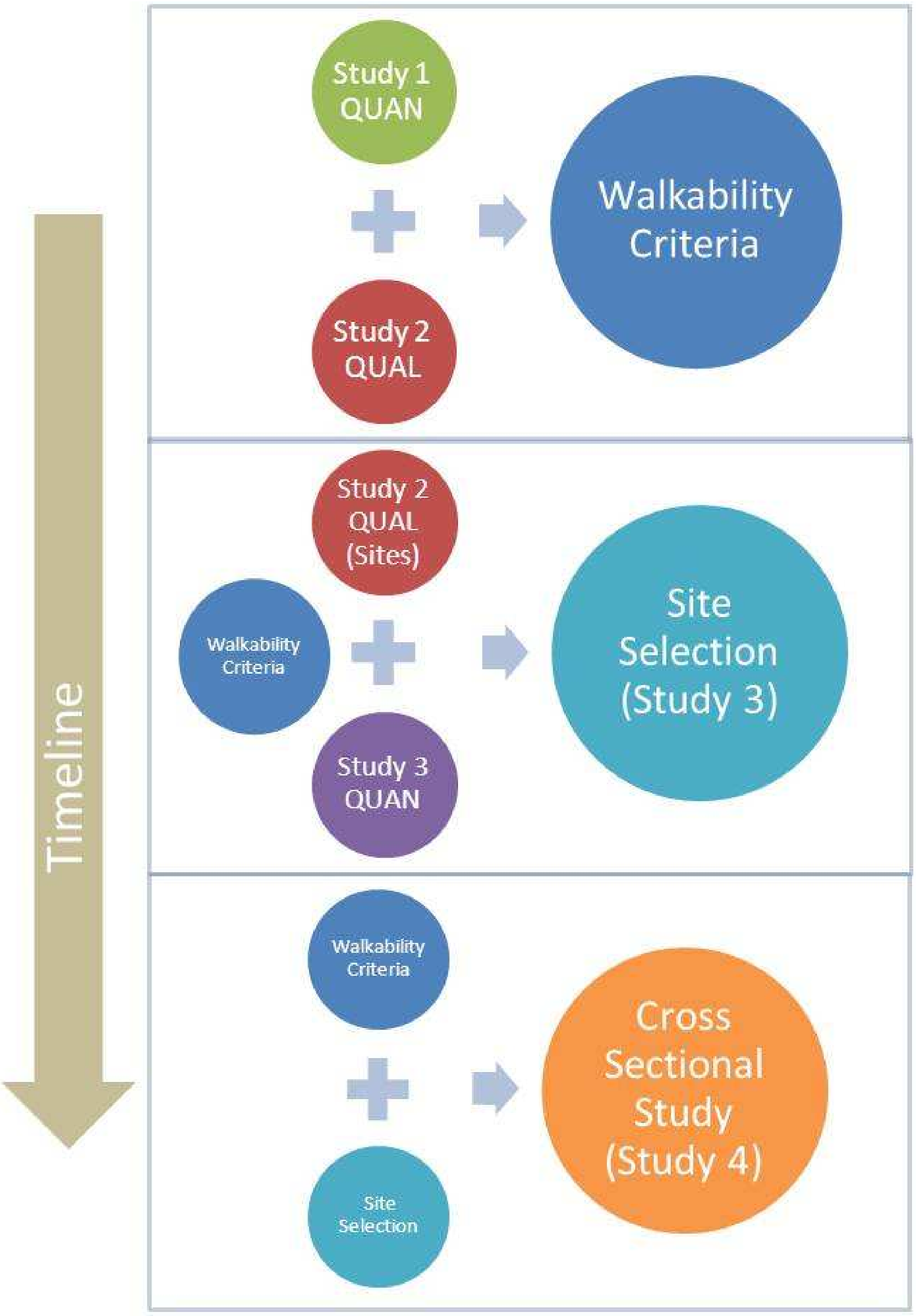

Figure 1-1: CGL Mixed Method Study Design

QUAN = Quantitative Study, QUAL = Qualitative Study, Study 1: Cross Sectional Stakeholder Study, Study 2: Focus Group Study, Study 3: Mixed Methods Site Selection and Study 4: Cross Sectional Population Study data collected in study two was used with quantitative data from study one to inform the exploration of the term ‘walkability’ (initiation or complementarity) and also with other quantitative data used in the site selection (study three). The results of both of these processes informed study four, a cross sectional quantitative study. Each study undertaken was informed by the previous studies.

1.4 Walking, Physical Activity and Health

Walking is an accessible, affordable and fundamental form of physical activity (Lee and Moudon, 2006; Reger-Nash *et al.*, 2006). We spend the first year of our lives striving to master it and we continue to walk every day until our bodies become too frail to manage it anymore. Walking is the only sustained dynamic aerobic exercise that is common to everyone except for the seriously disabled or very frail (Morris and Hardman, 1997). Our ability to walk gives us the independence to navigate our homes, communities and beyond. Walking is the first thing we do when we get out of bed in the morning and the last thing that we do before we get into bed at night; it is an integral part of our day. Walking is the most commonly reported physical activity behaviour (Owen *et al.*, 2004) with two thirds of Irish adults reporting walking for recreation (Ipsos MRBI, 2011).

Physical activity is defined as ‘any force exerted by skeletal muscles that results in energy expenditure above resting level’ (WHO Regional Office for Europe 2006, p.2). The National Physical Activity Guidelines for Ireland recommend that adults should get at least 30 minutes of moderate physical activity five days a week (or a minimum of 150 moderate minutes per week). Moderate intensity activity is described as brisk walking (a mile in 15 – 20 mins) or an activity which increases breathing and heart rate but still be able to carry a conversation. Neighbourhood walking in bouts of greater than 10 minutes, for transportation (utilitarian) or recreational trips, can contribute towards meeting the recommended minutes of physical activity (Department of Health and Children and Health Service Excutive, 2009). The health benefits of physical activity are well documented (WHO Regional Office for Europe 2006; Department of Health (UK) 2004; U.S. Department of Health and Human Services 1996). Warburton, Whitney Nicol and Bredin (2006, p.801) state ‘there is irrefutable evidence of the effectiveness of regular physical activity in the primary and secondary prevention of several chronic diseases and premature death'. The chronic diseases mentioned are cardiovascular disease, diabetes, cancer, hypertension, obesity, depression and osteoporosis. Physical activity also contributes to increased strength, flexibility, endurance and bone density (Edwards & Tsouros 2006). It is estimated that physical inactivity causes 9% of premature mortality worldwide and 14.2% of all-cause mortality is associated with physical inactivity in Ireland (Lee et al. 2012). Further to the benefits of walking as a physical activity on health, the social dimension of walking further contributes to individual well-being (WHO Regional Office for Europe, 2006; Warburton *et al.*, 2006; Edwards and Tsouros, 2006; Morris and Hardman, 1997).

1.5 Thesis aims and objectives

The aim of this thesis is to investigate the research questions: (i) what is walkability? and (ii) if population walking and mobility behaviours differ in neighbourhoods of different levels of walkability and socio economic status (SES)? The objective of this study was to answer these research questions using a mixed methods study by: (i) develop a working definition of walkability based on multidisciplinary perspectives, (ii) select neighbourhoods of high and low walkability and high and low SES based on the developed walkability definition, (iii) develop a survey instrument to assess neighbourhood perceptions and residents behaviours based on the findings of preceding studies and (iv) administer a cross sectional study in sixteen neighbourhoods in the Greater Dublin Area.

This was done as follows:

Chapter Two: Outlines a literature review to (i) investigate the term 'walkability', its origins, evolution and adoption into research literature and practice, (ii) identify the environmental elements which are commonly associated with an area's walkability, and identify and review methods used to assess and measure these elements. A critique of the relevant literature on the topic is presented which guides and informs arguments for conducting this research.

Chapter Three (Study One): The aim of study one was to answer specific research questions on walkability based on the outcome of the literature review: (i) determine the level of agreement with the CGL study hypothesis and (ii) explore the similarities and differences that exist between identified professional disciplines on the relative importance they place on the contribution of physical and social environments, and social and demographic correlates on walkability. This was done using a quantitative cross sectional study. Participants for the researcher-developed, web-based survey were identified using purposeful sampling and recruited by email. Differences between professional groups were identified which warranted further investigation into professional understandings of the term.

Chapter Four (Study Two): The aim of study two was to (i) further investigate the concept 'walkability' among a professionally diverse set of participants and (ii) develop a list of walkability criteria to select high and low walkable areas for further study. This was done using a qualitative focus group study which utilised a socio-spatial recall method.

Chapter Five (Study Three): The aim of study three was to select high/low walkable and deprived/not deprived neighbourhoods in the Greater Dublin Area for a cross sectional population study. Limitations were identified in the applicability of the GIS site selection model used in many major studies to select sites in Dublin. The standard method had to be adapted. A methodology was created which draws upon previous models, yet supplements what was identified as missing. This new adaptive methodology successfully enabled the selection of twenty areas that fall into four distinct walkability and deprivation categories.

Chapter Six (Study Four): Study four presents the methodology and preliminary results of a quantitative cross sectional neighbourhood study undertaken in sixteen neighbourhoods of the GDA. The aims of this study were to determine if area categories differ in: (i) resident's perceptions of their neighbourhood environment? and (ii) resident's travel and recreational walking behaviours? This was done by (i) developing a multi-section questionnaire, (ii) undertaking a door-to-door survey in the identified areas and (iii) analysing the study results. Differences in perceptions and behaviours were identified between the area categories.

Chapter Seven summarises the findings of the project. The findings from the four studies were used to inform the development of a behavioural model which can be used for further investigation of the collected data. This model is outlined in chapter seven. The applicability of the methods and resources developed in this thesis and their impact for future research and practice are discussed. Recommendations are made for future work.

2 Literature Review

2.1 Introduction

A term frequently used in walking behaviour research to describe how conducive an area is to walking is 'walkable' or it's 'walkability'. The purpose of this literature review is to investigate the concept 'walkability'. During the review; the origins of the concept, models and theories constructed to develop the understanding of 'walkability', the environmental features influencing walkability, and the strengths and weaknesses of different methods to measure walkability will be examined. The findings of this review will inform the design of the studies within this thesis.

For the initial phase of this literature review an academic journal search of peer reviewed publications using the keywords 'walkability' and 'walkable' published up tp the end of 2009 was conducted. The 'Summon' database searcher was used to search all 27 databases accessible through the Dublin City University library. These databases included; Informaworld (now Taylor and Francis online), BMJ, BioMed Central, Medline, SAGE Journals, Environment and Planning, Science Direct, Scopus and Academic Search Complete. These were recognised as the most relevant databases for papers on neighbourhood planning and design, and public health by virtue of their content. This initial search produced 575 references to peer-reviewed journal articles. A review of the publication year distribution of the papers showed that over 70% of these papers were published in the years 2007 to 2009 indicating that the search term is relatively new in the field of academic research. An internet search on the terms 'walkability' and 'walkable' were also carried out using the Google™ search engine to investigate applications of the word and the concept within fugitive information (reports and websites). The information trail led to a wide variety of documents including government policy documents, active living advocacy resources and urban design textbooks amongst others. These searches facilitated an exploration of the concept, its origins and its application which is presented in the first section of this review. A key finding from this review was that the term 'walkability' appears to have originated from the New Urbanist movement circa 1992 but no clear definition of the term exists. Descriptions and definitions used by different professional groups suggest that they have adopted the term to suit their individual remits.

A second journal search was conducted using the Summon database searcher for peer reviewed journal articles using a broader keyword search of 'walkability' and/or 'walkable' and/or 'built environment' and/or 'walking' and/or 'physical activity' and/or 'neighbourhood' and/or 'active travel' published earlier and including 2009. Results were filtered by content type and relevance, and 246 papers were identified. During the literature review process further relevant papers, reports and books were identified from references in those papers. This literature was the primary focus of the remainder of the literature review.

The multidisciplinary nature of walkability was the focus of the second section of this literature review. Studies that sought opinion of a range of disciplines to inform the understanding of characteristics of the built environment[1] which influence walking were identified and reviewed. Key findings were: (i) the diversity in field specific methods and terminology make investigations difficult, (ii) current policies and practices of the relevant professions should be cross referenced so results are transferable and communicable, and (iii) a gap was identified in the research as no studies were identified comparing how the concept of walkability was agreed on or differed between professional disciplines.

The third section of this chapter summarises a review of the theories and models of behaviour identified in relevant studies from a variety of disciplines. The role of perception was also discussed in the fourth section of this review. This informed the methods used in this thesis as it considered multidisciplinary perspectives. The key finding was there are a substantial number of elements of relevance which influence user's perception and behaviour in their environment that need to be considered when investigating an area's walkability and its residents resulting behaviours. To truly understand walkability and to communicate it effectively to relevant disciplines a

[1] In this thesis the terms built environment and physical environment will be used interchangeably.

substantial amount of information is required to generate a comprehensive picture of an individual's neighbourhood environment.

The purpose of the fifth section of the literature review was to investigate how the walkability of an environment is measured. Brownson and colleagues' (2009) review paper and Sauter and colleagues 'Measuring Walking' project (2010; 2008) formed the basis of this section along with additional information from identified studies, which were not included in their reviews. The key finding of this section was that all of the identified measurement methods have benefits and limitations and the suitability of a measurement method depends on the detail of information required, the contextual purpose of the study and the spatial scale of interest.

The sixth section of this literature review focuses on the elements of the built environment identified as having an effect on the walkability of an area and how they are measured. Key papers were identified from walkability studies, pedestrian needs studies, built environment and physical activity review papers and studies to generate lists of environment characteristics influencing pedestrian behaviour. Keyword searches were also carried out on elements (i.e. 'residential density'). Key findings were: (i) there are three levels of spatial data relevant to walkability research: macro city level, meso neighbourhood level and micro street level, and each is relevant to walkability for different reasons (ii) while macro and meso level considerations make trips feasible, the streetscape is the interface where an individual takes perceptual cues from the environment and both require consideration (and different measurement methods) when determining the walkability of a neighbourhood and (iii) the role of the social environment on walkability is unclear and warrants further investigation with consideration for both the individual and the community.

2.2 Walkability

2.2.1 Origin of the term

The word 'walkability' is in the vocabulary used by many streetscape designers and advocates of walking for health and recreation. Yet, the origins of the term and the meaning of the concept are not clear. Advocate Dan Burden estimates that the walkability movement began circa 1983 but believes the term came later circa 1992 or 1993 (Burden, 2010). There is no formal recognition of the words 'walkable' or 'walkability' in either the Oxford or Cambridge dictionaries[2].

The earliest references to the term walkability, identified in academic papers, were by urban designers and spatial planners in the early nineties (Southworth, 1997; Southworth and Ben-Joseph, 1995; Southworth and Owens, 1993). No definition was given to the term walkability but elements of the built environment and factors which contributed to it were identified (Southworth et al., 2005, 1995, 1993). Tables 2.1 and 2.2 outline the earliest identified definitions and descriptions of walkability or references of pedestrian friendly environments in the reviewed literature. The terms walkable and walkability frequently appear in texts advocating New Urbanist principles usually in relation to a positive association between New Urbanist theories and the walkable neighbourhood (Henson, 2000; Kelbaugh, 2000; Southworth and Owens, 1993). However, no definition of walkability is given by the authors of these texts.

New Urbanism planning, or neotraditional planning, is one approach to spatial planning and urban design which emphasises the physical characteristics that traditionally made successful neighbourhoods (Cowan and Rodgers, 2005). It emerged in the 1980s as an alternative to increasingly popular suburban developments to 'cure for all ills caused by suburban sprawl' (Tu & Eppli 1999, p.425). Neither the Charter of the New Urbanism (Congress of the New Urbanism, 2001) written in 1996 nor the principles advocated by the movement prescribe the use of particular techniques or practices, but rather advocate an idealised end product to work towards: a traditionally structured urban neighbourhood. Walkability is one of the principles

[2] search conducted 17th May 2010

advocated by New Urbanists on their website. Walkable neighbourhoods are described quite simply as having most destinations within a 10-minute walk from home or workplace, pedestrian friendly street design and pedestrianised streets where suitable (www.newurbanism.org; Table 2-1). Whilst New Urbanism had a strong advocacy base, Kelbaugh noted that 'New Urbanism enjoys little and often begrudging respect in academia' (2000, p.285). Since the origins of the term walkability appear to be connected with New Urbanism, the apparent lack of a definition of walkability in academic literature at this point may be a consequence of it being a non-academic movement.

New Urbanist ideals, and the term walkability, were also spreading out of spatial planning and urban design into other disciplines. The term walkability appeared in the Institute of Transportation Engineer's Journal for the first time in 2000 when Henson (2000) argued that pedestrian level of service[3], as outlined in the American Highway Capacity Manual (HCM) (TRB, 1985), was insufficient when considering a walkable pedestrian friendly environment. Do (2002) used the terms 'walkable' and 'walkability' in her article on the US Federal Highway Administrations' Pedestrian Facilities User's Guide (US Department of Transportation, 2002). This article outlined engineering improvements related to roadway design that were implemented in response to pedestrian incident records, such as traffic management measures and speed ramps. Walkable areas were described within Do's article as aesthetically pleasing, well lit with well-maintained footpaths but like other texts of the time, the terms were used interchangeably and no definition of walkability was given. Rather the term appears to be used as a general term for pedestrian friendliness. City or regional pedestrian plans have been found to use the term walkability and some have developed 'walkability indices' (Lo, 2009; Stangl, 2008) , for example, the City of Portland Pedestrian Master Plan (1998b). This Plan produced indices to estimate pedestrian traffic, to highlight deficiencies in pedestrian infrastructure, and to reflect both land planning and transportation elements of the environment. Usage of the term in plans of this nature, for example the Florida Department of Transport Report on Designing Walkable Communities (1995) suggests that the term walkability had been adopted by

[3] Level of service (LOS) is a ratio of pedestrian volume to sidewalk (footpath) width. It is illustrated later in Figure 2-1.

practitioners before academics, and thus was used in practice before research. This would also explain the lack of a definition at this point.

In public health literature, the first identified use of the words 'walkable' or 'walkability' was by Sallis, Bauman and Pratt (1998, p.391) when they suggested the advocacy group 'Partnership for a Walkable America' as a potential physical activity promotion partner. The term walkability was not defined nor discussed in the peer reviewed publication other than a brief description of the organisation's work. In 2002, the term walkability was introduced to the public health research field by King and colleagues in their review of personal level physical activity theory literature and concepts from other fields potentially relevant to the physical activity community, including social ecology and urban planning (2002). Similar to the introduction of the concept 'walkability' in transportation research, King and colleagues referred to New Urbanism. In 2003, public health research introduced 'walkability' indices and scales (Moudon & Lee 2003; Saelens et al. 2003, Table 2-2). It is important to note that these were not the first public health papers to discuss the associations and measurement of the built environment for physical activity research, references had been made to pedestrian or activity friendly environments (Pikora *et al.*, 2003; Sallis *et al.*, 1998). They are the first to use walkable or walkability as measurable concepts in the association between physical activity and the built environment in public health literature. It can be concluded that the term 'Walkability' has New Urbanist roots but its interpretation appears to be subjective depending on the professional background of the author.

Table 2-1: Definitions and defined indicators of walkability (or pedestrian friendly areas) in identified literature

First author (year)	Research Field	Description of main findings (actual definitions are highlighted in Bold)
Burden & Florida Department of Transport (1995)	Transport	A walkable area provides: continuously linked walkways, pedestrianised intersections, special accommodations for people with disabilities, signal placement, illumination, simplify median crossings, safe access to schools, eliminate backing out of parking spaces, commercial development access to have options other than vehicles, auto restricted zones, combine walking and transit, walkable scale land use planning (traditional neighbourhood design, planned mixed unit development, transit orientated design)
City of Portland (1998b)	Transport	Variables: Land use mix, destinations, connectivity, scale, topography. Pedestrian potential factors: transportation element, policy element, school proximity factor, other destinations factor, environmental variables factor (mixed uses and density, proximity to destinations, interception density/connectivity, parcel size scale, slope). Deficiency Index: missing sidewalks, pedestrian-vehicle crashes, traffic speed, traffic volumes, roadway width, block length)
Stoner (2003)	Transport	First order: Footway accessibility, ground level activity, pedestrian crossing design, traffic signal phasing, Time of day. Second order: Lighting, 'Type' of pedestrian (tourist/ visitor or resident) Footway width, Footway gradient, Movement generators – proximity to transport facilities, Signage, Weather, Day of the week, Presence or absence of other moving people, Presence or absence of other stationary people. Third order: Footway quality, Proximity to road traffic
Saelens (2003a)	Mixed (Public Health)	High/low walkability areas identified based on residential density, land use mix and street pattern. Based on Cervero and Kockelman (1997) developed further by Sallis and collegues (2009).
Mayor of London (2004)	Transport	A walking friendly city is a city where people select walking as their preferred choice of travel for health and to relax and one which exhibits a high degree of 'walkability'. **Walkability may in turn be defined as the extent to which walking is readily available to the consumer as a safe, connected, accessible and pleasant activity.** A walkable city is: Connected, Convivial, Conspicuous, Comfortable and Convenient
Southworth (2005)	Planning	Fine grained land uses, quality of path, connectivity, linkage to other modes, path context and safety
Ewing (2006)	Mixed (Urban Design)	Human scale, transparency, tidiness, enclosure and imageability
Burden (2010)	Advocate	**The extent to which the built environment is friendly to the presence of people walking, living, shopping, visiting, enjoying or spending time in an area.**

Table 2-2: Terms used to describe pedestrian friendly neighbourhoods in identified literature

First author (year)	Research Field	Description
Southworth (1997)	Planning	Grain and pattern of development (including density), land use patterns, public open space, street design and circulation systems, public transport access, pedestrian access and catchments implied as good for pedestrian activity. Noted character, suitability for children, teens and elderly and market success.
Henson (2000)	Transport	Level of service, comfort, convenience, safety, security and economy
Congress of the New Urbanism (2001)	Planning	Walkability alongside: connectivity, mixed use and diversity, mixed housing, quality architecture and urban design, traditional structure, increased density, green transportation, sustainability and quality of life.
King (2002)	Public Health	New Urbanist: mixed use, accessibility, compact and public transport. Environment stressors and restorative environments, imageability and legibility,
Do (2002)	Predominately Transport	Aesthetically pleasing, well lit with well-maintained footpaths
Pikora (2003)	Public Health	Model for walking for recreation, elements from the following groupings: Functional (Walking surface - 4 items, Streets – 1 item, Traffic – 5 items, Permeability – 4 items), Safety (Personal – 2 items, Traffic - 3 items), Aesthetic (Streetscape - 6 items, Views – 2 items) and Destinations (Facilities 2 items)
Moudon (2003)	Urban Design	Elements from the following groupings: Spatiophysical (roadway characteristics, environment along roadway, network, area), Spatiobehavioural (non-motorised traffic, vehicular traffic, safety), Spatiopsychosocial (perception) and area policy that affects walking
McCormack (2004)	Public Health	Land use patterns, urban design characteristics (as street networks) and transportation system links.
Alfonzo (2005)	Planning	Hierarchy of walking needs: feasibility, accessibility, safety, comfort, pleasurability
Urban Design Compendium (2007)	Urban Design	Connected, Convivial, Conspicuous, Comfortable and Convenient

Table 2-2 cont.

First author (year)	Research Field	Description
Brennan Ramirez (2006)	Public Health with participants from transportation, urban planning, parks and recreation and public policy	For activity friendly communities: Land use environment (density and land use mix), facilities, transport environment (availability of alternatives), aesthetics (presence of attractions and absence of physical disorder), travel patterns (frequency of active travel), social environment, land use economic (availability of funds for parks and recreation), transport economic (availability of funds for sidewalks and bike lanes), institutional and organisational policies (e.g. work place travel plans) and promotion
Mehta (2008)	Urban Design	Hierarchy of walking needs on the neighbourhood main street: feasibility, accessibility, usefulness, safety, comfort, sensory pleasure, sense of belonging
Sauter (2008)	Transport	Walking environment, accessibility, public space quality and infrastructure provisions
Stangl (2008)	Transportation	Level of service, wide, clean sidewalks with high green ratio, Attractiveness, comfort, convenience, safety, security, system coherence, and system continuity, Presence of sidewalk and lateral separation, motor vehicle volume and speed, and driveway access frequency and volume. Block segments along arterials, crossings at intersections and crossings at mid-block
Gehl Architects (Van Deurs, 2009)	Urban design and Architecture	Place: park of public space network, part of public space hierarchy, sense of place. Protection: protection against traffic & accidents – feeling safe, protection against crime & violence – feeling secure, protection against unpleasant sensory experiences. Comfort: opportunities for walking, opportunities to stand/stay, opportunities to sit, opportunities to see, opportunities to talk and listen, opportunities for play and exercise. Delight: Human scale, opportunities to enjoy the positive aspects of climate, positive sensory experience
Lo (2009)	Planning	From a Walkability review: presence of continuous and well maintained sidewalks, universal access characteristics, path directness and street network connectivity, safety of at-grade (ground level) crossing treatments, absence of heavy and high speed traffic, pedestrian separation or buffering from traffic, land-use density, building and land-use diversity or mix, street trees and landscaping, visual interest and a sense of place as defined under local conditions, perceived and actual safety

2.2.2 Definitions of walkability

Definitions of walkability and descriptions of pedestrian friendly neighbourhoods identified in the reviewed literature are outlined in tables 2-1 and 2-2. The variety of descriptions found would indicate that when comparisons are being made between findings from walkability studies there is a possibility like is not being compared with like. The high level of definitions from transportation literature may be because transport professionals predominantly use standards and guidelines and therefore may favour rules and definitions to follow in design (Table 2-1).

Transportation professionals, and their research, are concerned with the movement of people, whether it is the provision of public transport or roads between origins and destinations (trip generators) or footpaths and access points along those routes. Unsurprisingly transport discussions on walkability focused on the pedestrian walking as a transport mode, similar to the movement of a car along a road, and thus discuss walkability in terms of level of service (LOS) (space on the footpath) (Fig. 2-1), the provision of a route (connectivity and presence of a path) and the trip generators (origins and destinations) (Lo, 2009; Handy *et al.*, 2002; Henson, 2000). In doing this, the functional task of facilitating the movement of pedestrians is considered similar to the movement of traffic with little or no consideration given to the surrounding environment or the context of the trip being undertaken. A noted exception in early transport research is Do's (2002) article which incorporated multidisciplinary considerations in pedestrian infrastructure design by referencing the urban design texts of Appleyard (1981) and Gehl (2006), documents from the Institute of Transportation Engineers on residential street and pedestrian centred design, and to the Florida Department of Transport report on designing walkable communities (Burden and Florida Department of Transportation, 1995). Also in 2004 the Mayor of London (2004, p.5) defined walkability as 'the extent which walking is readily available to the consumer as a safe, connected and pleasant activity'. The Transport for London Report, '*Making London a walkable city',* states that a walkable city is: (i) connected, (ii) convivial (friendly, lively and enjoyable), (iii) conspicuous (attracting notice or attention), (iv) comfortable and (v) convenient. These are the same terms used in the

1 Introduction

This thesis is an exploration of the term 'walkability' and an account of the method development and preliminarily findings of the Cleaner, Greener, Leaner Study (CGL). A conceptual model illustrating the role of the environment on mobility behaviour is proposed based on the findings of this thesis. The CGL study is an investigation of the influence of neighbourhood walkability on resident's physical activity and transport behaviours in the Greater Dublin Area (GDA). It was funded by the Environmental Protection Agency (EPA) under their STRIVE programme (EPA 2013), a research funding stream supported by Ireland's National Development Plan (NDP) (REF: 2008-PhD-CC-1). A multi-disciplinary team consisting of researchers from public health, exercise science, social cohesion/ political science and transportation/ migration economics obtained funding for the CGL population study on 16 neighbourhoods in the GDA within four categories: high walkability low socio-economic status, low walkable low socio-economic status, high walkable high socio-economic status and low walkable high socio-economic status. The author was recruited to undertake the CGL research study.

1.1 Walkability

Informed by my professional knowledge and my experience of Irish development planning practices alongside a familiarity of physical activity promotion I undertook this project with what I believed was a comprehensive knowledge of walkability. However, as I researched into the concept of 'walkability' I discovered that my own understanding of the term was heavily biased by my academic training as a civil engineer and subsequent work as a transportation planner. What I considered best practice in physical environmental design for walkability was both complemented and contradicted by information obtained from casual conversations about my proposed research with former colleagues, with friends from other relevant professions and from preliminary literature and internet searches. Reflection on this diverse information prompted me to ask two questions i) what is walkability? and ii) How is it understood by different relevant professionals and those involved in physical activity promotion and public health? I believed this information was an essential step before selecting areas of high and low 'walkability' for inclusion in the CGL study. This information would (i) ensure that the process used to assign a walkability status to an area was not biased by a particular research field and encompassed as many neighbourhood design aspects associated with walkability by various disciplines as possible, (ii) contribute to the development of the research field and (iii) ensure the transferability of the information by ensuring its relevance to those who are tasked with considering walkability in their design practices.

To investigate the influence of the environment on walking behaviours, and subsequently health, we need to better understand the meaning of the concept walkability. Studies one and two of this thesis outline multi-disciplinary quantitative and qualitative studies designed to inform a working definition for walkability from an Irish context for use in this project.

1.2 The Role of the Environment on Behaviours

It is hypothesised that the way we plan and design our communities and transport systems matters for sustainable transport behaviours, human health and the natural environment. Ecological models emphasise the role of the intra (personal) and extra-individual (social, physical, contextual) variables on behaviour outcomes (TRB, 2005; Pikora *et al.*, 2003; King *et al.*, 2002; Humpel *et al.*, 2002; Sallis *et al.*, 1998; Stokols, 1992). Five levels of influence of the social ecological model were proposed by McLeroy and colleagues (1988) interpersonal (the individual), interpersonal (between people), institution (e.g. churches, schools or workplaces), community level and policy level. Ecological models not only assume that multiple levels of influence exist but also that these levels are interactive and reinforcing and may have different effects on individual people differently depending on their unique beliefs and practice, thus conceptualising behaviours, and outcomes such as health, as determined by an interplay of environment and individual factors (Golden and Earp, 2012).

Ecological models are considered appropriate for analysing the complex link between environments (social and physical) and physical activity and are frequently used for this purpose (Pikora *et al.*, 2003; King *et al.*, 2002; Sallis *et al.*, 1998). It is believed that the decrease in the number of people meeting the minimum physical activity requirements is exacerbated by the environmental barriers to walking and cycling to fulfil daily transport and recreational needs (Brownson *et al.*, 2009; Saelens and Handy, 2008; TRB, 2005; Sallis *et al.*, 1998). Historically, walking was the primary mode of transport for most humans (Ingold, 2004), however advancements in technology and residential patterns (inter alia home locations, work locations) have resulted in a modal change to motorised modes, predominately in recent years to the car (Frumkin *et al.*, 2004). The increase in motorised transport trips has environmental implications. Increased fuel usage results in greater transport related carbon emission which in turn can impact on the air quality and respiratory health of inhabitants (Younger *et al.*, 2008). An opportunity exists to reverse increasing motorised transport and reducing walking trends by designing and retrofitting neighbourhoods to make them more walkable or pedestrian friendly. It is also hypothesised that the way we design, plan and build our environments can influence the perceptions of the residents of these environments and that these perceptions could have an association with physical activity and mobility behaviours. The behaviours of interest in this thesis are recreational walking and transport behaviours. These transport behaviours include walking, other active travel such as cycling, public transport use and motorised transport behaviour.

1.3 Mixed Method Research

Mixed method research refers to the use of both qualitative and quantitative methods in one study, concurrently or one nested in the other, or sequentially in two or more studies drawing inferences from both approaches (Hesse-Biber and Leavy, 2011; Teddlie and Tashakkori, 2009; Creswell and Plano Clark, 2007). Qualitative research methods are defined as ‘the techniques associated with the gathering, analysis, interpretation, and presentation of narrative information’ (Teddlie & Tashakkori, 2009, p.343). Qualitative research gives information on individual level lived experiences and is useful to obtain in-depth perspectives and interpretations on a particular concept or phenomenon. However it is not very useful for getting an overall picture and can be costly in terms of time and finance (Hesse-Biber and Leavy, 2011; Creswell and Plano Clark, 2007). Quantitative research methods are defined as 'the techniques associated with the gathering, analysis, interpretation and presentation of numerical information' (Teddlie & Tashakkori, 2009, p.343). Research hypotheses are tested and results can be generalised for large populations but may be influenced by biased researcher questioning and interpretation (Hesse-Biber and Leavy, 2011; Creswell and Plano Clark, 2007). A synergistic research project can be created using mixed methods as one method can enable another to be more effective by providing a fuller understanding of the research problem (Hesse-Biber and Leavy, 2011).

Mixed method research encourages researchers to combine inductive and deductive thinking to answer questions that cannot be answered by qualitative or quantitative approaches alone (Creswell and Plano Clark, 2007). The combination of methods can assist in tackling highly complex problems involving several layers of understanding (Hesse-Biber and Leavy, 2011). However, mixed method research is not easy as it requires the researcher to be proficient in both forms of inquiry and it takes time to collect the required data (Creswell and Plano Clark, 2007). Reasons why researchers might want to use a mixed method approach include (i) using different theoretical approaches on the same research question to enhance credibility (triangulation), (ii) to give a fuller understanding of a research question or to clarify a result (complementarity), (iii) to use result from one method to develop or inform another method (development), (iv) where a studies results raise questions or contain contradictions which require clarification (initiation) or (v) where a researcher decides to expand into a whole new investigation (expansion) (Hesse-Biber and Leavy, 2011; Greene *et al.*, 1989).

This thesis addresses 'Walkability'. The concept is investigated using a multiple-study mixed method programme of inquiry, or sequential mixed-method studies, where each

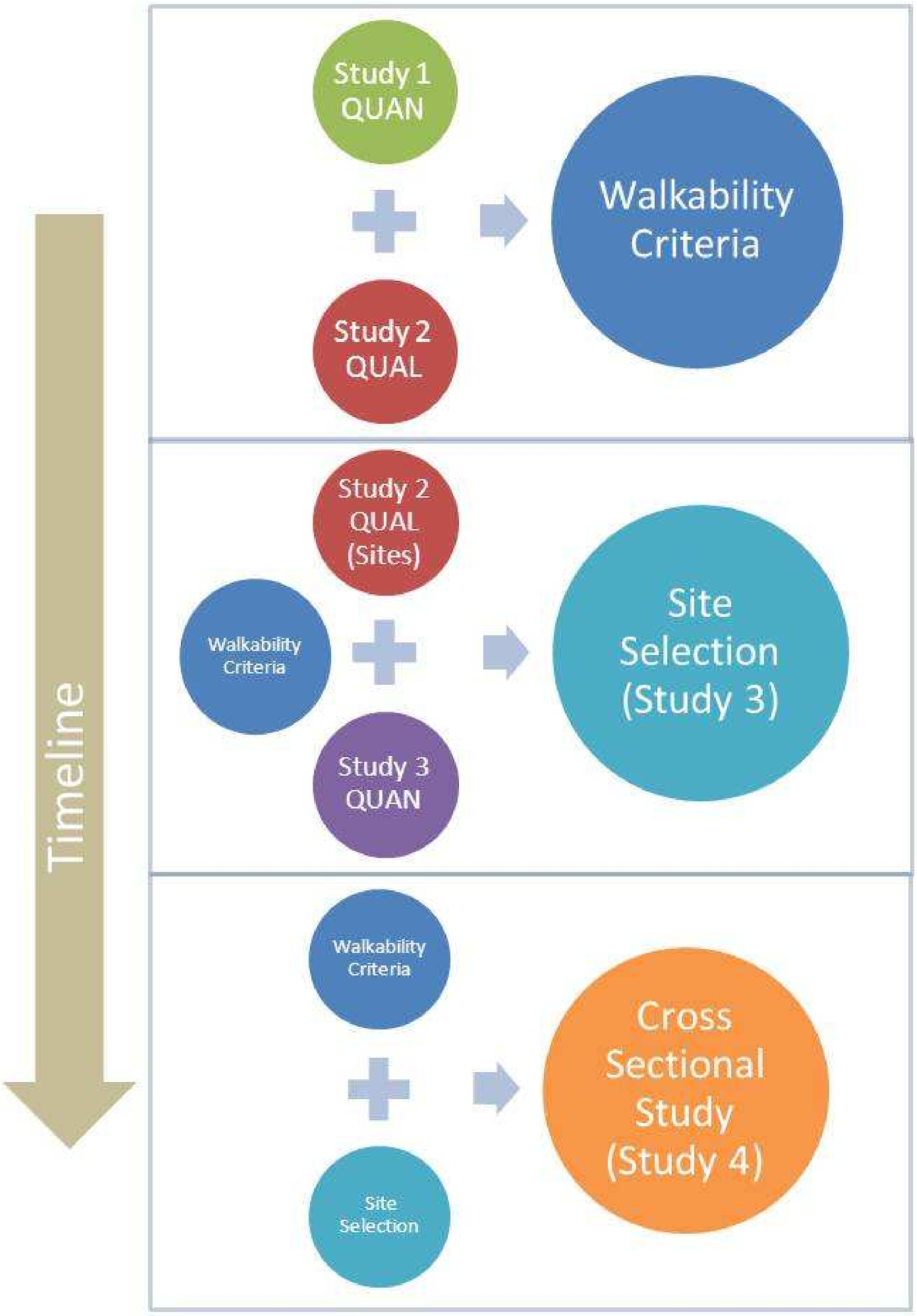

Figure 1-1: CGL Mixed Method Study Design

QUAN = Quantitative Study, QUAL = Qualitative Study, Study 1: Cross Sectional Stakeholder Study, Study 2: Focus Group Study, Study 3: Mixed Methods Site Selection and Study 4: Cross Sectional Population Study

study is reported separately as a distinct study but overall the programme of inquiry is mixed method (Creswell and Plano Clark, 2007). Figure 1-1 shows how the qualitative data collected in study two was used with quantitative data from study one to inform the exploration of the term 'walkability' (initiation or complementarity) and also with other quantitative data used in the site selection (study three). The results of both of these processes informed study four, a cross sectional quantitative study. Each study undertaken was informed by the previous studies.

1.4 Walking, Physical Activity and Health

Walking is an accessible, affordable and fundamental form of physical activity (Lee and Moudon, 2006; Reger-Nash *et al.*, 2006). We spend the first year of our lives striving to master it and we continue to walk every day until our bodies become too frail to manage it anymore. Walking is the only sustained dynamic aerobic exercise that is common to everyone except for the seriously disabled or very frail (Morris and Hardman, 1997). Our ability to walk gives us the independence to navigate our homes, communities and beyond. Walking is the first thing we do when we get out of bed in the morning and the last thing that we do before we get into bed at night; it is an integral part of our day. Walking is the most commonly reported physical activity behaviour (Owen *et al.*, 2004) with two thirds of Irish adults reporting walking for recreation (Ipsos MRBI, 2011).

Physical activity is defined as 'any force exerted by skeletal muscles that results in energy expenditure above resting level' (WHO Regional Office for Europe 2006, p.2). The National Physical Activity Guidelines for Ireland recommend that adults should get at least 30 minutes of moderate physical activity five days a week (or a minimum of 150 moderate minutes per week). Moderate intensity activity is described as brisk walking (a mile in 15 – 20 mins) or an activity which increases breathing and heart rate but still be able to carry a conversation. Neighbourhood walking in bouts of greater than 10 minutes, for transportation (utilitarian) or recreational trips, can contribute towards meeting the recommended minutes of physical activity (Department of Health and Children and Health Service Excutive, 2009). The health benefits of physical activity are well documented (WHO Regional Office for Europe 2006; Department of Health (UK) 2004; U.S. Department of Health and Human Services 1996). Warburton, Whitney Nicol and Bredin (2006, p.801) state 'there is irrefutable evidence of the effectiveness of regular physical activity in the primary and secondary prevention of several chronic diseases and premature death'. The chronic diseases mentioned are cardiovascular disease, diabetes, cancer, hypertension, obesity, depression and osteoporosis. Physical activity also contributes to increased strength, flexibility, endurance and bone density (Edwards & Tsouros 2006). It is estimated that physical inactivity causes 9% of premature mortality worldwide and 14.2% of all-cause mortality is associated with physical inactivity in Ireland (Lee et al. 2012). Further to the benefits of walking as a physical activity on health, the social dimension of walking further contributes to individual well-being (WHO Regional Office for Europe, 2006; Warburton *et al.*, 2006; Edwards and Tsouros, 2006; Morris and Hardman, 1997).

1.5 Thesis aims and objectives

The aim of this thesis is to investigate the research questions: (i) what is walkability? and (ii) if population walking and mobility behaviours differ in neighbourhoods of different levels of walkability and socio economic status (SES)? The objective of this study was to answer these research questions using a mixed methods study by: (i) develop a working definition of walkability based on multidisciplinary perspectives, (ii) select neighbourhoods of high and low walkability and high and low SES based on the developed walkability definition, (iii) develop a survey instrument to assess neighbourhood perceptions and residents behaviours based on the findings of preceding studies and (iv) administer a cross sectional study in sixteen neighbourhoods in the Greater Dublin Area.

This was done as follows:

Chapter Two: Outlines a literature review to (i) investigate the term 'walkability', its origins, evolution and adoption into research literature and practice, (ii) identify the environmental elements which are commonly associated with an area's walkability, and identify and review methods used to assess and measure these elements. A critique of the relevant literature on the topic is presented which guides and informs arguments for conducting this research.

Chapter Three (Study One): The aim of study one was to answer specific research questions on walkability based on the outcome of the literature review: (i) determine the level of agreement with the CGL study hypothesis and (ii) explore the similarities and differences that exist between identified professional disciplines on the relative importance they place on the contribution of physical and social environments, and social and demographic correlates on walkability. This was done using a quantitative cross sectional study. Participants for the researcher-developed, web-based survey were identified using purposeful sampling and recruited by email. Differences between professional groups were identified which warranted further investigation into professional understandings of the term.

Chapter Four (Study Two): The aim of study two was to (i) further investigate the concept 'walkability' among a professionally diverse set of participants and (ii) develop a list of walkability criteria to select high and low walkable areas for further study. This was done using a qualitative focus group study which utilised a socio-spatial recall method.

Chapter Five (Study Three): The aim of study three was to select high/low walkable and deprived/not deprived neighbourhoods in the Greater Dublin Area for a cross sectional population study. Limitations were identified in the applicability of the GIS site selection model used in many major studies to select sites in Dublin. The standard method had to be adapted. A methodology was created which draws upon previous models, yet supplements what was identified as missing. This new adaptive methodology successfully enabled the selection of twenty areas that fall into four distinct walkability and deprivation categories.

Chapter Six (Study Four): Study four presents the methodology and preliminary results of a quantitative cross sectional neighbourhood study undertaken in sixteen neighbourhoods of the GDA. The aims of this study were to determine if area categories differ in: (i) resident's perceptions of their neighbourhood environment? and (ii) resident's travel and recreational walking behaviours? This was done by (i) developing a multi-section questionnaire, (ii) undertaking a door-to-door survey in the identified areas and (iii) analysing the study results. Differences in perceptions and behaviours were identified between the area categories.

Chapter Seven summarises the findings of the project. The findings from the four studies were used to inform the development of a behavioural model which can be used for further investigation of the collected data. This model is outlined in chapter seven. The applicability of the methods and resources developed in this thesis and their impact for future research and practice are discussed. Recommendations are made for future work.

2 Literature Review

2.1 Introduction

A term frequently used in walking behaviour research to describe how conducive an area is to walking is 'walkable' or it's 'walkability'. The purpose of this literature review is to investigate the concept 'walkability'. During the review; the origins of the concept, models and theories constructed to develop the understanding of 'walkability', the environmental features influencing walkability, and the strengths and weaknesses of different methods to measure walkability will be examined. The findings of this review will inform the design of the studies within this thesis.

For the initial phase of this literature review an academic journal search of peer reviewed publications using the keywords 'walkability' and 'walkable' published up tp the end of 2009 was conducted. The 'Summon' database searcher was used to search all 27 databases accessible through the Dublin City University library. These databases included; Informaworld (now Taylor and Francis online), BMJ, BioMed Central, Medline, SAGE Journals, Environment and Planning, Science Direct, Scopus and Academic Search Complete. These were recognised as the most relevant databases for papers on neighbourhood planning and design, and public health by virtue of their content**.** This initial search produced 575 references to peer-reviewed journal articles. A review of the publication year distribution of the papers showed that over 70% of these papers were published in the years 2007 to 2009 indicating that the search term is relatively new in the field of academic research. An internet search on the terms 'walkability' and 'walkable' were also carried out using the Google^{TM} search engine to investigate applications of the word and the concept within fugitive information (reports and websites). The information trail led to a wide variety of documents including government policy documents, active living advocacy resources and urban design textbooks amongst others. These searches facilitated an exploration of the concept, its origins and its application which is presented in the first section of this review. A key finding from this review was that the term 'walkability' appears to have originated from the New Urbanist movement circa 1992 but no clear definition of the term exists. Descriptions and definitions used by different professional groups suggest that they have adopted the term to suit their individual remits.

A second journal search was conducted using the Summon database searcher for peer reviewed journal articles using a broader keyword search of 'walkability' and/or 'walkable' and/or 'built environment' and/or 'walking' and/or 'physical activity' and/or 'neighbourhood' and/or 'active travel' published earlier and including 2009. Results were filtered by content type and relevance, and 246 papers were identified. During the literature review process further relevant papers, reports and books were identified from references in those papers. This literature was the primary focus of the remainder of the literature review.

The multidisciplinary nature of walkability was the focus of the second section of this literature review. Studies that sought opinion of a range of disciplines to inform the understanding of characteristics of the built environment[1] which influence walking were identified and reviewed. Key findings were: (i) the diversity in field specific methods and terminology make investigations difficult, (ii) current policies and practices of the relevant professions should be cross referenced so results are transferable and communicable, and (iii) a gap was identified in the research as no studies were identified comparing how the concept of walkability was agreed on or differed between professional disciplines.

The third section of this chapter summarises a review of the theories and models of behaviour identified in relevant studies from a variety of disciplines. The role of perception was also discussed in the fourth section of this review. This informed the methods used in this thesis as it considered multidisciplinary perspectives. The key finding was there are a substantial number of elements of relevance which influence user's perception and behaviour in their environment that need to be considered when investigating an area's walkability and its residents resulting behaviours. To truly understand walkability and to communicate it effectively to relevant disciplines a

[1] In this thesis the terms built environment and physical environment will be used interchangeably.

substantial amount of information is required to generate a comprehensive picture of an individual's neighbourhood environment.

The purpose of the fifth section of the literature review was to investigate how the walkability of an environment is measured. Brownson and colleagues' (2009) review paper and Sauter and colleagues 'Measuring Walking' project (2010; 2008) formed the basis of this section along with additional information from identified studies, which were not included in their reviews. The key finding of this section was that all of the identified measurement methods have benefits and limitations and the suitability of a measurement method depends on the detail of information required, the contextual purpose of the study and the spatial scale of interest.

The sixth section of this literature review focuses on the elements of the built environment identified as having an effect on the walkability of an area and how they are measured. Key papers were identified from walkability studies, pedestrian needs studies, built environment and physical activity review papers and studies to generate lists of environment characteristics influencing pedestrian behaviour. Keyword searches were also carried out on elements (i.e. 'residential density'). Key findings were: (i) there are three levels of spatial data relevant to walkability research: macro city level, meso neighbourhood level and micro street level, and each is relevant to walkability for different reasons (ii) while macro and meso level considerations make trips feasible, the streetscape is the interface where an individual takes perceptual cues from the environment and both require consideration (and different measurement methods) when determining the walkability of a neighbourhood and (iii) the role of the social environment on walkability is unclear and warrants further investigation with consideration for both the individual and the community.

2.2 Walkability

2.2.1 Origin of the term

The word 'walkability' is in the vocabulary used by many streetscape designers and advocates of walking for health and recreation. Yet, the origins of the term and the meaning of the concept are not clear. Advocate Dan Burden estimates that the walkability movement began circa 1983 but believes the term came later circa 1992 or 1993 (Burden, 2010). There is no formal recognition of the words 'walkable' or 'walkability' in either the Oxford or Cambridge dictionaries[2].

The earliest references to the term walkability, identified in academic papers, were by urban designers and spatial planners in the early nineties (Southworth, 1997; Southworth and Ben-Joseph, 1995; Southworth and Owens, 1993). No definition was given to the term walkability but elements of the built environment and factors which contributed to it were identified (Southworth et al., 2005, 1995, 1993). Tables 2.1 and 2.2 outline the earliest identified definitions and descriptions of walkability or references of pedestrian friendly environments in the reviewed literature. The terms walkable and walkability frequently appear in texts advocating New Urbanist principles usually in relation to a positive association between New Urbanist theories and the walkable neighbourhood (Henson, 2000; Kelbaugh, 2000; Southworth and Owens, 1993). However, no definition of walkability is given by the authors of these texts.

New Urbanism planning, or neotraditional planning, is one approach to spatial planning and urban design which emphasises the physical characteristics that traditionally made successful neighbourhoods (Cowan and Rodgers, 2005). It emerged in the 1980s as an alternative to increasingly popular suburban developments to 'cure for all ills caused by suburban sprawl' (Tu & Eppli 1999, p.425). Neither the Charter of the New Urbanism (Congress of the New Urbanism, 2001) written in 1996 nor the principles advocated by the movement prescribe the use of particular techniques or practices, but rather advocate an idealised end product to work towards: a traditionally structured urban neighbourhood. Walkability is one of the principles

[2] search conducted 17th May 2010

advocated by New Urbanists on their website. Walkable neighbourhoods are described quite simply as having most destinations within a 10-minute walk from home or workplace, pedestrian friendly street design and pedestrianised streets where suitable (www.newurbanism.org; Table 2-1). Whilst New Urbanism had a strong advocacy base, Kelbaugh noted that 'New Urbanism enjoys little and often begrudging respect in academia' (2000, p.285). Since the origins of the term walkability appear to be connected with New Urbanism, the apparent lack of a definition of walkability in academic literature at this point may be a consequence of it being a non-academic movement.

New Urbanist ideals, and the term walkability, were also spreading out of spatial planning and urban design into other disciplines. The term walkability appeared in the Institute of Transportation Engineer's Journal for the first time in 2000 when Henson (2000) argued that pedestrian level of service[3], as outlined in the American Highway Capacity Manual (HCM) (TRB, 1985), was insufficient when considering a walkable pedestrian friendly environment. Do (2002) used the terms 'walkable' and 'walkability' in her article on the US Federal Highway Administrations' Pedestrian Facilities User's Guide (US Department of Transportation, 2002). This article outlined engineering improvements related to roadway design that were implemented in response to pedestrian incident records, such as traffic management measures and speed ramps. Walkable areas were described within Do's article as aesthetically pleasing, well lit with well-maintained footpaths but like other texts of the time, the terms were used interchangeably and no definition of walkability was given. Rather the term appears to be used as a general term for pedestrian friendliness. City or regional pedestrian plans have been found to use the term walkability and some have developed 'walkability indices' (Lo, 2009; Stangl, 2008) , for example, the City of Portland Pedestrian Master Plan (1998b). This Plan produced indices to estimate pedestrian traffic, to highlight deficiencies in pedestrian infrastructure, and to reflect both land planning and transportation elements of the environment. Usage of the term in plans of this nature, for example the Florida Department of Transport Report on Designing Walkable Communities (1995) suggests that the term walkability had been adopted by

[3] Level of service (LOS) is a ratio of pedestrian volume to sidewalk (footpath) width. It is illustrated later in Figure 2-1.

practitioners before academics, and thus was used in practice before research. This would also explain the lack of a definition at this point.

In public health literature, the first identified use of the words ‘walkable’ or ‘walkability’ was by Sallis, Bauman and Pratt (1998, p.391) when they suggested the advocacy group ‘Partnership for a Walkable America’ as a potential physical activity promotion partner. The term walkability was not defined nor discussed in the peer reviewed publication other than a brief description of the organisation’s work. In 2002, the term walkability was introduced to the public health research field by King and colleagues in their review of personal level physical activity theory literature and concepts from other fields potentially relevant to the physical activity community, including social ecology and urban planning (2002). Similar to the introduction of the concept ‘walkability’ in transportation research, King and colleagues referred to New Urbanism. In 2003, public health research introduced ‘walkability’ indices and scales (Moudon & Lee 2003; Saelens et al. 2003, Table 2-2). It is important to note that these were not the first public health papers to discuss the associations and measurement of the built environment for physical activity research, references had been made to pedestrian or activity friendly environments (Pikora *et al.*, 2003; Sallis *et al.*, 1998). They are the first to use walkable or walkability as measurable concepts in the association between physical activity and the built environment in public health literature. It can be concluded that the term ‘Walkability’ has New Urbanist roots but its interpretation appears to be subjective depending on the professional background of the author.

Table 2-1: Definitions and defined indicators of walkability (or pedestrian friendly areas) in identified literature

First author (year)	Research Field	Description of main findings (actual definitions are highlighted in Bold)
Burden & Florida Department of Transport (1995)	Transport	A walkable area provides: continuously linked walkways, pedestrianised intersections, special accommodations for people with disabilities, signal placement, illumination, simplify median crossings, safe access to schools, eliminate backing out of parking spaces, commercial development access to have options other than vehicles, auto restricted zones, combine walking and transit, walkable scale land use planning (traditional neighbourhood design, planned mixed unit development, transit orientated design)
City of Portland (1998b)	Transport	Variables: Land use mix, destinations, connectivity, scale, topography. Pedestrian potential factors: transportation element, policy element, school proximity factor, other destinations factor, environmental variables factor (mixed uses and density, proximity to destinations, interception density/connectivity, parcel size scale, slope). Deficiency Index: missing sidewalks, pedestrian-vehicle crashes, traffic speed, traffic volumes, roadway width, block length)
Stoner (2003)	Transport	First order: Footway accessibility, ground level activity, pedestrian crossing design, traffic signal phasing, Time of day. Second order: Lighting, 'Type' of pedestrian (tourist/ visitor or resident) Footway width, Footway gradient, Movement generators – proximity to transport facilities, Signage, Weather, Day of the week, Presence or absence of other moving people, Presence or absence of other stationary people. Third order: Footway quality, Proximity to road traffic
Saelens (2003a)	Mixed (Public Health)	High/low walkability areas identified based on residential density, land use mix and street pattern. Based on Cervero and Kockelman (1997) developed further by Sallis and collegues (2009).
Mayor of London (2004)	Transport	A walking friendly city is a city where people select walking as their preferred choice of travel for health and to relax and one which exhibits a high degree of 'walkability'. **Walkability may in turn be defined as the extent to which walking is readily available to the consumer as a safe, connected, accessible and pleasant activity.** A walkable city is: Connected, Convivial, Conspicuous, Comfortable and Convenient
Southworth (2005)	Planning	Fine grained land uses, quality of path, connectivity, linkage to other modes, path context and safety
Ewing (2006)	Mixed (Urban Design)	Human scale, transparency, tidiness, enclosure and imageability
Burden (2010)	Advocate	**The extent to which the built environment is friendly to the presence of people walking, living, shopping, visiting, enjoying or spending time in an area.**

Table 2-2: Terms used to describe pedestrian friendly neighbourhoods in identified literature

First author (year)	Research Field	Description
Southworth (1997)	Planning	Grain and pattern of development (including density), land use patterns, public open space, street design and circulation systems, public transport access, pedestrian access and catchments implied as good for pedestrian activity. Noted character, suitability for children, teens and elderly and market success.
Henson (2000)	Transport	Level of service, comfort, convenience, safety, security and economy
Congress of the New Urbanism (2001)	Planning	Walkability alongside: connectivity, mixed use and diversity, mixed housing, quality architecture and urban design, traditional structure, increased density, green transportation, sustainability and quality of life.
King (2002)	Public Health	New Urbanist: mixed use, accessibility, compact and public transport. Environment stressors and restorative environments, imageability and legibility,
Do (2002)	Predominately Transport	Aesthetically pleasing, well lit with well-maintained footpaths
Pikora (2003)	Public Health	Model for walking for recreation, elements from the following groupings: Functional (Walking surface - 4 items, Streets – 1 item, Traffic – 5 items, Permeability – 4 items), Safety (Personal – 2 items, Traffic - 3 items), Aesthetic (Streetscape - 6 items, Views – 2 items) and Destinations (Facilities 2 items)
Moudon (2003)	Urban Design	Elements from the following groupings: Spatiophysical (roadway characteristics, environment along roadway, network, area), Spatiobehavioural (non-motorised traffic, vehicular traffic, safety), Spatiopsychosocial (perception) and area policy that affects walking
McCormack (2004)	Public Health	Land use patterns, urban design characteristics (as street networks) and transportation system links.
Alfonzo (2005)	Planning	Hierarchy of walking needs: feasibility, accessibility, safety, comfort, pleasurability
Urban Design Compendium (2007)	Urban Design	Connected, Convivial, Conspicuous, Comfortable and Convenient

Table 2-2 cont.

First author (year)	Research Field	Description
Brennan Ramirez (2006)	Public Health with participants from transportation, urban planning, parks and recreation and public policy	For activity friendly communities: Land use environment (density and land use mix), facilities, transport environment (availability of alternatives), aesthetics (presence of attractions and absence of physical disorder), travel patterns (frequency of active travel), social environment, land use economic (availability of funds for parks and recreation), transport economic (availability of funds for sidewalks and bike lanes), institutional and organisational policies (e.g. work place travel plans) and promotion
Mehta (2008)	Urban Design	Hierarchy of walking needs on the neighbourhood main street: feasibility, accessibility, usefulness, safety, comfort, sensory pleasure, sense of belonging
Sauter (2008)	Transport	Walking environment, accessibility, public space quality and infrastructure provisions
Stangl (2008)	Transportation	Level of service, wide, clean sidewalks with high green ratio, Attractiveness, comfort, convenience, safety, security, system coherence, and system continuity, Presence of sidewalk and lateral separation, motor vehicle volume and speed, and driveway access frequency and volume. Block segments along arterials, crossings at intersections and crossings at mid-block
Gehl Architects (Van Deurs, 2009)	Urban design and Architecture	Place: park of public space network, part of public space hierarchy, sense of place. Protection: protection against traffic & accidents – feeling safe, protection against crime & violence – feeling secure, protection against unpleasant sensory experiences. Comfort: opportunities for walking, opportunities to stand/stay, opportunities to sit, opportunities to see, opportunities to talk and listen, opportunities for play and exercise. Delight: Human scale, opportunities to enjoy the positive aspects of climate, positive sensory experience
Lo (2009)	Planning	From a Walkability review: presence of continuous and well maintained sidewalks, universal access characteristics, path directness and street network connectivity, safety of at-grade (ground level) crossing treatments, absence of heavy and high speed traffic, pedestrian separation or buffering from traffic, land-use density, building and land-use diversity or mix, street trees and landscaping, visual interest and a sense of place as defined under local conditions, perceived and actual safety

2.2.2 Definitions of walkability

Definitions of walkability and descriptions of pedestrian friendly neighbourhoods identified in the reviewed literature are outlined in tables 2-1 and 2-2. The variety of descriptions found would indicate that when comparisons are being made between findings from walkability studies there is a possibility like is not being compared with like. The high level of definitions from transportation literature may be because transport professionals predominantly use standards and guidelines and therefore may favour rules and definitions to follow in design (Table 2-1).

Transportation professionals, and their research, are concerned with the movement of people, whether it is the provision of public transport or roads between origins and destinations (trip generators) or footpaths and access points along those routes. Unsurprisingly transport discussions on walkability focused on the pedestrian walking as a transport mode, similar to the movement of a car along a road, and thus discuss walkability in terms of level of service (LOS) (space on the footpath) (Fig. 2-1), the provision of a route (connectivity and presence of a path) and the trip generators (origins and destinations) (Lo, 2009; Handy *et al.*, 2002; Henson, 2000). In doing this, the functional task of facilitating the movement of pedestrians is considered similar to the movement of traffic with little or no consideration given to the surrounding environment or the context of the trip being undertaken. A noted exception in early transport research is Do's (2002) article which incorporated multidisciplinary considerations in pedestrian infrastructure design by referencing the urban design texts of Appleyard (1981) and Gehl (2006), documents from the Institute of Transportation Engineers on residential street and pedestrian centred design, and to the Florida Department of Transport report on designing walkable communities (Burden and Florida Department of Transportation, 1995). Also in 2004 the Mayor of London (2004, p.5) defined walkability as 'the extent which walking is readily available to the consumer as a safe, connected and pleasant activity'. The Transport for London Report, '*Making London a walkable city',* states that a walkable city is: (i) connected, (ii) convivial (friendly, lively and enjoyable), (iii) conspicuous (attracting notice or attention), (iv) comfortable and (v) convenient. These are the same terms used in the

Urban Design Compendium (The Housing Corporation and English Partnerships and Lyewelyn-Davies, 2000) thus showing colabration between professions.

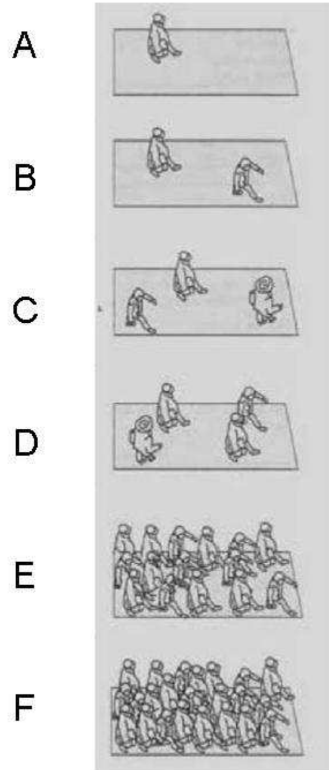

Figure 2-1: Pedestrian Level of Service, Pedestrian Volume to Sidewalk (Footpath) Capacity Ratio (Lo, 2009; TRB, 1985)

In 2004 researchers with spatial planning and urban design backgrounds reviewed the public health environment-behaviour literature and found that research in the urban/ transportation fields was 'complementary' to the public health research (Lee and Moudon, 2004, p.167). They recommended that future multidisciplinary research is likely to promise a better understanding of both the behavioural and environmental aspects of physical activity and physically active travel. This suggestion for a multidisciplinary research perspective to the challenge of defining and understanding walkability was also made by other researchers (Lo, 2009; Stangl, 2008; Southworth, 2005). However, the adoption of walkability indices and scales, based primarily on transport principles, by public health researchers (Sallis, 2009; Sallis *et al.*, 2009; Saelens *et al.*, 2003a) has raised concerns among other professions. Urban designers highlighted that the focus on walkability for physical health has perhaps deflected attention from other types of walkable environments and meanings of walkability.

They note that ‘walkable does not necessarily mean encouraging physical activity’ (Forsyth and Southworth, 2008, p.2). The presence of stationary individuals enjoying an area was suggested as a measure of walkability (Sauter and Wedderburn, 2008; Van Deurs, 2009). This seemingly contradicts the view that a walkable area implies people there are more physically active. Walkability can include more than just the physical environment, it is also the social environment, the perceptions of the area and the comfort of the pedestrian (Lo, 2009). When an individual is in a walkable area or place they may be more likely to be active, socially engage with others and avail of local services. Another articulation of what a walkable environment entails is ‘upscale, leafy, or cosmopolitan’ (Forsyth and Southworth, 2008, p.2) which suggests physical desirability of the place.

Active community and neighbourhood advocates and advocacy organisations outside the health research field have collaborated with policy makers to produce guidelines to make their areas more walkable. For example Living Streets Scotland have worked with Healthier Scotland (2012) and www.walkable.org founder Dan Burden had input on the Florida Department of Transportation guidelines (1995). Burden defines walkability as ‘the extent to which the built environment is friendly to the presence of people walking, living, shopping, visiting, enjoying or spending time in an area’ (2010). These advocates bring additional perspectives, often from residential populations, when trying to understand and promote walkability. User perspectives can greatly inform policy and understanding without professional bias and should be considered.

To conclude, the terms ‘walkability ‘or ‘walkable’ do not have a clear definition in the literature and while there is substantial evidence that the term originated with the New Urbanist movement, built environment professional groups appear to have adopted the term to suit their own agendas. The core meaning of the term relates to facilitating and encouraging walking trips by providing both attractive routes and destinations and functional paths and routes. However, walkability is a multidisciplinary concept which means different things to many different people. Lo (2009, p.148) states that because of this multi-disciplinarily element when ‘considering the question of “what is walkability?” what is important seems to depend on who is asking'. The elements of each of the definitions outlined on Tables 2.1 and 2.2 will be discussed later in this review.

2.3 Multidisciplinary walkability research

Four studies that represent identified research on walkability and the determinants of walking behaviour which engaged multidisciplinary groups are reviewed in this section. These studies have included the views of architects, landscape architects, urban planners, urban designers, transport planners, academics, government decision makers, social ecologists, public health professionals and user advocacy groups (Ewing and Handy, 2009; Allender *et al.*, 2009; Brennan Ramirez *et al.*, 2006; Pikora *et al.*, 2003). The purpose of reviewing the four identified studies in this section was to compare multidisciplinary expert opinions in order to develop a wider understanding of the many built environment factors and their influence on walking.

A study to develop a conceptual framework including a hierarchy of environmental items in order to understand the correlates of walking and cycling was undertaken by Pikora and colleagues (2003). Urban planning, transport and public health professionals and advocacy groups (n=31) were recruited to partake in both structured interviews and a Delphi study[4]. The study, which grounded itself in the social ecological model[5], produced lists with relative weightings for four scenarios; walking for recreation, walking for transport, cycling for recreation and cycling for transport, each with items grouped under four headings; functional, safety, aesthesis and destinations. This exercise, using a variety of opinions, showed that differences exist between the environmental items influencing walking or cycling as behaviours, but also on these behaviours within their contextual purpose, transport or recreation. In

[4] A Delphi study is a process where a systematic approach is taken to gain group consensus by administering a series of questionnaires to collect and rank data. Results are circulated amongst the group for participants to review their responses and amend if they wish. The final data outputs have reduced hierarchical lists of items with corresponding rank and level of agreement scores.

[5] The social ecological model outlines a hierarchy of individual, social, environmental and natural factors influencing behaviours. The model sometimes includes the influence of living and working conditions, institutional structures such as churches and schools and the influence of policy on these environments and the physical structure of the built environment. Ecological models not only assume that multiple levels of influence exist but also that these levels are interactive and reinforcing and may have different effects on individual people depending on their unique beliefs and practice. Ecological models are explained further in Appendix A.

2003 this research was very informative and gave an indication of items which should be considered in walkability research. However, by the nature of the process they underwent, the lists were stripped of the context of their influence on the local environment. The resulting list, while useful, gives a barren framework with little reference to the participant's reasoning as to why items are important or their relevance within local contexts (inter alia level of urbanisation/land use characteristics of the area). From a behavioural perspective it is interesting to note which environmental items are perceived to influence the different types of walking behaviour in a neighbourhood. From a design perspective both behaviours need to be considered to facilitate all trip types within the neighbourhood. Interestingly, the authors listed personal or professional convictions influencing individual's decisions rather than a knowledge of the published literature as a limitation of this study. They thought it contributed to a lack of agreement and variation in item weightings. In my opinion a strength of this study is it requires participants to reflect on their own beliefs and behaviours as well as considering their professional opinion therefore giving a more thorough layered understanding. Relying solely on previous findings as a basis for research can limit understanding of a concept, particularly one with multidisciplinary influences and implications.

Brennan Ramirez and colleagues (2006) also carried out a multidisciplinary Delphi study on items derived from a comprehensive literature review. An initial list of 230 indicators of physical activity-friendly communities were identified from peer reviewed literature and fugitive information to link measures of community environments and policies, to measures of population level physical activity. The twenty five invited Delphi study participants were an expert stakeholder group consisting of local, state, national and international professionals from epidemiology, behavioural science, urban planning, travel behaviour, psychology and policy. Ten indicators of activity friendly communities emerged, with examples of how to assess both perceptual and objective measures of these indicators and potential sources for information within the community environment. The researchers reported that this process posed challenges to them as the literature requiring review was large, multi-disciplinary and had field/discipline specific methods and terminology which created barriers to communication. However a reported strength of the study was the identified indicators had a foundation in multi-disciplinary policies and practices, making their findings transferable and communicable. As a result, the study recommendations bring together responsible groups and policy makers and highlight potential areas of collaboration. The mix of opinions present in this study made it difficult to undertake but the multidisciplinary nature of the outputs made it easier to communicate findings and provided a strong foundation for future collaborations.

Allender and colleagues (2009) conducted qualitative research in order to discuss draft UK government public health guidance (NICE 2008) aimed at modifying environmental factors to promote physical activity. Eight focus groups and three one-to-one interviews were conducted with participants from transport planning (20 persons), urban planning (18), designers and managers of public open spaces (17), architects and designers (3), facility managers from public buildings, transport professional (1), and other relevant professionals including school and sports partnership staff (8). The study concluded that the public health research recommendations relating to the determinants of walking were reflected in the 'accepted wisdom' of those involved in area planning and design (Allender et al. 2009, p.102). They found these guidelines had significant overlap with other documents, inter alia the Manual for Streets urban design guidelines (Department for Transport UK 2007). Suggestions were made for the cross-referencing and integration of future guidance documents for a more unified approach. In essence, the findings of this study reiterated the need for a multidisciplinary approach to walkability to ensure that the relevant wisdom, knowledge and work practices of all disciplines are incorporated into the production of guidelines for their consideration.

Ewing and colleagues (2006) recruited ten experts from the fields of urban design and planning, social ecology, architecture and landscape architecture and tasked them with operationalising eight urban design (perceptual) concepts of the built environment. The aim was to enhance the communication of these concepts, predominantly from environmental psychology, to individuals with no design background. It was deemed necessary by the researchers to recruit experts who use these concepts, such as 'legibility' and 'coherence', in their work because they believed asking a random sample of street users to rate streetscapes with regard to these concepts would be pointless. Video clips of diverse street scenes were used to facilitate the study discussion, and a consensus definition of each of the eight perceptual qualities was reached. These concepts were imageability, enclosure, human scale, transparency, complexity, legibility, linkage, coherence and tidiness. In this mixed method study, panel members rated different scenes with respect to the listed urban design qualities of the streetscapes to produce supporting quantitative data. These ratings were considered valid by virtue of their specialised expertise. While this study only incorporated some of the professions with an interest in walkability an outcome of the study was to create a measurement tool that makes the subjective urban design concepts more transferable and easier to measure and understand. This in turn can benefit further multidisciplinary collaboration.

Overall, this review of multidisciplinary research highlights that there is a diversity of literature and vocabulary used which is a potential challenge when research areas overlap. This is of particular importance when communicating the perceptual and subjective understandings of designers to more logical and practical professions such as engineers and scientists. Allender and colleagues' (2009) made a sensible suggestion that when communicating findings from an individual field it is important to cross reference recommendations with existing literature and guidelines, particularly for professions who are guided by rules and codes of practice such as engineering design manuals. The findings of Brennan Ramirez and colleagues (2006) who identified difficulties relating to the diversity of disciplines and their associated terminologies, work practices, guidelines and tasked outcomes reiterate the need for a cohesive definition of walkability which incorporates the multi-disciplinary fields of relevance. A gap was identified in the knowledge. While previous multidisciplinary work has been carried out among professional groups who are walkability stakeholders no research was identified comparing how the concept of walkability was agreed or how it differed between professionals from various fields of expertise. Also, the views of urban designers or environmental psychologists, arguably the key professions in neighbourhood design/ walkability (Southworth, 2005), were only included in two of the four studies reviewed.

As a result of the importance of multidisciplinary perspectives from the findings of this section of the literature review, in this thesis the first study will focus on exploring the similarities and differences among varied professional groups in their beliefs of what constitutes a walkable area.

2.4 Behaviour models and their role in walkability research

While reviewing walkability and environment related behaviour research it was noted that the behavioural models and theories underpinning the research varied in the different disciplines. The question of how walkability is evaluated was approached in diverse ways. A brief study to explore the role of theories and models adopted by public health researchers, transport planners and environmental psychologists (including urban designers and geographers) in the study of individuals' interactions with, and behaviours within, built environments was undertaken and is reported in Appendix A of this thesis. It is worth noting that one researcher found that the ability of current theories to predict physical activities such as active transportation is quite limited and research on physical activity would benefit from including variables from other behavioural theories (de Bruijn *et al.*, 2009). Conversely other behaviour theories would benefit from including variables from physical activity research. Therefore, understanding the theoretical backgrounds underpinning the research fields gives context and perspective to their approaches. This will potentially inform (i) the information that should be collected in a walkability study and (ii) how to better interpret, integrate and disseminate research findings by making results applicable to the different research interests.

A model proposed by Mehta (2008), which combines the perceptual element of Ewing and Handy's (2009) conceptual model of the environment[6] with an ecological model of walking behaviour that incorporated Alfonzo's (2005) hierarchy of walking needs, to create a comprehensive model for a main street setting (Figure 2-2) was identified as the most informative model. As outlined in the introduction to this thesis the socio-ecological model has been considered appropriate for analysing the link between the built environment and physical activity (Pikora *et al.*, 2003; King *et al.*, 2002; Sallis *et*

[6] Ewing and Handy's model is described further in section 2.5

al., 1998) as it emphasises the role of both the intra (personal, behaviour) and extra-individual (social, physical, contextual) variables on behaviour outcomes (King *et al.*, 2008; TRB, 2005; Pikora *et al.*, 2002; Humpel *et al.*, 2002; Sallis *et al.*, 1998). Mehta's model includes the accessibility and feasibility affordances of a trip consistent with Perceived Behavioural Control (PBC)[7] as a determinant of behaviour (Godin, 1994). The physical and land use characteristics correspond to the physical environment factors on Pikora and colleagues' model (2003) and the street characteristics correspond to Gehl Architects' considerations of place, protection, comfort and delight (Van Deurs, 2009). The purpose of the walking trip outcome is not included in this model as it relates to a specific environment, the main street, but the model does encompass the self-efficacy[8], perceived behaviour control and individual demographic considerations discussed in the review behavioural models (Appendix A) and is therefore a good foundation for further ecological models of walking behaviour. Also missing from the model is a pathway by which an individual's emotional response to an area triggers a coping response (Bell *et al.*, 2001, p.122) whereby the pedestrian adapts by taking an alternative route rather than abandoning the trip which still results in walking behaviour despite the negative perceptual response to their environment.

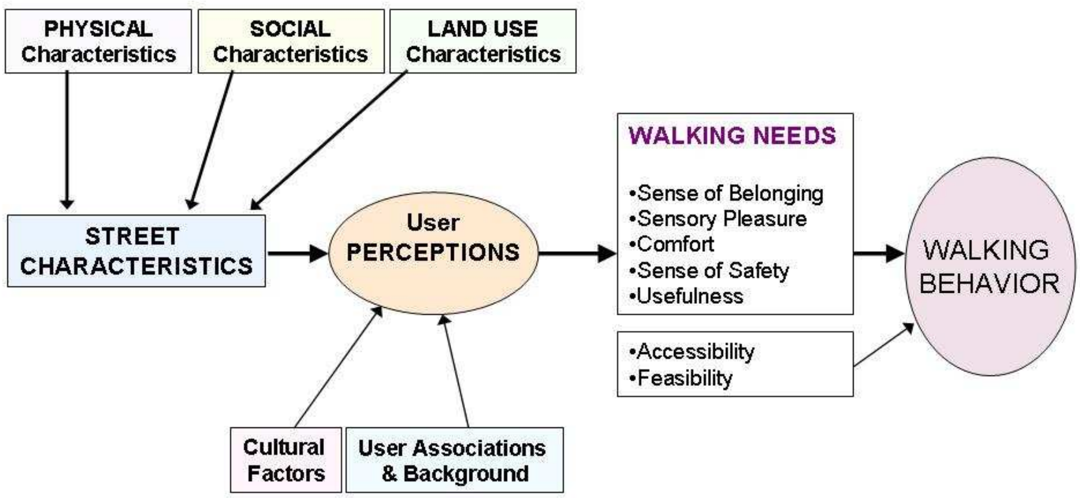

Figure 2-2: Conceptual framework of walking needs on Main Street Adapted from Mehta (2008)

[7] PBC is where the behaviour may or may not be in control of the individual because of a requirement for opportunities, resources or skills, discussed further in Appendix A.
[8] Self-efficacy is a belief that one can successfully perform a desired behaviour

When constructing ecological models of behaviour it is also important to recognise that environment – behaviour relationships are transactional in nature and should be represented as such (King *et al.*, 2002). This is consistent with Social Cogitative Theory (SCT) which explains behaviour as the interplay among the person, the behaviour, and the environment in which the behaviour is performed (Bandura, 1977) (Figure 2-3). An example of this interplay is how litter and graffiti are products of human behaviour which can influence an individual's perception of their environment.

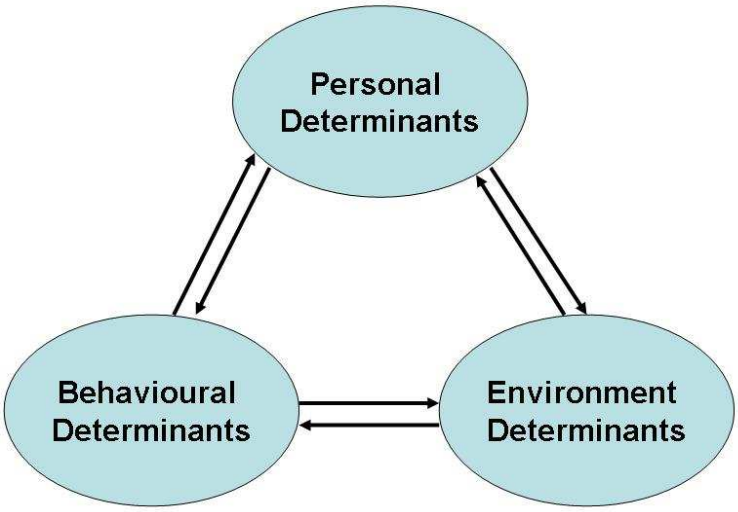

Figure 2-3: Social Cognitive Theory (SCT)

The relationship between exercise adherence theories such as self-efficacy[9] theory and the Theory of Planned Behaviour (TPB)[10] may relate well to recreational behaviours (Biddle and Mutrie, 2008), however these theories may require additional theoretical considerations for transportation walking trips which have a more functional outcome. For example, health outcomes may be a factor in modal choice decisions but is not necessarily the primary motivation for undertaking the trip. This limitation of current models, alongside the need to encompass environment models and theories, may warrant the construction of a new model. To truly understand walkability and to communicate effectively between disciplines we need to collect as much of this

[9] ibid

[10] TPB suggests that determinants of behaviour are an intention to engage in that behaviour and perceived behavioural control (PBC)

information as feasible to generate a comprehensive picture of an individual's environment. This is an extensive list and consideration should be given to feasibility and expense.

Another consideration for a walking specific behavioural model of the environment is the individual's response to environmental stimuli, or perceptions of the environment. While Biddle and Mutrie (2008) note that perception is rarely studied in exercise research, it is the foundation stone of environmental psychology, one theory behind urban design (Carmona *et al.*, 2003). A greater emphasis on perceptions, thus embracing urban design theory, could potentially strengthen (physical) environment - behaviour research and the application of SCT.

2.5 Perceptions

Perception is the term applied by environmental psychologists to 'the complicated processing, integration, and interpretation of complex, often meaningful stimuli' we encounter in everyday life (Bell *et al.*, 2001, p.57). Public health research focuses predominantly on the psychosocial correlates of physical activity and features of the structural environment on the decision to walk in the neighbourhood while urban designers and environmental psychologists concurrently consider perception of the physical environment as an entity or 'place' (section 2.7.2). Kusenbach (2003) relates our perceptions of the environment to a series of veils through which our views are filtered. These veils symbolise our personal capacities (our emotions, tastes, values, abilities and previous experiences) and are shaped by and sensitive to social contexts. Perceptions can vary greatly throughout our life course and from one moment to another and as individuals we are not aware of the fact that what we notice in the environment is determined by a 'complex and selective process' (Kusenbach, 2003, p. 466). Awareness and appreciation of environmental perception, and in particular of perception and experience of 'place', is an essential dimension of urban design (Carmona *et al.*, 2003, p.87, Figure 2-4). These perceptions, which are also informed by the activity and physical setting, feed into the image or sense of a place. Sense of place is described in more detail in section 2.7.2.1 of this chapter. The design of an area can affect the perception of the choices available to an individual, for example: (i) good permeability dictates that they can go many routes, (ii) the variety affects the range of uses available to them and (iii) the legibility affects how easily people can understand the area. These concepts are fundamentals of good urban design to create responsive places which people will engage with.

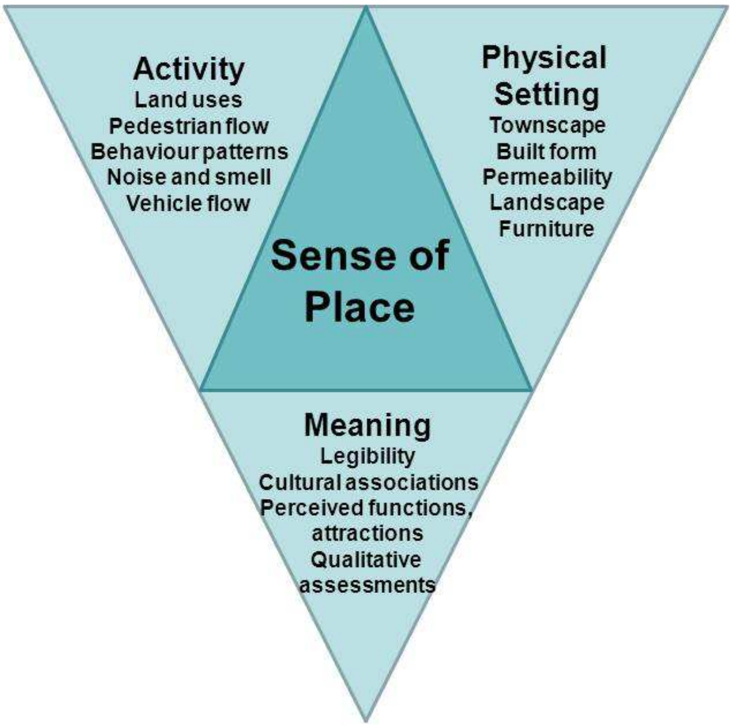

Figure 2-4: Fostering an Urban Sense of Place from Punter (1991) (Source: Carmona *et al.*, (2003) via Montgomery (1998))

Figure 2-5 illustrates how an individual responds to an environment can depend on how (i) pleasant and (ii) arousing they interpret it further emphasising the importance of contextual relevance in neighbourhood or streetscape design. Although the importance of these subtle and complex perceptual qualities is well documented in urban design literature, few attempts have been made to objectively measure these qualities (Ewing and Handy, 2009). One facet of urban design is the conceptual design of the streetscape to reflect the context and purpose of the area. Individual street or building design elements conform to this overall design plan. Figure 2-6 shows how urban design qualities are considered an element in individual reactions to place (such as a sense of safety or a sense of comfort) in Ewing and Handy (2009)'s conceptual framework. These qualities may produce different reactions in different people given their own attitudes and perceptions. Ewing and Handy (2009, p.67) note that while the urban design qualities 'can be measured with a degree of objectivity of outside observers, individual reactions cannot'. Some of the urban design qualities listed on

Figure 2-6 are explained under elements of walkability in section 2.7.2. This list contains a sample of urban design qualities; a description of each of the items on the extensive lists of urban design qualities is beyond the scope of this project.

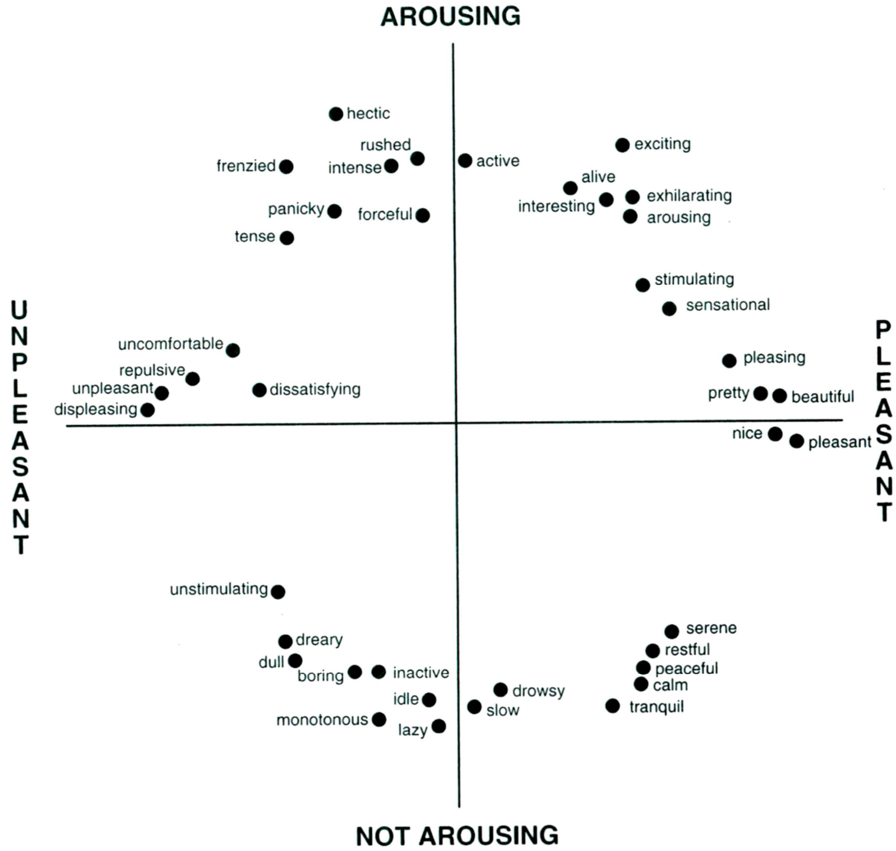

Figure 2-5: Perceptive response to arousing/ not arousing and pleasant/ unpleasant environments (Bell *et al.*, 2001) **adapted from (Russell and Lanius, 1984)**

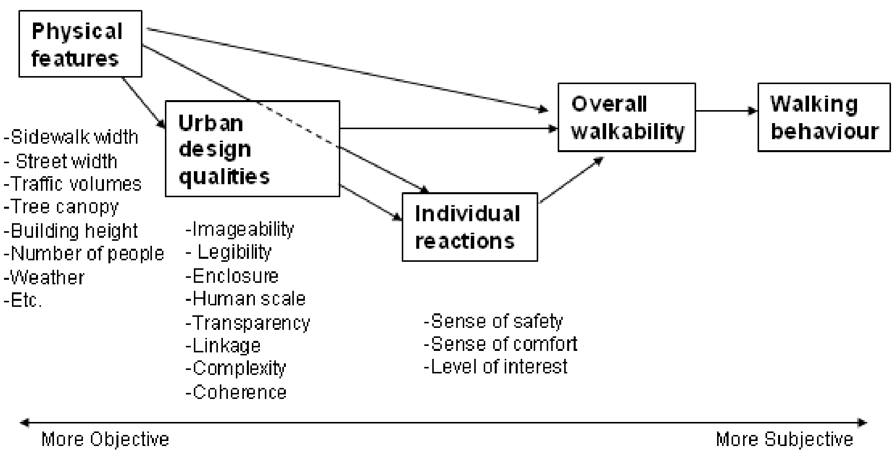

Figure 2-6: The role of perceptions as they intervene (or mediate) between the physical features of the environment and walking behaviour (Ewing and Handy 2009).

Brown and colleagues (2007) used a mixed method approach to investigate how people experience different aspects of the environment. They collected data via self-report questionnaires and walk-in-time interviews in audited areas (N=73, mean age= 24yrs, 34% male). Their results highlighted the importance of understanding the subjective experience of pedestrians for walkability research. By focusing on the multiple forces that create pleasant or unpleasant walks, the aim was to better understand how these countervailing forces (physical, psychological, social and cultural aspects) come together to influence walking. In particular, the social environment (e.g. evidence of homelessness or depravity) of an area was one of the most important features people noticed and commented on. Qualitative methods such as phenomenology[11] can measure perceptions as they can detect and directly observe 'the workings of such perceptual filters which not only create the 'visibility' of objects but also determine how they are interpreted' (Kusenbach, 2003, p.468). In-person audit measures of the environment or place interviews such as those used in Brown and colleague's (2007) study are time consuming and Brownson and colleagues (2009) recommend that researchers consider whether alternative methods of assessing the built environment would suffice for their study. However, they also note that for studies where research questions involve the human qualities of the environment, the look and feel of a place, direct observations are especially appropriate. It is unclear if Brownson and colleagues are referring to observations by the researchers or by participants.

A number of public health studies have compared objective measures of the environment to perceptual responses from subjective self-report questionnaires and noted discrepancies between them (Brownson *et al.*, 2009; Brown *et al.*, 2007; Gebel *et al.*, 2009; McGinn *et al.*, 2007). These discrepancies were then discussed as limitations in the survey instrument's validity rather than being embraced as a valid perception of the environment by the individual. In public health research the physical environment is frequently compared to physical activity behaviours controlling for the demographic profile of participants while giving little consideration to the role of the

[11] Phenomenology is a philosophical approach to the study of lived experiences. The approach concentrates on the study of consciousness and objects of direct experience

perceptual nature of the environment and the contextual neighbourhood design. This is an identified gap in the literature which warrants further investigation.

The question of how one assesses walkability has been approached in diverse ways. In particular, the transportation profession have fundamentally different perspectives and models for planning for vehicles in comparison to those for planning for pedestrians (Stangl, 2008, p.759). In contrast, urban design texts (Gehl, 2006; Carmona *et al.*, 2003; Bentley *et al.*, 1985; Lynch, 1965; Cullen, 1964) describe how the process of moving through an area creates a series of user-perceptions of that area, and these perceptions impact on the decision processes of how that individual chooses to move through an area. The appreciation of these experiences can potentially differ greatly between individuals who have been trained in environmental psychology (urban designers, architects and planners), or the functional mechanics of movement and flow (engineers and traffic planners) and others who have not been trained in either of these disciplines. The pathway from environment to behaviour is complex which makes the investigation of the relationship between them complicated.

To conclude, in order to draw associations between the built environment and behaviours many facets of the environment need to be considered and not just the physical environment but also its context (including social context), individual emotional responses and the purpose of the area (e.g residential area, a row of nightclubs, a park or historic area). Habitual behaviours and occasional trips should both be considered, also in context, where possible. An individual's personal characteristics are also important. Individual, family, community and city level social considerations may all influence perceptions and behaviours. To truly understand walkability and to communicate effectively between disciplines we need to collect as much of this information as feasible to generate a comprehensive picture of an individual's environment. This is an extensive list and consideration must be given to feasibility and expense. A challenge for the current study is to incorporate all of these facets (or as many as feasible) into a study methodology and model for studying the relationship between the environment and behaviours.

2.6 Measurement of walkability

Historically, physical activity researchers measured built environment variables they thought to be related to recreational physical activity such as the presence and proximity of facilities and destinations such as schools, workplaces and recreational facilities (Sallis, 2009). In recent years public health research investigating the influence of the built environment on physical activity has evolved embracing transportation planning principles and land planning rationales (Frank *et al.*, 2010; Badland and Schofield, 2005; Pikora *et al.*, 2003; Brownson *et al.*, 2009; Hoehner *et al.*, 2005) and urban design streetscape design concepts (Ewing and Handy, 2009). An increasing use of ecologic models of behaviour which highlighted other important categories of influence, such as land planning and transport, has been credited with this evolution of the research field (Sallis, 2009). The purpose of this section is to review the literature on the measurement of the built environment, in the context of walking/physical activity behaviours, and consider the findings in the context of neighbourhood design practices and policies.

In the second literature search, outlined in Section 2.2, two papers were identified which reviewed methods used to measure the built environment for walking/ physical activity (Brownson *et al.*, 2009; Sauter and Wedderburn, 2008). The latter paper was a working paper which informed the Pedestrian Quality Needs (PQN) final report on measuring walking (Sauter and Tight, 2010). A third paper was identified which outlined the historic development of measuring the built environment for physical activity (Sallis, 2009). Reference lists and keywords from the eligible studies were scanned to identify additional relevant studies to inform this section of the literature review. Both of the identified reviews combined information from literature searches, expert input and feedback from workshops on the topic (Sauter and Tight, 2010; Brownson *et al.*, 2009).

Many diverse methods and tools exist for measuring the built environment and the merits of using any measurement method depends on the required detail of information, the spatial scale of interest (i.e. city wide or street specific) and the contextual purpose of the study (Kelly *et al.*, 2011; Brownson *et al.*, 2009; Sauter and Wedderburn, 2008; Brown *et al.*, 2007; Ewing *et al.*, 2006b). Three categories for measuring the built environment were identified by Brownson and colleagues (2009) in their review; (i) perceived measures from interviews and self-report questionnaires, (ii) observational measures from audits and (iii) archival data sets which are often layered and analysed using Geographical Information Systems (GIS). Sauter and Tight (2010) also include recently developed mobile interviewing methods, measures of time spent in spaces and pedestrians' perceptions using images (i.e. 'measuring the smiles'). Studies collected qualitative and/or quantitative data which was classified as subjective or objective. An interesting difference between Brownson and colleagues' (2009) health science academic study and Sauter and Tight's (2010) transportation practice based study was the discrepancy in the categorisation of street audits. Sauter and Tight (2010) describe audits as qualitative data, defined as being based on small numbers, approximations and judgements as well as verbal descriptions whereas Brownson and Colleagues (2009) classify 'expert' audits as objective quantitative data from the systematic coding of observations into attributed scores and is analysed as such. This discrepancy highlights the contextual nature and limitations of street audits which are discussed in greater detail in section 2.6.2. Identified categories will be the headings for this section of the literature review.

Table 2-3: Classification of assessment (adapted from Sauter and Tight (2010))

	"qualitative" results usually based on small numbers, approximations, judgments, descriptions (verbal data)	**"quantitative"** **results usually based on larger (representative) figures**
"subjective" **results usually based on personal perceptions and opinions**	Example: Community street audit (How community members judge safety of a crossing)	Example: Population survey about attitudes towards walking (How safe people feel generally)
"objective" **results usually based on 'immediate reality' ('objectivated' judgments)**	Example: Expert street audit based on norm checklist (How well a street fulfills official safety requirements)	Example: Counts and 'hard' data collection (How many people got killed and seriously injured)

2.6.1 Self-report or interview questionnaires

Most of the evidence on the association between the built environment and physical activity has been collected using self-administered or telephone interviews in cross sectional studies (Brownson *et al.*, 2009). Many survey instruments were produced to assess the environmental perceptions of individuals living in an area by public health researchers. Theses questionnaires have been predominately designed and tested on populations in Australia and the USA (Spittaels *et al.*, 2009; Brownson *et al.*, 2004b). In a review of questionnaires used to measure the built environment Brownson and colleagues (2009) reviewed 15 studies varying in length from 6 items to 68 and found that land use, traffic, aesthetics and safety from crime were the most commonly assessed variables. Measures varied in reported reliability and validity. The reported validity of structural items such as footpaths tended to be higher than items relating to perceived level of crime (Brownson *et al.*, 2009). This finding is not surprising considering the diverse individual influences that are known to effect perceptions, particularly in relation to social or non-structural items.

The most frequently used tool internationally is the NEWS[12] (68 items), or the abbreviated version (ANEWS, 54 items) which has been fostered by collaborations such as the IPEN[13] (Brownson *et al.*, 2009). The NQLS[14] survey incorporates the NEWS instrument and also asks quality of life and social cohesion measures. NEWS was developed by a multidisciplinary team including two public health professionals and individuals from transport, an environment protection specialist and an urban planner (Saelens *et al.*, 2003a). The questionnaire includes questions relating to residential density, proximity to destinations, connectivity, pedestrian paths and trails, aesthetics, traffic safety and safety from crime. The IPAQ[15] physical activity questionnaire (Craig *et al.*, 2003) is frequently used alongside the NEWS environmental questions as a measure of physical activity behaviours.

[12] Neighbourhood Environment Walkability Scale
[13] International Physical Activity and the Environment Network
[14] Neighbourhood Quality of Life Survey
[15] International Physical Activity Questionnaire

Environment assessment questionnaires vary in content and often the tools are produced with little or no input from built environment professionals. Future questionnaire design should include items relating to an individual's perception of comfort, safety and social environment consistent with ecological models which encompass environmental psychology theories.

2.6.2 Environment audits

The path context (or micro environment) was described by Southworth (2005) as the most problematic and least developed walkability criteria which can only be measured with street level information. Environmental audits; a systematic observation of the physical environment at street level, are frequently undertaken to measure built environments for physical activity (Brownson *et al.*, 2009). Audit tools vary in content, structure and formality depending on their purpose. Tools used in physical activity research were found to predominately look at paths, cycle lanes and parks in two reviews of 13 and 20 audit tools respectively (Moudon and Lee, 2003; Brownson *et al.*, 2009). Also, little consideration is given to sense of place or pedestrian comfort with an assessment of overall attractiveness or comfort generally only a small element of an audit tool if present (Brownson *et al.*, 2009; Brown *et al.*, 2007; Day *et al.*, 2006; Moudon and Lee, 2003; Pikora *et al.*, 2002). Purciel and colleagues (2009) have recently developed and tested an audit tool which considers five perceptual urban design streetscape factors. This method is heavy on audit data but considers street elements which were omitted from other studies that focus on collecting functional information on items such as street furniture and traffic lanes.

In transportation, pedestrian counts were used to objectively measure the success of a highly pedestrianised area but thinking has evolved in recent studies. Now the enjoyment of an area is often measured by the time spent in the public space (Sauter and Wedderburn, 2008; Gehl, 2006; Van Deurs, 2009). The Pedestrian Environment Review System (PERS) is an environment audit tool developed by Transport for London (TfL) which considers; (i) moving in the space; (ii) interpreting the space; (iii) personal safety; (iv) feeling comfortable; (v) sense of place; and (vi) opportunity for activity (Clark and Davies, 2009). In the application of this tool auditor results are imputed into a GIS dataset where segment scores are represented with a traffic light colour system alerting local authority departments to areas requiring attention. Auditors can also upload images of audited segments for reference and verification. By considering all of the elements of the street network and trip stages, including public transport trips, a complete route profile is captured. This tool is an excellent example of how environmental audits can be used to translate walkability research into practical works.

In Ireland, the National Roads Authority require road safety audits of all newly built roads and junctions and road sections undergoing amendments (NRA, 2004) as part of a traffic and transport assessment (NRA, 2007). Road safety audits have legal implications and are based on traffic safety design standards. Audit guidelines were developed with consideration for highway standards and favour the movement of vehicles by the nature of their remit. Ireland’s Design Manual for Urban Roads and Streets (DTTAS & DECLG, 2013) was published in early 2013 to counteract the perceived overdesign of urban streets which previously had to conform to highway standards. These new guidelines recommend a variety of audit types depending on scheme context. One such audit is a Community Audit. These audits are often carried out by community groups for political lobbying (Burden and Florida Department of Transportation, 1995; Brownson *et al.*, 2009). Urban planners and designers also use community audit tools during public consultation processes and disability advocacy groups use community and accessibility audits to lobby for inclusive facilities. Each groups’ needs are identified in the streetscape characteristics which they highlight. Audit results may therefore be contradictory. Despite this the variety of views raised are useful for designers to consider. Public health physical activity audits, although limited in their considerations, also play a role in this process but like others do not present a complete picture on their own.

Rich street level data comes at a price. The time-intensive nature of in-person data collection makes a street level auditing approach unfeasible at a large scale (Purciel *et al.*, 2009). For reproducible scientific studies observed item audits require a greater level of detail, researcher training and reproducibility testing (Brownson *et al.*, 2009; Millington *et al.*, 2009; Clifton *et al.*, 2007; Day *et al.*, 2006; Lee *et al.*, 2005; Pikora *et al.*, 2002). The desire for an audit tool which can measure streetscape features reliably can result in some identified items omitted from the tool therefore limiting the comprehensiveness of an audit instrument (Pikora *et al.*, 2003). For larger (macro) scale projects, street level inspection (ground-truthing) can be carried out to verify neighbourhood attributes obtained from GIS datasets. This was done by Sallis and colleagues (2009) in their SMARTRAQ[16] project to avoid boundary problems, i.e. areas with very different walkability characteristics in an area identified as being consistent on a macro scale GIS dataset.

An advantage of the detailed data that can be collected in street audits is that professionals such as urban designers, landscape architects and traffic engineers can act on particular references in the study findings (Brownson *et al.*, 2009). Consideration must be given to the level of detail and the type of information required for a project before embarking on a data collection exercise. Caution must also be applied to calling a dataset collected by a street audit 'objective'. Most audit tools are subjective in nature as they only collect information on environment features which have been identified as important for walkability by particular subgroups. Perceptions of what characterises walkable areas differ between professions and as a result audit tools have an inherent bias. When a project does not have the time or means to undertake a street level audit it is important to at least do a site visit to verify neighbourhood characteristics, particularly when using second hand data on an area.

2.6.3 Qualitative neighbourhood measurement

While environment audits and self-report questionnaires record information on individual items or elements of the built environment, qualitative neighbourhood measurement methods assess the cumulative effects of these different facets that impact on pedestrians' perceptions and their resulting behaviours (Kelly *et al.*, 2011; Mehta, 2008; Brown *et al.*, 2007; Kusenbach, 2003; Gustafson, 2001; Lynch, 1965). Also, while area audits provide information of auditors' perceptions of the environment and questionnaires rely on recall of environmental perceptions of large areas, often over a number of days, these studies cannot answer the question of how individual pedestrians would perceive particular sections or specific elements of the

[16] Metropolitan Atlanta's Regional Transportation, Land use and Air Quality Study

environment, such as a particular street crossing, in the same way (Brown *et al.*, 2007). This information would be useful for local authorities to identify remedial measures but also to identify more specific elements of the environment for study.

Qualitative studies on the environment, like audits, are time consuming (Brownson *et al.*, 2009). However, they are also data rich with valuable information on individual perceptions. They also inform how personal demographics and social environments impact on these perceptions. This is consistent with the ecological models outlined in section 2.4. Kelly and colleagues described the shared experience of the researcher and participant on their mobile interviews (N=20) as ‘worth a thousand words’ (2011, p.1506). This was because context specific responsive behaviours (moving in on the footpath when a car passed), expressions, gesturing and body language were all observed by the researcher. This shared experience also enabled discussion using real examples they experienced and comparison with other areas they passed through. In situ discussions on items/elements in context specific examples, i.e. what you like/dislike about them and their interaction and juxtaposition within the greater streetscape, were also very informative as walking and environmental perception are situated practices (Kelly *et al.*, 2011). Kusenbach (2003, p.457) highlights warnings by sociologists that phenomenology should not be taken as a substitute for an empirical method[17]. When used in conjunction with objective measures of the environment, mapping or audits, results from phenomenological, ethnographic[18] or interview studies can be incredibly informative as was observed in studies by Kelly and colleagues (2011), Mehta (2008), Brown and colleagues (2007), Anderson (2004), Kusenbach (2003), Elwood and Martin (2000), Gustafson (2001) and Lynch (1965). Kusenbach’s (2003) ethnographic study using a phenomenological approach (N= 61 ‘go-along interviews’) confirmed the influence of (i) an individual’s perceptions (including those related to profession), (ii) an individual’s spatial practises, route choices and familiar geographies (which are symbols of someone’s identity), (iii) life experiences and spatial associations, (iii) the importance of the social architecture of an area, the web of social relationships between individuals who live in the area and (iv) the social realms an

[17] An empirical method is one based on, concerned with, or verifiable by observation or experience rather than theory or pure logic

[18] An ethnographic study is one which observes a cultural or social group

individual passes through, where they have social encounters with people familiar to them and with strangers, on an individual's perception of their neighbourhood. A qualitative data collection tool called 'Photovoice' was used in the URBAN[19] study in New Zealand alongside objective GIS measures, the SPACES community audit tool (Pikora *et al.*, 2002) and a cross sectional population study using a self-report questionnaire (Badland *et al.*, 2009) however no results have been published on the qualitative data collected to date.

Like micro-level audits the feasibility of data-rich qualitative studies investigating individuals' perceptions of areas in real-time should be considered when investigating the influence of the environment (physical and social) on individual's behaviours. Collected data gives a rich insight into how perceptions of the environment are constructed. Further utilising this information to inform the ecological model of walking behaviour and research on the influence of the built environment on physical activity, merging environment and exercise psychology knowledge bases, would be an important advancement in walkability research.

2.6.4 Geographical information systems (GIS)

The most common method used to identify study neighbourhoods for city-wide or international walkability studies is using GIS datasets (Brownson *et al.*, 2009). A GIS system is a computerised system for storage, management and analysis of spatial (locationally defined) data which can be spatially displayed on digital interfaces such as computer screens (Leslie *et al.*, 2007). Datasets can be layered to facilitate the interaction of multiple digital datasets at a defined spatial point or areas, Figure 2-7. Everyday examples of GIS applications include using GOOGLE Maps™ to find directions to a location of clicking on an online map to retrieve information relating to a location or region.

[19] Understanding the Relationship Between Activity and Neighbourhoods

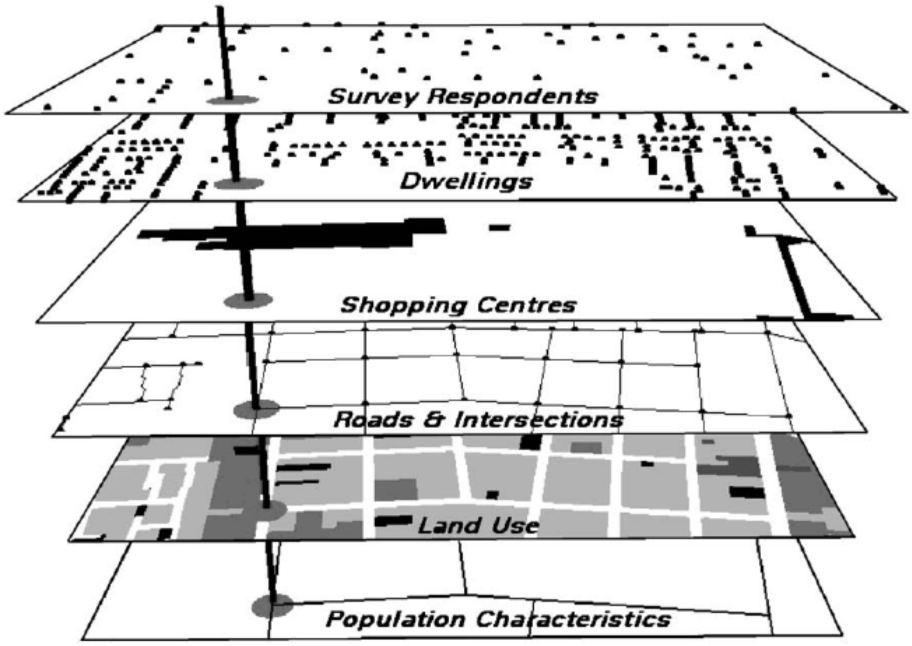

Figure 2-7: Simplified model of a GIS system (Leslie *et al.*, 2007)

In public health walkability/ built environment research GIS references refer to measures of the built environment derived primarily from existing data sources that have spatial references. Brownson and colleagues (2009) describe GIS as the only feasible way to generate objective measures for studies involving individuals or neighbourhoods dispersed across large areas. The most frequently assessed variables listed in Brownson and colleagues' review (2009) are population density, land use mix, access to recreational facilities, street pattern/ connectivity, vehicular traffic, crime and others including building design, public transit, slope and greenness/vegetation. Composite variables/ indexes are also used. This information is usually obtained from City authorities and census databases. Additional information collected, like neighbourhood survey or audit data can be added to a GIS dataset by Geocoding. Geocoding is the process of matching home address location information (e.g. global positioning system (GPS) point at the front door) with a digital spatial dataset which includes all addresses of interest (Thornton *et al.*, 2011). This process allows for contextual analysis of collected data, for example a combination of GIS environment mapping data and neighbourhood audits were used by Hoehner and colleagues (2005) to identify and assess the neighbourhood characteristics within a 400 metre radius of respondent's homes which were geocoded.

GIS relies on the assumption that the information provided is constant over the sample area and is limited by the quality of the data available. For example, depending on the rate of development of a city, datasets may be outdated quickly particularly in areas undergoing urban regeneration, suburban development or areas that have being abandoned by their residents following a spate of high profile serious crimes. Merged dataset information may have been collected years apart and from different sources where the collected data could have been for alternative purposes, therefore potentially biasing the data. The validity and reliability of GIS based measures is threatened by the accuracy and completeness of existing data sources as well as the scales at which the data is measured. These are frequently cited limitation of GIS studies (Moudon *et al.*, 2007; Van Dyck *et al.*, 2009; Badland *et al.*, 2009; Brownson *et al.*, 2009) particularly when applying macro scale datasets to meso or micro scale environments. GIS is useful in public health population scale research as it is easy to use when you have the skills and software and it allows for large scale statistical associations and the combination of information from a variety of sources. However, when it is being used to study links to the built environment, if possible, data should be informed or verified using alternative street level information. The availability of consistent, reliable, detailed datasets which could be utilised to build models fully replicating the structure and street level attributes of a neighbourhood would enable more micro scale analysis of larger areas.

2.6.5 Composite GIS Indices

Eleven studies were identified by Brownson and colleagues (2009) which used composite variables constructed using a combination of GIS measures. These studies claim that using indices ‘reduce spatial collinearity, capture the inter-relatedness of built environment characteristics and ease the communication of results’ (p.S115). A key purpose of GIS walkability indices is to identify areas of high and low walkability from large, city-wide GIS datasets. Sites can be selected based on a combination of walkability elements and demographic information form census datasets. The most frequently used index was identified as the neighbourhood walkability index (WI) developed by Frank and colleagues (2010).

2.6.5.1 The walkability index (WI)

In a review of ten studies from transportation literature Saelens and colleagues (2003b) identified that the lack of a consistent or any quantified objective walkability index to assign high- and low – walkability neighbourhoods based on environmental factors was a common limitation of the studies. Informed by this review which identified population density, land use mix and the walking and cycling infrastructure as factors which demonstrate associations with walking or cycling for transport and a walkability index was developed. The developing index was used to select areas by the PLACE[20] (Leslie *et al.*, 2005), NQLS (Frank *et al.*, 2005) and SMARTRAQ projects (Frank *et al.*, 2010). The WI methodology has been used by IPEN projects with some variability. These projects, which include the URBAN study in New Zealand (Badland *et al.*, 2009) and the BEPAS[21] study in Belgium (Van Dyck *et al.*, 2010) select their areas based on the composite WI measure using comparable data available to them.

For the Australian PLACE study, two areas with similar median household weekly income and median resident age (from census data) were selected using GIS data which assigned walkability scores based on the developing WI walkability index (Leslie *et al.*, 2005). The smallest spatial unit available to the researchers was used and the data layer was filtered to include only urban spatial units with a population density of over 200 people per square kilometre, their identified urban density cut-off. GIS datasets for roads, intersections and land use were layered and analysed for intersection density, dwelling density and a measure of land use mix. Each variable was assigned a score from one to ten and a summation score was calculated. The top and bottom quartiles of the remaining areas were used to represent high and low walkable areas respectively. In the SMARTRAQ study (Frank *et al.*, 2005) measurements of net residential density, street connectivity and land use mix (described in greater detail in section 2.7.1) were combined into a walkability index using normalized (z) scores. A range of weights were assigned to the elements in the walkability index to find the combination with the greatest explanatory power of the variation of objectively measured minutes of moderate physical activity

[20] Physical Activity in Localities and Community Environments Study
[21] Belgian Environmental Physical Activity Study

(accelerometers). It was reported that the environmental elements were combined into an index because of the degree of correlation between density and connectivity which creates model estimation problems associated with interactive variables or spatial multicollinearity. The resulting index was:

*Walkability index = (6 * z-score of land use mix) + (z-score of net residential density) + (z-score of intersection density).*

The NQLS project, (Sallis *et al.*, 2009) extended the WI index to include a measure for retail floor area ratio using pre-existing parcel-level land use data. The revised walkability index was:

*Walkability index = (z-score of land use mix) + (z-score of net residential density) + (z-score retail floor area ratio) + (2 * z-score of intersection density).*

The rationale given for the item weightings were evidence of a strong influence of street connectivity on non-motorised travel choices and prior evidence of regarding reported utilitarian walking distances (Frank *et al.*, 2010). Similar to other studies using the developing WI index variability in walkability was measured using the index. Limitations due to data availability have been reported in attempts to replicate the WI walkability measure. The BEPAS study did not use a retail floor area measure in the index due to information not being available and the residential density was a ratio construct (Van Dyck *et al.*, 2010). While the WI is a useful tool for differentiating between areas within a city for a single study, the differences in the application of the index between studies warrants caution, particularly when comparing the walkability or behaviour associations between cities or sites selected using different variations of the model.

Despite the WI's foundations in transportation, results for areas assigned high and low walkability using the developed WI index continue to report on associations with recreational walking despite there being no consideration for recreational walking in the assignment of the walkability score (Van Dyck *et al.*, 2010; Cerin and Leslie, 2008; Sallis *et al.*, 2009). Sallis and colleagues (2009) clarified the transport walking focus of the WI in a discussion note making it clear that the WI measure was designed for transportation walking and not walking for recreation. This key limitation of the WI index has been addressed in some studies using the WI index by using street audit tools to collect street level information. Hoehner and colleagues. (2005) used additional audit data on pavement existence/ quality, places to exercise, public transport stops, aesthetics and social environments. It is unclear what made either of the cities identified for comparison 'high' or 'low' walkable in the literature on the study. The URBAN study (Badland *et al.*, 2009) and the BEPAS study (Van Dyck *et al.*, 2009) used the SPACES audit tool (Pikora *et al.*, 2002) to audit the neighbourhoods for additional street level information on the areas selected for survey using the WI index but neither study amended the walkability classification of the area based on this information.

2.6.5.2 Urban design walkability index

Recently a New York City (NYC) study described in Purciel and colleagues (2009) and Neckerman and colleagues (2009) encompassed a wider variety of available datasets to expand the range of relevant built environment variables considered on objective GIS databases to select study areas. This was done as poorer areas in NYC which scored high on the WI objective walkability showed chronically low levels of physical activity. It was also acknowledged that streetscapes in these neighbourhoods were less aesthetically attractive. The constructed index comprised of the sum of five standardised scores (z score) measuring (i) population density, (ii) unique intersection density (which consolidates intersections on divided streets), (iii) minimum distance to nearest subway stop, (iv) a measure of the balance among five types of land use and (v) the ratio of retail building floor area to retail land area (i.e. retail density). In addition to these measures, information from a land use database for New York City, which includes information on building height, usage type and block size, was combined with information from other public service datasets including the NYC Department of Parks and Recreation Database (green spaces/ recreational amenities/ street trees census) and the NYC Department of Consumer Affairs (presence of outdoor dining) and other data on historic buildings, street cleanliness, crime statistics and traffic safety measures to build a more comprehensive database of streetscape features. Parcel level[22] GIS data from these datasets and field observation of a matched-pair sample of 76 block faces on commercial streets in poor and non-poor neighbourhoods were compared. Poor census tracts had significantly fewer street trees, landmarked buildings, clean streets, and sidewalk cafes, and higher rates of felony complaints, narcotics arrests, and vehicular crashes. The field observation showed similar results. It was concluded that improving aesthetic and safety conditions in poor neighbourhoods may help reduce disparities in physical activity among urban residents (Neckerman *et al.*, 2009). This finding is really informative. Streetscape elements are a critical part of a pedestrian's perception of their environment and while the quality of GIS information available for streets in NYC may be difficult to replicate in lower density/ less populated cities it is process that is worth attempting. Findings such as this also justify efforts to compile a central database within urban authorities that combines as much walkability-relevant data as possible.

Purciel and colleagues (2009) attempted to replicate the operational definitions of five urban design features associated with walking in a GIS index developed by Ewing and Handy (Ewing and Handy, 2009; Ewing *et al.*, 2006b) using the detailed data collected for the streetscape study (Neckerman *et al.*, 2009). Despite the quality and complexity of the data collated in the New York study the model was not replicated fully (Purciel *et al.*, 2009). Work is continuing to develop and validate an audit tool to measure these urban design features (human scale, imageability, transparency, complexity, tidiness and enclosure) (Ewing and Handy, 2009). This is a very positive development considering the identified importance of urban design features in earlier sections of this literature review (section 2.5) and the identified limitations of macro scale objective GIS measures in identifying walkable neighbourhoods (section 2.6.4).

2.6.6 Comparison of indices/ measures

Two recent comparative studies were identified where different methods of evaluating the walkability of an area were compared. In the first (Manaugh and El-Geneidy, 2011) objective GIS indices were compared for evaluating the odds of walking to school, a

[22] Parcel level data is data from small spatial units

specific transportation walking trip, and in the second (Kelly *et al.*, 2011) compared methods of assessing walkability from pedestrians perspectives.

Manaugh and El-Geneidy (2011) tested four different methods, these were 'Walkscore Index' (www.walkscore.com), 'Walkability Index' (Frank *et al.*, 2010, section 2.6.5.1), the 'Walk Opportunities Index' and the Pedshed. The Walk Opportunities index uses destinations weighted by importance and desirability and a weighted intersection connectivity score (Manaugh and El-Geneidy, 2011). The Pedshed (connectivity) measure is a percentage of the catchment area within a crow flies distance which can be reached within the same distance using the street network (Chin *et al.*, 2008). A high ratio score indicates high area connectivity, the maximum score is 1. They found that the Pedshed model provided the best walkability index to measure the odds of walking to school, but the differences between measures was negligible. As the walk opportunities and walkscore indices both rely on a number of destination locations, and not just a school, they are not appropriate measurements for this context. However the negligible differences between the indices illustrate the context of the neighbourhood, and suggest that areas with high connectivity (Pedshed) are likely to have a mix of destinations and a higher density than lower connected areas. Further work to compare and develop measurement tools is required to refine replicable, multidimensional indices for walkability research.

In their transport infrastructure focused study, Kelly and colleagues (2011) compared methods of assessing walkability from pedestrians' perceptions of the built environment by administering an on-street recall survey (N=200), environmental audit using the PERS audit tool (section 2.6.2), and mobile interviewing (N=20) on an identified segment of road. They concluded that while complementary the methods offered different perspectives of walkability and different depths of understanding of pedestrian's perceptions of the built environment and that the experience of pedestrians is influenced by the cumulative impact of multiple interactions in the pedestrian environment consistent with reviewed research.

2.6.7 Consideration for spatial definitions

The preferred method for measuring the built environment will depend on the spatial or geographic scale of the study being undertaken (Brownson *et al.*, 2009). That is whether the study is a city wide macro-scale study, a meso-scale neighbourhood study or a micro-scale street study (King *et al.*, 2002). Public health studies have focused on collecting subjective neighbourhood perceptions using self-report questionnaires or telephone interviews (Brownson *et al.*, 2009). However, the term neighbourhood has many definitions (Moudon *et al.*, 2006). Examples include 'a district or community within a town or city', 'the area surrounding a particular place, person, or object', and 'a diverse, dynamic social and economic entity with unique characteristics, which are recognized by residents of both the neighbourhood and community at large' (Oxford Dictionaries online[23]; Cowan & Rodgers 2005, pp. 256-259). These definitions leave an ambiguity as to whether a defined area for study should reflect a radial space around a person's home or around a defined village core/ locally identifiable area and also the size, geographic spread and composition characteristics of the area.

It was observed that public health walkability studies have focused on defining neighbourhoods as radial distances from people's homes. The NQLS and NEWS questionnaires (Saelens *et al.*, 2003a; Cerin *et al.*, 2007) define neighbourhood as the area within a half mile or a ten-minute walk from the respondent's home. The NPAQ[24] used in the RESIDE[25] study defined neighbourhood as a 10 - 15 minute walk from a defined point. The rationale for this was because a destination within 15 min could be included in a 30-min circuit from the participant's origin point which corresponded to the Australian public health recommendations of 30 min of moderate activity for adults (including walking) on most days of the week' (Giles-Corti *et al.*, 2006). However, Moudon and colleagues (2006) concluded from their study to determine operational definitions of walkable neighbourhoods that a walkable neighbourhood seems to be contained as within a 1km network buffer[26] from an origin point which they noted was considerably smaller than area used in public health and social science

[23] Sourced 09/10/10
[24] Neighbourhood Physical Activity Questionnaire
[25] RESIDential Environment Study
[26] Network buffer is explained in detail in section 2.7.1.2 connectivity

research and planning practice. Threshold levels of walkability were determined using objectively measured environment variables associated with sufficient walking for health. These areas were also determined to contain attractor destinations relating to everyday food needs (grocery stores and restaurants) therefore suggesting the importance of a service/ retail area within the neighbourhood. This also suggests that the functional neighbourhood may be around this service core. Frank and colleagues (2005**,** p. 122) echoed this 1km recommendation and measured the 'micro environments within 1km of people's homes'.

The functional urban fabric surrounding a 'village' core or a collection of houses can be difficult to determine and assess from mapping unless the city is well known to the researcher. Changes are potentially identifiable while travelling through an area at street level but this too can be difficult in unfamiliar areas, particular in newer estates of similarly designed houses. Local knowledge is essential when determining area boundaries or at the very least a site visit to attempt to establish an approximate location of operational neighbourhood boundaries. This is a particular concern when using GIS archival datasets which are predominantly available in census parcel level boundaries (Brownson *et al.*, 2009). Leslie and colleagues recommend using the smallest GIS units available (Leslie *et al.*, 2005). In Ireland census data is available in spatial units called Electoral Divisions (ED)'s. This data is not suitable for neighbourhood level investigations as there is a large variance in ED size and composition, ranging in size from 76 individuals to 32,000 individuals (Haase and Pratschke, 2008). The greatest limitation relating to the ED level data is the location of the area boundaries, many of which dissect natural neighbourhood centres. They do not reflect the functional neighbourhoods that exist in the GDA. Morphotypes, the smallest type of area of basic homogenous urban form (Cowan and Rodgers, 2005)[27], are not necessarily the answer either. The urban form may be homogenous but the neighbourhood may not operate as a whole community. This mismatch between GIS mesh blocks and natural boundaries is a noted limitation in GIS/ Walkability research (Badland *et al.*, 2009).

[27] Morphology is the study of urban shape. A morphological region is an area basically homogenous in urban form.

In this section it can be concluded that all of the identified measurement methods for assessing the walkability of an area have benefits and limitations. The suitability of any one measurement method or a combination of methods will depend on the research question that needs to be answered and consequently the detail of information required, the contextual purpose of the study and the spatial scale of interest to the researcher.

2.7 Elements of walkability and how they are measured

This section outlines the environmental correlates which have been associated with walkability or walking friendly built environments in the reviewed literature. The diversity of correlates which influence the walkability of an area requires a multidisciplinary research perspective. The diverse list of potential correlates is ever-growing as this field of research evolves. Consequently, it is beyond the scope of this review to provide an absolute picture of the current influences, and consequently the most commonly identified items are reported.

The search strategy outlined in Section 2.2 identified 27 papers and books which generated lists of built environment/ walkability elements The list of environment items generated for this review combines items from early walkability papers (Tables 2-1 & 2-2), pedestrian needs studies (Alfonzo, 2005), built environment and physical activity review papers (Brownson *et al.*, 2009; Saelens and Handy, 2008; Ewing *et al.*, 2006b; Owen *et al.*, 2004; De Bourdeaudhuij *et al.*, 2003; Humpel *et al.*, 2002), urban design texts (Gehl, 2006; The Housing Corporation and English Partnerships and Lyewelyn-Davies, 2000; Schurch, 1999; Bentley *et al.*, 1985; Lynch, 1965; Cullen, 1964) and studies to generate lists of built environment factors influencing pedestrian behaviour (Sauter and Wedderburn, 2008; Mehta, 2008; Brown *et al.*, 2007; Darker *et al.*, 2007; Brennan Ramirez *et al.*, 2006; Southworth, 2005; TRB, 2005; Kusenbach, 2003; Pikora *et al.*, 2003; Stonor *et al.*, 2003; Henson, 2000; King *et al.*, 2002; Cervero and Kockelman, 1997; Burden and Florida Department of Transportation, 1995). Reference lists from the eligible studies were scanned and searched to identify additional relevant studies to inform this section of the literature review.

2.7.1 Functional environment

The functional environment refers to the structural, constructed environment that forms a city or town structure and its streetscapes. Elements which contribute to the functional environment include buildings, roads and footpaths and how the layout and connectivity of these elements impact on the urban form and resulting walkability of an urban area. The key functional environment elements most frequently associated with walkability are density (Frank et al. 2010; Brownson et al. 2009; Forsyth et al. 2007; Saelens, Sallis & Frank 2003; Handy et al. 2002; Cervero & Kockelman 1997), connectivity (Frank et al. 2010; Brownson et al. 2009; Chin et al. 2008; Pikora et al. 2003; Saelens, Sallis & Frank 2003; Handy et al. 2002), land uses (Frank et al. 2010; Brownson et al. 2009; Giles-Corti et al. 2005; C. Lee & Moudon 2004; Leyden 2003; Handy et al. 2002) and the streetscape (Foster *et al.*, 2010; Brownson *et al.*, 2009; Brown *et al.*, 2007; Ewing *et al.*, 2006b; Southworth, 2005; Pikora *et al.*, 2003; Stonor *et al.*, 2003). In this section these elements are discussed with examples of how they are measured.

2.7.1.1 Density

Density is a measurement of units in an area (Forsyth, Oakes et al. 2007). In the context of land planning, the density of an area refers to the concentration of the population, residences or other land uses in a unit area. Brownson and colleagues' (2009) review of GIS based variables used in walkability/ built environment research list population per unit area (gross population density) and net residential density[28] from census population datasets as the most popular measures of population density used in physical activity research. High population densities[29] can sustain a greater number of services within a neighbourhood and can justify the provision of public transport stops. They tend to have lower levels of car ownership, less motorised trips and fewer requirements for parking provision because a higher proportion of trip origins and destinations are closer together (Forsyth *et al.*, 2007; Schurch, 1999;

[28] Residential density was reported in a variety of ways; residential buildings, housing units or households per unit area.
[29] The terms high and low density used in the literature can be deceiving. In most studies it was a relative measure, contextual within the range of densities in the cities/areas being considered. No reference was found to high or low walkability density thresholds.

Cervero and Kockelman, 1997). High population densities are positively associated with transportation walking trips (Brownson *et al.*, 2009).

Traditional urban cities and villages have higher population densities than newer suburbs and infill areas. The availability and popularity of the car post World War II facilitated a move to the lower density suburbs (Badland and Schofield, 2005; Lee and Moudon, 2004) which was desirable for cleaner air, more space and ease of movement (Leinberger, 2009; McManus, 2002; Cullen, 1964). A generalised association was drawn between low density and suburban development and low walkability in a number of walkability studies (Frank *et al.*, 2007; Moudon *et al.*, 2006; Giles-Corti *et al.*, 2005) which may be in part due to associations between early walkability studies and the New Urbanist movement which seeks to promote urban living (Section 2.2.1). However, there is historic evidence to suggest the association may be between walkability and era of development rather than density/suburbanisation. Many suburban town centres are small towns and villages which have been swallowed up by expanding cities. The earliest suburban estates were built in the era of one car households. Areas were well serviced with local shops, schools and often public transport stops within walking distance so families' needs were still met while the primary earner was gone to work with the car (Leinberger, 2009; Wickham, 2006). As car ownership increased so did the distance to travel to destinations such as services and employment. Infill residential developments without adequate service provision within walking distance between these towns and villages, were built with the assumption that residents owned one or more cars. Increased demand and prices for housing in urban areas resulted in many people moving to more affordable suburban areas which required a car to access basic services. In the United States, the cost of running the car to travel to work was up to 25% of the household income in these new suburban areas (Leinberger, 2009) and in Dublin, Wickham (2006) found that some people in these new suburbs were working to afford a car to travel to work resulting in a cyclical poverty trap. Development (sub-division) age has been used as a proxy of urban form in New Zealand by Badland and Schofield (2005), acknowledging the variety of urban forms within the suburbs.

In the Twin Cities Walking Study (N=715), Forsyth and colleagues (2007) found no liner relationship between density and overall walking (objectively measured and self-reported) using multiple measures of density. However, they did find that higher density environments facilitated more travel walking and lower density environments promoted more leisure walking. While this result is seemly contradictory to the many walkability studies who report an association between higher densities and more walking (Brownson *et al.*, 2009), reflection on the fact that these study sites are mainly selected using a tool developed based on transportation theory with no consideration for streetscape features (Cervero and Kockelman, 1997; Sallis *et al.*, 2009; Sallis, 2009; Frank *et al.*, 2010) it is possible that the results are biased. Low density areas are more spacious and are more likely to have natural features both of which are associated with stress reduction (King *et al.*, 2002) and thus may facilitate more leisure walking. Walkable site selections which do not consider the streetscapes or proximity to parks and recreational walking facilities can overlook this potential influence on overall walking behaviour.

There is an important distinction between density and crowding (a negative perception that there is too many people), sprawl, intensity of land use (high rise buildings) and perceived density with an association of being ugly or unlandscaped with parking problems (Schurch, 1999; Forsyth *et al.*, 2007). In Bell and colleagues' environmental psychology textbook (Bell *et al.*, 2001, pp.293-332) their chapter on high density and crowding discusses social density and spatial density and their influences on behaviours (e.g. societal withdrawal) and human health/well-being. Consideration should be given to multidisciplinary experiences before definitely suggesting that high density urban development is good for walkability/ public health. Ironically, suburban estates were built as a response to the public health issues such as bad sanitation and the spread of infectious diseases aggravated by crowding in high density urban areas (Frumkin *et al.*, 2004; McManus, 2002). In many studies promoting high density as a positive factor for walkability (Frank *et al.*, 2007; Cerin *et al.*, 2007; Sallis *et al.*, 2009), neither the context nor an upper density threshold past which crowing occurs is considered. Early New Urbanist walkability references refer to fine grained land use, intensity or compactness rather than using the term density (Southworth, 2005; King *et al.*, 2002). Schurch (1999, p.21) associates density with ‘attainment of compactness which promotes mixed uses, accessibility, a pedestrian realm and alternative forms of transportation’. The convenience of accessible GIS census data on density has facilitated large scale walkability studies but its use should be cautioned and considered.

In Moudon and colleagues’ (2006) cross sectional telephone survey (N=608), respondents who lived in areas with a net density of greater than 21.7 residential units per acre were more likely to walk (all-purpose walking) than those whose homes where in a spatial parcel with a lower density. However, when the density was higher than 15.5 residential units per acre and using a smaller area buffer measurement around respondents’ homes, they found that walking was negatively associated with higher densities. This seemingly contradictory result was clarified in the discussion when the authors described historic development patterns of the areas within these spatial parcels, the 1920’s developments had a mix of apartment buildings and low density housing within the spatial boundaries used in measuring the environment. Brown and colleagues (2007) reported how in the qualitative elements of their mixed method study on area perceptions (N= 73, 66% Male, Mean age 24yrs) there were very few comments about the density when discussing the walkability of the areas visited. Significant differences in perceived walkability were noted across city blocks that were rated as equally walkable using macro scale density, connectivity and land use measures. It was also noted that area perceived walkability changed frequently between blocks in urban areas. This finding supports the concerns raised in Section 2.6.7 on spatial definitions and context and highlights the need for contextual reference of the area’s history and land use characteristics. It also promotes caution when generalising study findings.

Despite the popularity of the association of high density environments as a proxy for walkability and the suburbs as a proxy for low walkability (Giles-Corti *et al.*, 2006; Frank *et al.*, 2010; Sallis *et al.*, 2009; Frumkin *et al.*, 2004) the relationships are unclear and warrant further investigation. The origins of the walkability term from the New Urbanist movement who promote high density living may have influenced the prominence of this association. Future research should consider the neighbourhood context and an optimum density range identifying an upper threshold past which crowding occurs. Research should also consider measuring the emotional wellbeing of residents alongside physical activity levels in high and low residential density areas.

2.7.1.2 Connectivity and permeability

The connectivity of an area is a measure of the street network or street pattern forming the structural skeleton of an area. During this literature review it was noted that the terms connectivity, street pattern and permeability were used interchangeably in the literature. While the terms connectivity and street pattern reflect the same concept, when environmental psychology and planning perspectives are considered land can be more or less permeable for physical or social reasons. For example; physical barriers may include the absence of footpaths and social barriers may include a perception of an area being unsafe (Hess, 1994, p.18). Considering this, for the purpose of this review and communicating the difference in the remainder of this thesis, the term connectivity will be the measure of the physical street and road network, junctions and pathways (formal and informal) which you would expect to see on a map of an area. The term permeability will reflect a micro (street) measure of the ease of movement through an area which encompasses pedestrian surfaces, crossing facilities, degree of path continuity and perceptual factors (including social) which may influence the movement of people through an area.

Connectivity can be described as 'the number of alternative ways through an environment' (Bentley *et al.*, 1985, p.10) or a measure of street design, intersection design, intersection distance and other access points (Brownson *et al.*, 2009; Pikora *et al.*, 2003). A high density of path intersections and small block sizes usually correlates with a high degree of connectivity (Southworth, 2005). The most frequently used objective measures of connectivity is intersection density (Brownson *et al.*, 2009), a significant relationship between moderate physical activity and intersection density was found by Frank and colleagues (2005). Other measures include number of three-way or more intersections per unit area, or number of intersections per length of road (Brownson *et al.*, 2009) or link road ratio[30] (Chin *et al.*, 2008). Moudon and colleagues

[30] Link node ratio is a ratio of the number of road segments (links) to the number of intersections (nodes) in a pre-defined area

(2006) found that respondents to their cross sectional telephone interview study (N=608) who reported walking more than the recommended 150 mins per week for health (30 mins, five days a week) lived on smaller street blocks than those that did meet the recommend number of minutes. They also found that large land parcels of office complexes within 3km and a high concentration of schools within 1km of respondents' homes were a deterrent for walking. This may be due to these land uses being a barrier to movement with no through-routes but this reasoning is not discussed in the paper. All of these listed measurements are based on the formalised street network.

An integral part of the connectivity of an area are the shortcuts that allow pedestrians to cut out a section of their journey by taking a route that is not part of the formal street network (inter alia through a park, between cul-de-sac ends). These paths are often locally referred to as shortcuts. Some of these paths are not formalised, for example muddy routes trodden out by pedestrians travelling along the desire line of their journey. Cul-de-sacs are a factor which has conflicting relationships with walkability. Cul-de-sacs reduce an area's connectivity as the closed off road blocks through movement. However, cul-de-sacs are perceived as safe places to let children play on the street and the residents essentially police their area by controlling who passes their doorways (Kumar, 2009; Jacobs, 1993).

Connectivity measurements which allow for the integration of pedestrian paths include Pedshed (described in section 2.6.6), Link Node Ratio and pedestrian route directness (PRD). These three methods were used by Chin and colleagues (2008) in their study to compare the connectivity of traditional versus conventional neighbourhoods using just the street network and repeated to include pedestrian paths. A high Pedshed ratio indicates a well-connected area. This measure is the only measure listed which illustrates actual route choices available and the effect of long cul-de-sacs as barriers to movement in an area. However, the measure only considers the radial network from an identified point. The measure of PRD is the ratio of actual route distance travelled to a straight line distance between specific origins and destinations. The use of specific origins and destinations could be a limitation when used for a population study/area analysis as they do not necessarily reflect all of a resident's potential destinations of interest (i.e. friends or family's homes) and only measures one direction. Chin and colleagues (2008) made no comparison of the measurement tools used in the study, only a comparison of neighbourhood types based on the different measurement scores. They found that when pedestrian paths (not included in the street network) were considered along with the street network the connectivity of areas slightly improved. This improvement was greater in conventional (newer) than traditional neighbourhoods (up to 120% greater). In summary, this may be a reflection of how in traditional neighbourhoods most existing historic pedestrian routes were formalised into roads with the introduction of motorised transport. In contrast, in newer neighbourhoods streets are designed for the movement of vehicles and mapped as such, thus resulting in unmapped pedestrian routes. This morphological process, the process shapes the urban form and street network, is associated with the age of the neighbourhood; when it was first built and if the area was subsequently redeveloped, when this happened (Shaffery, 2011; Cowan and Rodgers, 2005).

The functional permeability of an area depends on more than just the street network. Suitable road crossings which facilitate movement are also very important.

Road crossings

In an urban street network the presence of many well designed pedestrian crossings contributes to the route permeability as well as protecting the pedestrian from traffic. A well designed pedestrian crossing with a short waiting time provided at the pedestrian's desire line[31] will result in greater compliance. When faced with a badly located or badly designed crossing, pedestrians do one of two things: either they do not cross, which has economic consequences for businesses at the other side of the street, or they cross but do not use the formal crossing which has road safety consequences (Stonor *et al.*, 2003). In Turkey, Räsänen and colleagues (2007) found that pedestrian bridges are more likely to be used when the convenience and safety benefits outweigh crossing at street level without considerable time loss. Kumar (2009) suggests that at an individual level we try to organise things in our head and how we behave within a street network can show the shortcomings of the area.

[31] This is the route that the users subconsciously desire to walk. It describes the human tendency of carving a path between two points.

Public transport provision

A simple supply and demand model has been applied to road design for many years, resulting in more and wider roads built to cater for an increasing number of motorised vehicles (Wickham, 2006, p.25). In recent years, transportation engineers and planners have recognised that building more infrastructure is not the answer but distributing modal share for trips. Focus and funds are now being directed to improving public transportation, better pedestrian and bicycle provision, encouraging car-sharing and public awareness campaigns highlighting the many benefits of modal change (Department of Transport, 2009; Clark and Davies, 2009; Lo, 2009). Accessible links to public transport within a reasonable time-distance provide connections to the larger city and region (Lo, 2009; Southworth, 2005) thus increasing the connectivity of the area. This is important as every public transport trip includes another link-trip, potentially walking, at the origin and destination. Hoehner and colleagues (2005) (N=1053, 34% Male) found that proximity to public transport stops was associated with transportation activity (walking or cycling), however this relationship was not significant.

Footpaths

A good quality, well maintained surface to walk on is desirable with associations with both the functionality and personal comfort/safety of the user (Millington *et al.*, 2009; Van Deurs, 2009; Saelens and Handy, 2008; Southworth, 2005; Pikora *et al.*, 2003; Stonor *et al.*, 2003; Cullen, 1964), however, in London no correlation was observed between footway quality and level of use (Stonor *et al.*, 2003). Stonor and colleagues (2003) highlight that mud paths indicate the degree to which people will go to take their desired route, whether or not that route is made of high-quality materials. Textured paving or wood[32] are beneficial to people with visual impairments (Grey *et al.*, 2012; Stonor *et al.*, 2003; Cullen, 1964). The gradient (or slope) of a route also influences the decision to walk as there is considerably more effort required to walk along a steep route rather than a flat surface (Brownson *et al.*, 2009; McGinn *et al.*, 2007; Southworth, 2005; Pikora *et al.*, 2003; Stonor *et al.*, 2003). Hills or steep

[32] to feel vibrations

gradient have been found to be associated with less walking for transport (Moudon *et al.*, 2006; Hoehner *et al.*, 2005) but positively associated with recreational walking (Moudon *et al.*, 2006).

The level of service (LOS) of a path is a measure of congestion, and hence comfort, determined using a ratio of footpath width to the number of people using the path (Figures 2-1 & 2-8). It is a functional measure originating from the application of traffic demand/capacity theories to pedestrian facilities (Lo, 2009; Stangl, 2008; Stonor *et al.*, 2003; Landis *et al.*, 2001; Henson, 2000; TRB, 1985; City of Portland, 1998a). The width of paths can also influence the feasibility of a route for those who use wheelchairs, mobility scooters and buggies. LOS is a crude measure which is determined without consideration for the street context or the variable nature of pedestrian behaviour.

Figure 2-8: Crowded Footpaths Regent Street London (Gehl Architects 2009)

In summary, connectivity is the functional skeleton for permeability (perceptual ease of movement through an area) and both should be considered for walkability. Consideration should be given to all paths, formal and informal, and access points and not just the road structure. The relationship between cul-de-sacs and walkability warrants further investigation which considers both connectivity and safety implications. Pedshed considers the influence of cul-de-sacs and blocked routes but the measure only considers the radial network from an identified point. Thus, the selection of a method for measuring the connectivity of an area will have to consider the best method to use on the type of GIS data available to the researcher. Finally, the importance of connectivity/ permeability for different trip types, transport versus recreational for example, needs to be investigated further.

2.7.1.3 Land use

A study of early research investigating the association between the built environment and physical activity noted a focus on the proximity and availability of recreational facilities (Sallis 2009). The investigation of the relationship between land uses, destinations and walkability has developed considerably in subsequent years. Land use mix has been defined as the level of integration within a given area of different types of uses for physical space, including residential, office, retail/ commercial, and public space (Saelens *et al.*, 2003, p.81). Measures of land use mix (LUM) include; i) distance from residential land uses (or an identified house) to non-residential land uses, ii) summation scores of accessible non-residential land uses, iii) summation scores of destinations which account for the attractiveness of destinations, iv) counts or densities of specific destinations in an area, v) proportion of the land devoted to non-residential land uses and vi) degree of evenness of various land use types (Brownson *et al.*, 2009; Handy *et al.*, 2002; Frank *et al.*, 2005; Leyden, 2003; Lee and Moudon, 2004). The GIS data required for these measures has been sourced from telephone directories, property databases, geocoded employment records, census data and planning departments among others. The website and mobile phone application www.walkscore.com, uses an algorithm on a geographic information system (GIS) dataset to calculate the proximity of an address to a variety of destinations which they call the 'Walkscore'. This accessible information uses Google Maps^{TM} as its base mapping and relies on destinations being geocoded onto the online maps. While it is available internationally some countries have better or more recent information than others. High walkscore scores have been linked to higher property values, a proxy for desirability, across a variety of locations in the United States (Leinberger, 2009).

Subjective measures of land use mix include the Leyden Instrument which determines walkability solely on proximity to destinations. Leyden (2003) identified nine particular destinations for consideration (in an Irish context) when determining the walkability of an area. Participants were asked which of the following they could walk to without too much trouble, a cornershop/newsagent, a church, a park (or sports pitch), a local school, a community centre or recreation centre, a crèche, a chemist (pharmacy), a pub and 'the place I work'. Leyden considered a score of seven or more a walkable area. Saelens and Sallis (2002)'s NEWS questionnaire asks how long would it take to walk from your home to the nearest… on a list of 23 destinations using a 5 point Likert scale (1-5mins, 6-10mins,…31+ mins) with a 'don't know' option. Hoehner and colleagues (2005) used a similar tool to Leyden and NEWS' in the USA using 13 destinations. Respondents were asked 'how long would it take to walk to each of the listed destinations?' This data was then cleaned to reduce the measure to how many could be accessed in a trip time limit of less than five minutes. They found for both perceived and objective (audited) land use, active transportation activity was positively associated with having one or more destinations within walking distance of one's home. Results also showed that people in the highest quartile for the total number of non-residential destinations were two to three times more likely to engage in any active transportation activity or meet physical activity recommendations through transportation activity than respondents in the lowest quartile (Hoehner *et al.*, 2005). Using the NEWS instrument, Cerin and colleagues found that proximity to the workplace emerged as the most significant contributor to transport-related walking in Hong Kong (2007) and in Australia overall access to destinations was positively associated with transport-related walking (McCormack *et al.*, 2008)**.** These measures give useful information on how individuals perceive their neighbourhoods and how they are serviced for their particular needs but have a bias towards transportation walking unless recreation facilities are included in the measure. It would however be useful to have a 'not relevant' option on the instruments as there may be an apparent lack of awareness of the presence of theoretically important land uses may be because they are irrelevant to some of the populations (e.g. schools to childless people) (Moudon *et al.*, 2006).

Lee and Moudon (2004) in their review of twenty empirical studies addressing environmental characteristics that influence physical activity for planning audiences found that destinations other than recreational facilities (for example the number of local shops) have a positive relationship on physical activity. Subsequently, in their cross sectional study in the USA (N=438), positive correlations were found between transport walking and the perceived social environment and distances to grocery stores, restaurants, post office and banks (Lee and Moudon, 2006). Service destinations showed stronger associations with both walking purposes (transport and recreational) than recreational destinations. Destinations which were expected to show less association with walking (big box stores, shopping centres, hospitals, theatres and museums) did not show any significant relationship with walking. It is difficult to interpret these results without knowing the contextual settings of these destinations and the quality of the service destinations. The destinations alone may not be sufficiently attractive to encourage a walking trip.

Similar mixed relationships between the proximity and availability of recreational facilities and walking behaviours has been reported in other studies (Hillsdon *et al.*, 2006; Giles-Corti *et al.*, 2005; Hoehner *et al.*, 2005; Moudon *et al.*, 2006). In considering the importance of the distance to, attractiveness and size of public open spaces for walking behaviour in Perth, Australia, Giles-Corti and colleagues (2005, p. 169) found that those with very good access to large, attractive public open spaces were fifty percent more likely to achieve high levels of walking. Hoehner and colleagues (2005) found a positive association between total physical activity and the perceived and objective number of destinations in the neighbourhood. This study had a strong bias towards recreational facilities, with three of the five measures related to recreational facilities. However, a limitation was that participants were not asked how they travelled to the facilities and therefore it could not be determined what the actual proximity to these facilities was. A five minute drive would cover a considerably longer distance than a five minute walk. Insignificant relationships with parks, trails access to green spaces and type of walking have also been found (Moudon *et al.*, 2006).

Similarly Hillsdon and colleagues (2006) found no clear relationship between recreational physical activity and access to green spaces with the individuals with best access to high quality, large green spaces actually reported significantly lower levels of activity compared to those with the poorest access.

Individuals who live in neighbourhoods with a variety of well-organised behaviour settings (inter alia schools, recreational facilities, neighbourhood restaurants, places of worship, public spaces and shops) are also more likely to be associated with high levels of social cohesion (community spirit) (Leyden, 2003; King *et al.*, 2002). King and colleagues (2002, p.19) suggest that these communities should consequently be more conducive to residents' active use of community open spaces and transit (transport) systems for both transport and recreational purposes. Social cohesion and trust were found to be associated with positive emotional well being, thus mental health, in a cross sectional study of 140,000 Australians (Araya *et al.*, 2006). These examples illustrate further benefits of walkable areas.

It would useful to measure both the objective and subjective measures of available destinations if feasible as it is unclear which measures yield the strongest association with physical activity or perceived neighbourhood walkability. Additionally the inconsistencies and lack of detail in GIS datasets was noted as a limitation of land use mix measures in Brownson and colleagues review paper (2009), subjective local knowledge or neighbourhood audits could supplement these datasets. Details of the context of the area would further inform these studies.

2.7.2 The streetscape

The streetscape, or micro level environment, is possibly the most critical environment scale for walkability (Southworth, 2005). The streetscape represents the area to the pedestrian who will in turn act and behave informed by their perceptual response. The streetscape is also the level at which the greatest discrepancy was identified in walkability literature. Public health and transportation literature was found to focus primarily on physical walking facilities; footpaths, protection from traffic and level of service with some acknowledgement for aesthetical features such as cleanliness/maintenance, biodiversity (i.e. trees, parks) and interesting architecture

(Pikora *et al.*, 2003; Hoehner *et al.*, 2005; Stonor *et al.*, 2003; Henson, 2000; Do, 2002; Stangl, 2008; Lo, 2009; Saelens *et al.*, 2003a, 2003b). Consequently, in public health research streetscape information was predominately collected using streetscape audits and self-report questionnaires (section 2.6). GIS datasets which were considered relevant to micro-level walkability included information on: traffic (speed limits, volume of traffic, traffic accidents which involve vulnerable road users and street width), crime, slope or gradient, greenness/ vegetation, proximity to the coast, number of registered dogs, street lighting, trees, public transport stations and home age (Brownson *et al.*, 2009).

In contrast, urban design and planning literature discuss design concepts such as: path context, diversity, quality architecture and urban design, pleasurability, delight, comfort, convenience, protection, scale and sense of place (Southworth, 2005; Gehl, 2006; Mehta, 2008; Alfonzo, 2005; Ewing *et al.*, 2006b). Brown and colleagues (2007) reported how in the qualitative element of their mixed method study (outlined in section 2.6.3) on area perceptions that positive comments about areas were on perception of pleasantness, attractiveness, vibrancy, interest and the area being well maintained.

Brennan Ramirez and colleagues (2006) note that neighbourhood features identified in their multidisciplinary literature review on indicators of activity friendly communities (section 2.3) that some items seemed to address the same problem, but were phrased differently. For example, in their discussion the terms 'attractive features' and 'absence of physical disorder' were taken to mean the same. While these two items both relate to the visual appearance of the environment, they reflect very different characteristics and perceptions. This is an example of where the generalisation of streetscape features using the commonly used term 'aesthetics' (public health) into a single measure can give a misrepresentation of the streetscape and therefore to the perceptual response to an area. An area can have both attractive features and physical disorder, but how an area is interpreted will depend on the balance of the features, the context of the area and the individual's own characteristics as outlined above and in section 2.5. Although this note in their study would indicate a low level of understanding they did use separate measures of neighbourhood pleasantness[33] and neighbourhood maintenance/ disorder in their cross sectional walkability study alongside a measure of trees along streets (Hoehner *et al.*, 2005). Their project, outlined in these studies, found that recreational physical activity was positively associated with objective measures of attractive neighbourhood features.

2.7.2.1 Sense of place

Sense of place is a feeling of appreciation for the distinct character of a locality which Cowan and Rodgers (2005, p.347) say depends on 'the characteristics (i.e. gender, beliefs, values) of the observer as well as those of the place'. Sense of place is informed by the 'genius loci' or the spirit of the place which comes from the Roman belief that every independent being or place has its own spirit determined by its character. When conceptualising an area plan urban designers try to identify the genius loci and express it in their designs (Cowan and Rodgers, 2005). 'Placelessness' is a negative term used to describe standardised homogenous landscapes, typical in suburban areas, resulting in the loss of meaning in places or areas deterritorialised because people do not feel like they belong or no longer care for their environment (Carmona *et al.*, 2003). Imageability is a term used in urban design to describe the qualities of a place that makes is distinct, recognizable, and memorable. High imageability is when 'specific physical elements and their arrangement capture attention, evoke feelings and create a lasting impression' (Ewing *et al.*, 2006, p.S226). In a study where an expert panel of urban design and planning professionals reviewed a library of video clips, high imageability was directly and significantly associated with the expert panel's overall area walkability rating (Ewing *et al.*, 2006b). The perceptual nature of sense of place and imageability make them difficult to measure objectively and while an audit tool is being developed by Ewing and Handy (2009) which includes a measure of imageability, these important concepts are not common in walkability research. Imageability reflects a distinctiveness, however this distinctiveness can be due to positive or negative features of the environment. Figure 2-9 illustrates the influences on an area's sense of place according to the Project for Public Spaces (www.pps.org) a non-profit planning, design and educational organization dedicated to

[33] Audited segments with attractive features and perceptual self-report question to rate your neighbourhood as a place to be physically active

helping people create and sustain public spaces that build stronger communities. The diagram shows the importance of the street and transport networks, the social and economic characteristics of the area and the streetscape in determining the sense of place or distinctiveness of an area.

Figure 2-9: Project for Public Spaces' Place Diagram (http://www.pps.org/)

2.7.2.2 *Safety*

In walkability and pedestrian design literature safety is generally considered under two sub-headings; safety from traffic and safety from crime. Both refer to an individual's perception of their vulnerability or safety from a perceived threat (Alfonzo, 2005). These perceptions are from environmental cues which may or may not be a direct result of design features.

In 2006, 20% of fatalities on Irish roads were pedestrians (RSA, 2009), the majority of which were children and older adults, indicating a genuine concern for pedestrians on Irish roads. According to Do (2002) the most important factors in pedestrian – vehicle incidents are traffic volume, speed, time of day (or daylight) and alcohol intake. She also reported that 65% of pedestrian incidents happen at places other than junctions. Since the majority of pedestrian crossing facilities are at junction points this finding suggests that incidents may be due to non-compliance with crossing facilities or a lack of crossings mentioned in section 2.7.1.2. The reaction from those responsible for road safety is often to reduce speed limits, traffic volumes and introduce traffic calming measures (Southworth, 2005). A core concept of the Irish Road Safety Authority's (RSA) pedestrian road safety action plan is to 'change the road system into one which seeks to eliminate all known opportunities for human error and to reduce the physical damage in crashes that do occur' (RSA, 2009, p.49). As a result characteristics of the built environment used to measure safety from traffic in environment audit tools and/or self-report questionnaires are predominately associated features such as: the presence of a buffer between pedestrian and road (for example: grass verge/ parked cars/ barriers), the speed of passing traffic, good street and footpath lighting, the number of traffic lanes, level of traffic volume, posted speed limits, perceived compliance with speed limits, presence of pedestrianised streets, presence of traffic calming measures, good quality pedestrian crossings, perceived quality of pedestrian crossings, perceived convenience of pedestrian crossings and the presence and quality of continuous footpaths (Day *et al.*, 2006; Moudon and Lee, 2003; Brownson *et al.*, 2004b; Brown *et al.*, 2007; Brownson *et al.*, 2009; Stonor *et al.*, 2003; Saelens and Sallis, 2002b; Pikora *et al.*, 2003; Forsyth *et al.*, 2003; Do, 2002). However, these measures reflect environments where drivers perceive a reduced risk of a pedestrian walking out onto the road and streetscapes can look cluttered or sterile, Figures 2-10 & 2-11.

Figure 2-10: Cluttered Street with emphasis on features to segregate traffic from pedestrians (Source: Hamilliton-Ballie 2009)

Figure 2-11: Sterile environment with an emphasis on segregating traffic from pedestrians

Shared space is a concept where all road users have equal rights to the space encouraging drivers to behave more accommodatingly towards pedestrians and other road users (Department of Transport UK, 2011), Figure 2-12. This is done through risk compensation where in the absence of rules, predictability and certainty, drivers have to be more aware of their surrounding and give due consideration to other road users. Because of reduced controls more powerful social behavioural constraints come into play (Hamilton-Baillie, 2008). In the five years following redesign to a shared space pedestrian causalities were reduced by 64% in Kensington High Street, London (Hamilton-Baillie, 2009). The shared space concept is not without limitations, in particular it poses difficulties for people with sensory disabilities that rely on kerb edges and signalised road crossings (Grey *et al.*, 2012). However, indications that areas void of the features listed in the previous paragraph are also safe from traffic questions the suitability of these measures of safety from traffic in walkability studies.

Figure 2-12: Example of a Shared Space (Source: Hamilton-Baillie 2009)

Fear of crime is an emotional reaction to crime or to visual cues that a person associates with crime, which can heighten feelings of anxiety and unease and in turn constrain people's social or physical activities by avoiding certain places or situations they perceive to be unsafe (Foster *et al.*, 2010; Mehta, 2008). Hoehner and colleagues (2005) found no significant relationships between audit scores of street safety or perceived safety from crime and walking or cycling behaviour for recreation or transport. Brown and colleagues (2007) found that responses relating to concern from crime safety (from environmental cues or the people present and their activities) on their walk-in-time qualitative study far exceeded comments relating to traffic safety. Individuals expressed discomfort at seeing homeless people and people engaging in anti-social behaviour and while many participants expressed fear for these people others expressed empathy or feeling guilty that they had so much whereas these people had so little (Brown *et al.*, 2007). This suggests that discomfort because of visual cues may not always equate to a fear from crime. They also reported no gender difference on the perception of crime problems contrary to previous research they reviewed. It is reported that women and elderly people tend to feel more physically vulnerable and hence have greater concerns for personal safety than men and younger people (Foster and Giles-Corti, 2008; Coakley, 2003; Frumkin *et al.*, 2004). The social nature of places was found to be influential as people take cues from the dominant social relations in an area such as groups of people smoking outside public houses and places that they may have been conditioned to fear in a general manner like cash machine foyers and locations of historic violent events (Coakley, 2003; Valentine, 1989; Foster *et al.*, 2010). The bus station in Cork, Ireland's second largest city, which was the scene of violent crimes in the past but has subsequently been completely redeveloped, was one such location. Coakley (2003) found in his qualitative study on women's fear of violent crimes (FOVC) in public spaces that despite the redevelopment women in the study reported avoiding the area because of a perceived risk based on these historic events. In response to their negative perceptions of personal safety the top precautionary measures adopted by the interviewed women was general spatial avoidance (43.7%). Foster (2010) identified significant relationships between perceptions of neighbourhood maintenance, social incivilities, graffiti and vandalism, property crime, violent crime, vacant houses or blocks, loitering teenagers and dangerous or drink driving and self-reported fear of crime. The opposite of some of these physical disorder indicators is tidiness which refers to the condition and cleanliness of a place. It refers to a place that is 'tidy, well maintained and shows little sign of wear and tear' (Ewing *et al.*, 2006, p.S226). In a study where an expert panel of urban design and planning professionals reviewed a library of video clips tidiness was directly and significantly associated with walkability (Ewing *et al.*, 2006b).

Safety is evaluated in self-report measures as an assessment of the likelihood of crime-related problems and/or perception of crime, for example NEWS (Saelens and Sallis, 2002; 'There is a high crime rate in my neighborhood' and 'The crime rate in my neighborhood makes it unsafe to go on walks at night'). Other measurement methods include an objective reporting of crime statistics (Ewing *et al.*, 2006a). However, these methods record information related to crime rates and do not consider an individual's emotional response/fear of crime regardless of reported crime rates. The individual's response may be influenced by a number of factors thus, solely using this information possibly creates a disconnect when measuring neighbourhood safety. Information on individual's memories and spatial associations within areas which may have undergone change and hence cannot be measured objectively are also valuable. Consequently, qualitative data collection or mixed methods studies should be considered when investigating perceptions of safety.

Foster and Giles-Corti's (2008) theoretical (ecological) model of the factors influencing real and perceived safety is outlined in Figure 2-13. This model was generated from their review of quantitative studies with references to crime related safety and a physical activity outcome in adult populations published before July 2007 (N=41). In addition to physical environment cues and individual factors mentioned in previous paragraphs, the social environment (including partaking in outdoor physical activity), the time of day and natural surveillance, otherwise known as overlooking or transparency, were identified as influences on an individual's perception of safety and crime. This comprehensive model gives an excellent overview of the diversity of influences on actual and perceived safety and greatly informs the scope of information that should be collected in a walkability study.

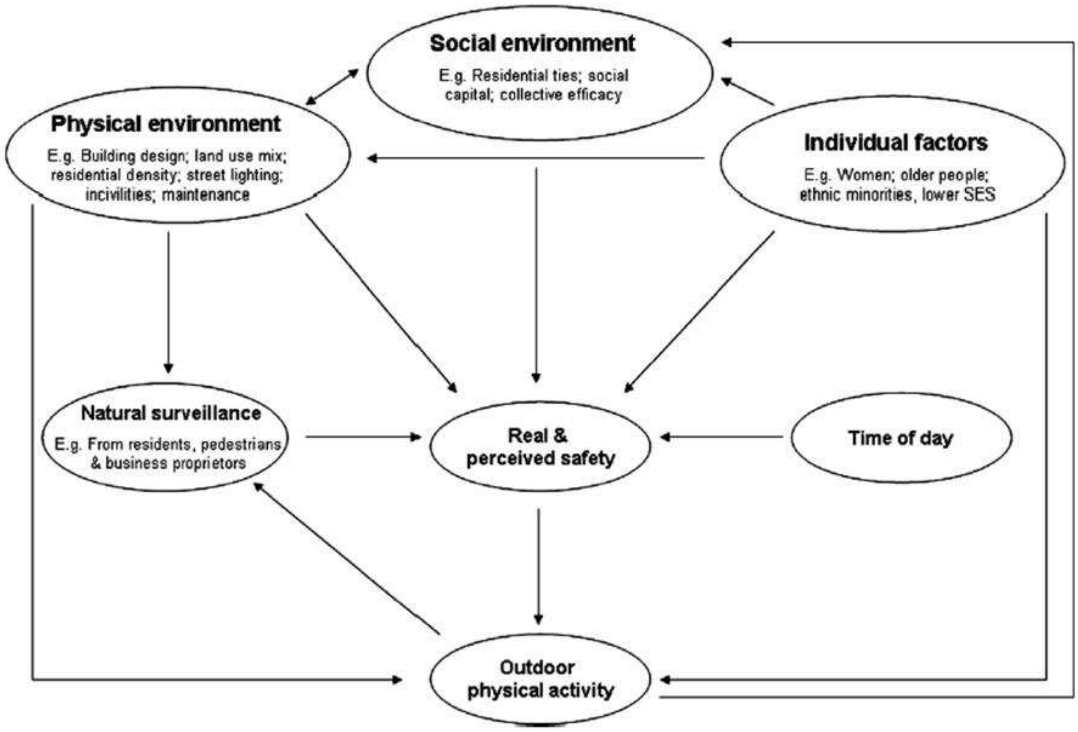

Figure 2-13: Theoretical Model of Real and Perceived Safety (Source: Foster and Giles-Corti, 2008)

Transparency is an urban design quality of a place that refers to the degree to which people can 'see or perceive what lies beyond the edge of the street or other public space and, more specifically, the degree to which people can see or perceive human activity beyond the edge' (Ewing *et al.*, 2006, p.S226). Physical elements that influence transparency include walls, windows, doors, fences, landscaping, and openings into midblock sections. In a study where an expert panel of urban design and planning professionals reviewed a library of video clips high transparency was directly and significantly associated with participants assigned walkability ratings (Ewing *et al.*, 2006b).

When residents of buildings, both homes and work places, are prevented from exercising surveillance over outside areas adjacent to their building their sense of defensible space (the extent to which they believe they have jurisdiction and control over) is diminished (King *et al.*, 2002; Carmona *et al.*, 2003; Gehl, 2006; Foster *et al.*, 2010; Mehta, 2008). Higher density areas with tall apartment blocks and/or no front doors onto the street reduce the sense of jurisdiction (Jacobs, 1993). A lack of control over outdoor spaces adjacent to people's homes has been linked to fear of crime (King *et al.*, 2002; Alfonzo, 2005; Foster *et al.*, 2010). Figure 2-14 demonstrates how an area which is not overlooked can be claimed by perpetrators of anti-social behaviour[34] leaving a sense of disorder which may deter occupants from using the space. Urban designers in professional practice use a number of data sources when considering the design of an area. For example, Gehl Architects (Van Deurs, 2009) when looking at indicators of protection against crime and violence (feeling secure), collected data on the number of residences and the types of mixed uses in the area, activities open at night, street lighting and ground floor shops and facades with the shutters down at night (from observations), and user satisfaction from a questionnaire or public consultation. In addition, based on suggestions and practices outlined in the literature the presence of other people walking, occupied buildings overlooking the street and overlapping day and night functions in an area should be considered (Alfonzo, 2005; Gehl, 2010; Hoehner *et al.*, 2005; Foster and Giles-Corti, 2008; Foster *et al.*, 2010; Carmona *et al.*, 2003). Before Foster's recent work (Foster *et al.*, 2010; Foster and Giles-Corti, 2008) public health walkability research related FOC to the social environment and evidence of disorder rather than the physical attributes as a result of neighbourhood design. Future research should consider design features when reviewing or making recommendations on the walkability of a neighbourhood.

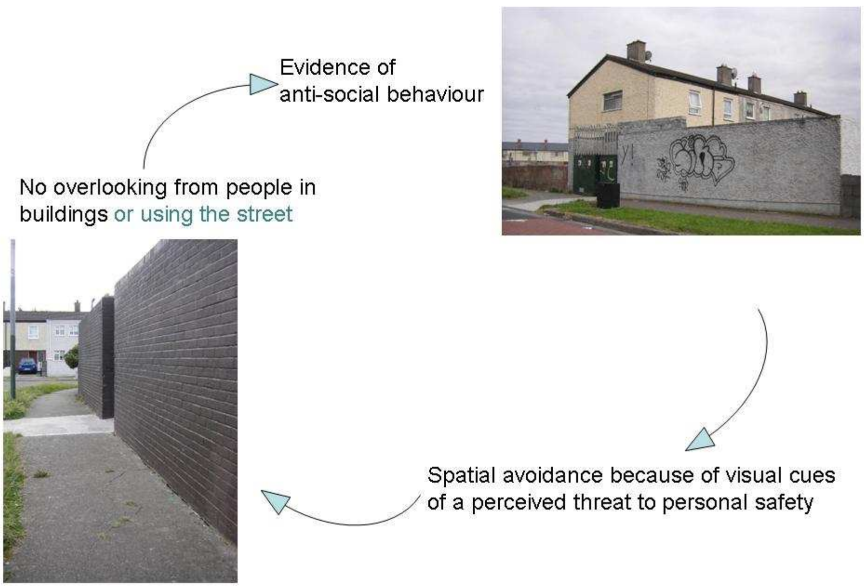

Figure 2-14: An example of how no overlooking can impact on sense of personal safety

[34] Anti-social behaviour is behaviour that lacks consideration for others and may cause damage to the society, whether intentionally or through negligence.

2.7.2.3 Comfort

Comfort refers to a person's level of ease, convenience and contentment (Alfonzo, 2005) and may be affected by a myriad of factors including weather, physical conditions, perceived level of safety, familiarity, other people and convenience (Mehta, 2008). Exposure to environmental stressors such as crowding (section 2.7.1.1), noise, bad air quality, traffic congestion, crowded or badly maintained footpaths (section 2.7.1.2), information overload and threat of violence and crime (section 2.7.2.2) can lead to a sense of diminished wellbeing, vulnerability, diminished self-control over daily routines and reduced social support (Hart and Parkhurst, 2011; Van Deurs, 2009; Mehta, 2008; Brennan Ramirez *et al.*, 2006; Southworth, 2005; Stonor *et al.*, 2003; Pikora *et al.*, 2003; King *et al.*, 2002). Gehl Architects (Van Deurs, 2009; Gehl, 2006) list opportunities to walk, sit, stand/stay, see/enjoy views, talk and listen and play and exercise as contributors to an individual's comfort. Protection from unpleasant weather and opportunities to enjoy the positive aspects of climate also contribute to comfort (Van Deurs, 2009; Mehta, 2008; Carmona *et al.*, 2003).

The urban design concepts of human scale and enclosure contribute to an individual's comfort within a physical space (Cullen, 1964). Human scale is an urban design quality of a place that refers to 'size, texture and articulation of physical elements that match the size and proportions for humans', and equally important, correspond to the speed that people walk (Ewing *et al.*, 2006, p.S226). Building details, pavement texture, street trees, and street furniture are all physical elements contributing to human scale. Enclosure refers to the degree to which 'streets and other public spaces area visually defined by buildings, walls, trees, and other elements' (Ewing *et al.*, 2006, p.S226). Spaces where the height of vertical elements is proportionally related to the width of the space between them have a room like quality (Cullen, 1964). In a study where an expert panel of urban design and planning professionals reviewed a library of video clips human scale and enclosure were directly and significantly associated with walkability (Ewing *et al.*, 2006b)[35].

Similar to a perception of vulnerability from crime the importance of an individual's comfort on their perception of the place where they are will have a bearing on how

[35] Enclosure is important because if a street is too wide it deters crossing. Enclosure also facilitates a sense of community through interaction with opposite sides of the street.

they may behave in that environment. Yet, despite its importance in urban design it is a concept which is rarely addressed in walkability research and warrants more consideration.

2.7.2.4 Interest

The interest an area or streetscape presents to a pedestrian can be either visual or social, or both. According to Jan Gehl, when areas are of poor quality only strictly necessary activities occur, when the quality is good optional activities occur with increasing frequency and as levels of opportunity arise, the number of social activities usually increases (Gehl, 2006, Figure 2-15). When an individual has a number of modal choices available to them walking becomes an optional activity. While a physical footpath/route may be safe and continuous a monotonous physical setting will not invite pedestrians (Southworth, 2005). Interest can be provided by the design of the street as a whole, transparency of fronting structures, visible activity, street trees and other natural features, lighting, views, places to socialise, varied and interactive shop fronts and the presence of other people (Gehl, 2010; Lo, 2009; Sauter and Wedderburn, 2008; Ewing *et al.*, 2006b; Hoehner *et al.*, 2005; Southworth, 2005; Carmona *et al.*, 2003; Pikora *et al.*, 2003; Stonor *et al.*, 2003; Bentley *et al.*, 1985; Cullen, 1964).

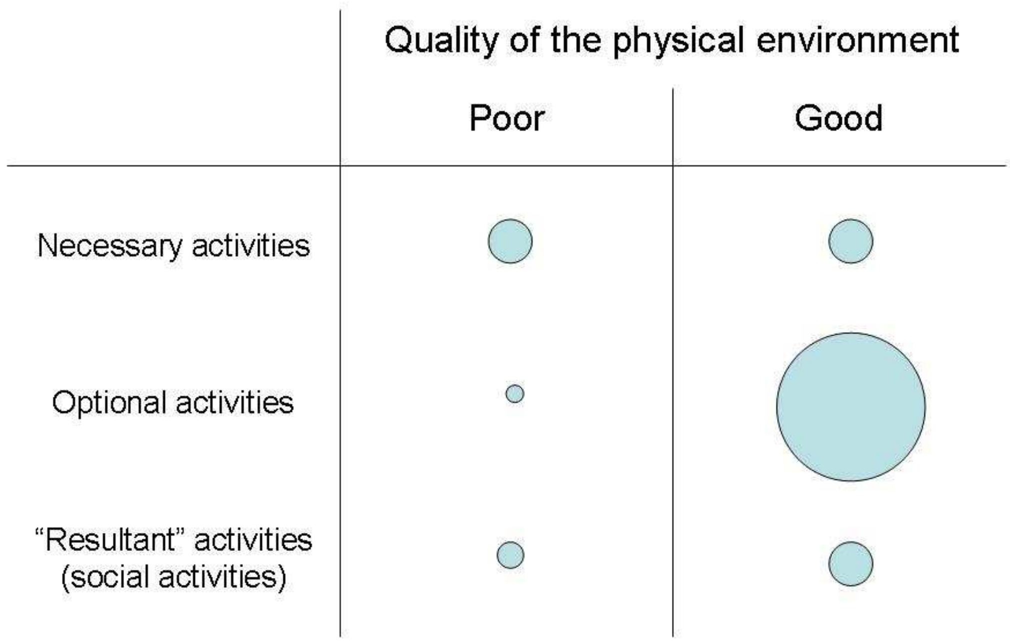

Figure 2-15: Outdoor activities and quality of outdoor space (Source: Gehl, 2006)

Most self-report walkability questionnaires include items on the neighbourhood surroundings but focus on the presence of trees and other natural features and the absence or presence of litter. While this assessment of the streetscape is limited, these items are important for walkability. Restorative (stress reducing) environments within urban areas are described as having a high prevalence of natural features including water, foliage, extended vistas of open space, aesthetic elements that afford novelty and a sense of escapism which may facilitate engagement in physical activities, particularly for recreational purposes (King *et al.*, 2002). Positive associations have been found between good architecture, aesthetics, visual quality and the presence of sidewalks for recreational walking (Hoehner *et al.*, 2005; Moudon *et al.*, 2006) however the relationship with transportation walking is not clear (Van Dyck *et al.*, 2010). This may be due, in part, to the site selection methods used for the research or a need for a greater understanding of how an individual interacts with their surroundings depending on the trip purpose. Features of the built environment which provide interest along a route are best identified qualitatively to understand how the features are interpreted by different individuals within the context of the area.

2.7.2.5 Legibility, wayfinding and feasibility

Legibility is an urban design quality which refers to the ease of navigation and sense of orientation within an area (Ewing *et al.*, 2006b). It is an important element of the route and modal choice decision making process when planning a trip. In the absence of a familiar route an individual has to make route decisions based on environmental cues and wayfinding aids such as signage or identifiable landmarks. This process can cause stress and anxiety when an individual has a fear of being lost (Bell *et al.*, 2001). An active modal choice can be an option in choice-enabling environments when considered feasible by the individual (Alfonzo, 2005; King *et al.*, 2002; Bell *et al.*, 2001). A trip can be more or less feasible depending on an individual’s mobility and/or their time constraints and other responsibilities such as dependent children (Alfonzo, 2005). Ecological models of active travel behaviour such as those outlined in section 2.4 need to consider the ease of trip planning and the perception of availability and suitability of routes as a factor in the trip decision-making process.

While comparing methods of assessing walkability from users perceptions, Kelly and colleagues (2011) concluded that the experience of pedestrians was influenced by the cumulative impact of multiple interactions in the pedestrian environment. An example given outlined how 'traffic volume' a negative correlate of walkability, translated to a specific spot where traffic volume impeded the movement of pedestrians at the crossing places when quantitative survey data was considered alongside qualitative data. This was in part due to the lack of a pedestrian crossing facility, which led to feelings of inferiority by the pedestrian with respect to motorised traffic. The resultant 'traffic volume' conclusion was limited, as the factors influencing walking behaviour also included 'lack of crossings' and 'fear of traffic'. This example shows the benefit of mixed method walkability research and the limitations of quantitative data when assessing micro-level correlates of walkability.

The danger in reducing measures of walkability into simplified frameworks such as Pikora and colleagues' model (2003) is that they remove the context. In translating the actual problem into a small number of predetermined correlates, the responses received are likely to be incomplete and possible inaccurate. The reference to 'traffic volume' may be more to do with 'comfort of the pedestrian' rather than the number of cars. Qualitative or mixed method studies should be considered to give contextual reference to structural models of the environment, particularly those relating to the streetscape.

2.8 Sociodemographics and walkability

The ecological models reviewed in Appendix A and referenced in section 2.4 suggest cultural and social characteristics of the neighbourhood in which an individual resides can influence their walking behaviours as well as their own demographics, biological influences, background and behaviour and psychological influences. In this section literature relating to these relationships is examined. As communities comprise of individuals living in the same place or with similar characteristics these social environments can impact on the perceived walkability of a neighbourhood.

2.8.1 The individual

Individual level information frequently collected in walkability neighbourhood studies include demographics (inter alia age, gender, ethnicity and marital status), socioeconomic indicators (inter alia income, education level, home ownership), individual characteristics (inter alia disabilities, self-efficacy, health status, body mass index, behaviours and habits) and household characteristics (inter alia car ownership, dog ownership, number of people living at the household, number of dependants) (Kamphuis *et al.*, 2009; Cerin *et al.*, 2009b; Van Dyck *et al.*, 2010; Frank *et al.*, 2008; Cutt *et al.*, 2008; Hoehner *et al.*, 2005; Lee and Moudon, 2006; Saelens and Sallis, 2002b). These correlates of behaviour are useful when investigating individual behaviours and perceptions, and also to generate a profile of the community residing in the neighbourhood or area under investigation. This thesis focuses on the walkability of neighbourhoods/areas and while it is intended that individual level investigations will be carried out at a later date these are not the focus of this thesis.

The Irish Sports Monitor (Ipsos MRBI, 2011) is a national survey used to measure and monitor physical and social participation in sport and other forms of exercise in a representative sample of Irish adults (N=8,749 in 2011). The sampling nature of the survey means that while generalisations can be made in relation to demographics and socio-economic indicators, no association can be made with the environments in which people reside. In the 2011 study men were more likely to walk for recreation than women. Unemployed people were also more likely to walk for recreation than those in employment. The number of people walking for transport had declined since 2009 but this was likely to be due to the economic downturn as less people were working. A longer term trend from four studies since 2007 showed a decline in transport walking was matched with an increase in recreational walking. It was considered likely that overall walking behaviour was sustained by individuals who were now unemployed. These findings, while vague, give important context to Irish behaviours and cultural contexts.

2.8.2 The community

Consensus exists among researchers that there is a link between the socio-economic status (SES) (i.e. social inequalities (Cerin and Leslie, 2008)) of a neighbourhood and the health of its residents, with those from lower socioeconomic neighbourhoods more likely to suffer from ill health (Cerin *et al.*, 2009b; TRB, 2005; Frumkin *et al.*, 2004; Stokols, 1992; Neckerman *et al.*, 2009), particularity the incidence of obesity (Lovasi *et al.*, 2009; Frank *et al.*, 2008). Studies have also shown that there is a positive relationship between low SES and low physical activity levels (Cerin *et al.*, 2008, 2009b; Kamphuis *et al.*, 2009; Frank *et al.*, 2008; Frömel *et al.*, 2009; Giles-Corti and Donovan, 2002; Biddle and Mutrie, 2008). However, the links between walkability, minutes walking and SES are less clear primarily because of inconsistencies in how an area's walkability is derived.

A negative relationship between SES and transport walking was identified at individual and area level by Cerin and colleagues (2009), but non-significant and positive associations (Hoehner *et al.*, 2005; Frank *et al.*, 2008) or no relationship (Van Dyck *et al.*, 2010) were found in relationships between neighbourhood SES and transport walking in other studies. With the exception of Hoehner and colleagues (2005), these studies identified high walkable neighbourhoods using a composite GIS index (WI index, section 2.5.6) which does not consider the streetscape (section 2.6.2), the aspect of the built environment on which an individual makes a perceptual response when making behaviour decisions. Socio-economic ratings were assigned to areas using census information stored on spatial datasets (Sallis *et al.*, 2009; Cerin *et al.*, 2009b; Van Dyck *et al.*, 2010). Using the same walkability construct, Sallis and colleagues (2009) found that lower and higher income groups benefited similarly from living in high-walkable neighbourhoods and that moderate to vigorous physical activity did not differ by neighbourhood income. However, individuals living in neighbourhoods with low incomes showed a less favourable neighbourhood satisfaction score and higher perceived danger from crime than those with higher incomes (Sallis *et al.*, 2009). Zhu and Lee (2008) concluded that lower SES is related to lower levels of maintenance, aesthetics and safety. Similarly, in New York City neighbourhood conditions (clean streets, trees, safety from traffic, crime and sidewalk cafes) were found to differ significantly between poor and non-poor neighbourhoods (Neckerman *et al.*, 2009) this relationship remained when controlled for the WI walkbility index (section 2.5.6). In Mississippi and Missouri, USA, uneven footpaths and physical disorder were primarily concentrated in the lower income areas where more people walked or cycled for transport (Hoehner *et al.*, 2005). In the Netherlands the GLOBE study (N=6377, 46% male, postal survey) found that in addition to low objective neighbourhood aesthetics scores, low social neighbourhood cohesion was a strong predictor of not feeling safe in lower SES neighbourhoods which was in turn linked to lower levels of physical activity (Kamphuis *et al.*, 2010). These findings are all consistent with the negative neighbourhood perceptions and associated fear of crime individual's had in response to visual disorder on the streetscape outlined in section 2.6.2 and may mediate in the relationship between neighbourhood SES and walking behaviours as outlined in section 2.4.7, perceptions.

In the absence of a definitive definition of walkability it is difficult to clarify if SES compromises the walkability of a neighbourhood but given the suggestive results outlined above there is a requirement to investigate theses links further. However, consideration should be given not just to physical activity levels but also to mental health and exposure to pollutants relating to neighbourhood design.

2.8.3 Measurement of SES

Self-report questionnaires or interview questions are used to collect individual demographic information in most walkability studies. Information collected includes items outlined in section 2.7.1, the individual. GIS datasets comprising of census based income data at area unit level are frequently used to identify high and low SES areas (Sallis *et al.*, 2009; Cerin *et al.*, 2009b; Sallis *et al.*, 2001). In their review of studies examining built environments and obesity in disadvantaged populations Lovasi and colleagues (2009) found income and race were the most common identifiers of low SES areas used in the USA.

Deprivation indices built on census or other available population databases have also been used to identify high or low SES areas for population studies (Kamphuis *et al.*, 2010; Lovasi *et al.*, 2009; Hoehner *et al.*, 2005; Kingham *et al.*, 2007). These indices have included measures such as the proportion of the population economically non active, the average income, the proportion of the population of non-western origin, age, education, marital status, race, education, and employment status. When available, these indices are very useful because of the variety of information considered in their construction. Studies often collect self-report measures relating to demographics and SES to verify the neighbourhood selection. In the absence of reliable and consistent SES information an alternative would be to collect SES related data in a self-report questionnaire and then construct a measure. Frömel and colleagues (2009) study on the association between residential neighbourhoods and physical activity in Czech Republic (N=9950, 49% male, self-report survey) used a measure built on self-report employment status, ownership of material goods, education, residential status, age and gender to identify respondents SES. The index was constructed as there were no existing national indices available.

Irish Central Statistics Office (CSO) census data is freely available on their website down to a minimum division of Electoral District (ED). Electoral divisions vary greatly in size and composition ranging in size from 76 individuals to 32,000 individuals. The CSO does not collect information on income on the census of population but does collect information on education level, gender, age, ethnicity, marital status and employment status. An income question was included in a pilot study of a revised census questionnaire for the 2006 census of population but was excluded from the census. The reason for the exclusion was a low response rate in deprived areas, a potential non-compliance for the remainder of the questions and the danger of a negative impact on the public responses to the census (CSO Central Statistics Office, 2004). Income data is collected in the EU survey on income and living conditions and the Household survey which are carried out by the CSO annually and quarterly respectively. However, this data is a representative sample of the population presented regionally and not transferable to local area statistics. Hoehner and colleagues (2005) reported a high non-response to their income question in their US study which led the team to using education level to assess SES.

The elements of the environment to be considered for walkability are diverse and studies will be limited in their capacities to capture information on the built environment. Consideration will have to be given to the levels of spatial data relevant to the walkability research being undertaken: macro city level, meso neighbourhood level and/or micro street level. The role of the social environment on walkability is unclear and warrants further investigation with consideration for both the individual and the community.

2.9 Challenges for future research

In light of the ambiguity of what 'walkability' means, a key challenge for future work on walkability is to ensure that the elements under investigation, the methods used and the findings are relevant, transferable and communicable to all relevant disciplines. To better understand how to do this a study identifying how the concept of walkability is agreed on or differs between professional groups is warranted. Additionally, a working definition of walkability, in the absence of a definition incorporating multidisciplinary perspectives, should be developed.

The findings of the review of theories and models of behaviour from a variety of disciplines revealed that there are a substantial number of elements of relevance to investigate when studying an area's walkability and residents resulting behaviours. These include the environment, how it is perceived by the user, their response/behaviour and the context and purpose of the behaviour. This may require collecting a substantial amount of information to generate a comprehensive picture of an individual's neighbourhood environment. Each of the models reviewed addressed an element or overview of walkability. The development of a comprehensive model of behaviour that can feasibly incorporate the reviewed theories should be considered to enhance multidisciplinary walkability research.

Methods used for the measurement of the environment for walkability, and identification of study sites, were primarily dictated by the professional interests of the investigators and the availability of data. All of the identified measurement methods have benefits and limitations, mainly because of the context in which they are being used and the suitability for the associations being investigated. In particular, the reliance on macro scale GIS measures of walkability to investigate street level perceptions and behaviours is highly unsuitable and results should be reviewed with caution. The appropriateness of a measurement method will depend on the detail of information required, contextual purpose of the study and the spatial scale of interest and measurement methods should be selected accordingly. Additionally, clarity should be sought on the suitability of spatial boundaries and how the areas being studied actually reflect assumptions made such as consistency in urban form or area character.

A review of the elements of the built environment identified as having an effect on the walkability of an area identified a substantial number of influential features. Limiting walkability investigations to features previously investigated in a particular field of study (e.g. transport) restricts the potential for understanding and transferability and for the development of the research field. However, it would be prudent to reduce the large range of features identified to facilitate an efficient study. Consideration should be given to how this can be achieved without compromising the quality of the study.

3 Study 1 - Quantitative Study Investigating Professional Opinions on Walkability

3.1 Introduction

Walkability is a complex concept with varying opinions between professions on what constitutes a walkable environment (Lo, 2009; Southworth, 2005). The elements of the built and social environments used to identify or define an area as walkable are diverse. Therefore before embarking on a study to investigate the relationship between the walkability of a neighbourhood and the resident's behaviours it is imperative to have a clear understanding of what constitutes a walkable area. Differences in walkability definitions are due, in part, to the different opinions held by those responsible for designing and building these 'walkable' areas (Lo, 2009; Foster and Giles-Corti, 2008; Ewing *et al.*, 2006b; Southworth, 2005; Stonor *et al.*, 2003). The purpose of study one of this thesis was to conduct a multidisciplinary study to explore the similarities and differences among various professional groups in their beliefs of what constitutes a walkable area, an identified gap in the research literature (section 2.3). Informed by the literature review on walkability, the identified stakeholders required to answer the research questions were professionals and academics from spatial and transportation planning, architects, landscape architects, urban designers, civil engineers, public representatives and public health and advocacy professionals. Purposive sampling[36] was used to recruit these individuals.

3.1.1 Planners

In relation to 'walkability' planners can be divided into two categories; (i) spatial planners and (ii) transport planners. Spatial planners are concerned with land uses. They are tasked with ensuring new developments have access to services. They plan and enforce sustainable development, urban renewal and the diversity of destinations. Spatial planning has two primary functions: forward planning and development control. Forward planners study future growth prospects and decide on the variety of

[36] Purposive sampling is a process by which research participants are selected on the basis they possess characteristics, roles, knowledge, ideas or experience which is of relevance to the research, in this case their profession (Gibson & Brown 2009, p.56).

uses for land. Development control planners manage physical development by processing planning applications and enforcing planning law (Irish Planning Institute, n.d.; American Planning Association, n.d.; Boarnet, 2006). Transport planners provide for the movement of people including the design, routing and provision of roads, public transport, footpaths and bicycle lanes. They measure and project the demand for transport modes and design systems to suit and inform decisions on transportation investment (Amekudzi and Meyer, 2006). Their role is fundamental in generating and providing for trips.

3.1.2 Architects and Designers

Professionals involved in the design of streetscapes are primarily urban designers, architects and landscape architects. Urban designers have been advocating walkable communities for decades (Forsyth and Southworth, 2008). Urban designers highlight the need for routes to offer comfort and visual delight in order to make the trip enjoyable (Southworth, 2005; Cullen, 1964; The Housing Corporation and English Partnerships and Lyewelyn-Davies, 2000; Carmona *et al.*, 2003). Architects and landscape architects are tasked with designing for comfort and interest.

3.1.3 Public Health and Advocacy Professionals

Advocates can be divided into two groups: those whose main purpose is to promote improved health by walking, and those who want to promote walking for its own sake as a pleasurable activity. This is predominately done by promoting walking as a recreational activity (Sallis, 2009). In this study individuals involved in public health research and professionals in health promotion roles were targeted along with identified advocacy groups.

3.1.4 Elected Public Representatives

In Ireland, local government planning, engineering and transportation planning departments oversee urban and rural development, the design of which is sometimes undertaken by private design consultancies. Local governments are advised and informed by national policies and strategies developed by government departments and agencies such as the Department of Transport; the Department of the Environment, Heritage and Local Government; the Department of Community, Rural and Gaeltacht affairs; and the National Transportation Authority. The policies, plans and budgetary spending proposals of these government agencies or departments are approved by elected national or local government officials. In this role they have the potential to influence the financial resources allocated to walkable environments and are therefore included in this study. A limitation was pre-empted based on the previous experience of surveying public representatives by a member of the research team (Leyden) which suggested a reluctance of public representatives to respond to surveys.

3.1.5 Engineers

Whilst the transport planners decide the routes, engineers are tasked with designing, building and maintaining the pedestrian infrastructure and road crossings along the route. The term 'engineer' is broad and encompasses a myriad of disciplines. In this study civil, structural and transport engineers in local authorities and consultancies were contacted.

3.1.6 Aim

The aim of this study is to answer specific research questions on walkability based on the outcome of the literature review. These are:

a. Determine level of agreement with hypothesis of the CGL study
b. Explore the similarities and differences that exist among varied professional disciplines in relation to the relative importance they place on the contribution of the physical and social environment and social and demographic correlates on walkability.

The method employed for this study was a cross sectional web-based questionnaire. Participants were identified using purposeful sampling and recruited by email. Ethical approval was obtained from the Dublin City University Research Ethics Committee (REC/2010/030).

3.2 Methodology

A cross sectional study, using a web-based platform for data collection, was undertaken to investigate what environment correlates are important for walkability.

The opinion of identified neighbourhood creators (stakeholder) groups on what social and demographical correlates are perceived to influence walking behaviour was also collected.

3.2.1 Procedure

a) A survey instrument was developed from first principles using items identified in the literature review (Chapter 2). This process included a pilot study undertaken to test the developed questionnaire.

b) The recruitment of participants, distribution methods and processes were decided on and the questionnaire was circulated accordingly.

c) Results from completed questionnaires were transferred into statistical software and analysed.

3.2.2 Instrument: The Neighbourhood Creators' Walkability Questionnaire (NCWQ)

This study was designed to investigate a gap in the literature identified in chapter two. As no previous work on this topic was known, a questionnaire was developed from first principles to test the hypothesis 'that different neighbourhood creators (stakeholders) have different views on what constitutes a walkable environment'. The key focus of this instrument was the perceived influence of environment correlates (physical and social) on the walkability of an area. Guided by the socio ecological model items were also included on the neighbourhood creators' perception of the influence of personal and demographic variables on an individual's likelihood of walking in their neighbourhood. The survey instrument development was advised by a research team consisting of individuals qualified in the areas of public health, exercise science, transport planning, sociology and political science. To ensure validity, professionals from other relevant professions were consulted during the development process. Items included in the instrument were derived from the literature review and the survey development consultation process. The changes made to the questions at each stage are outlined in tables B.1 to B.10 in Appendix B.

The developed NCWQ consists of sections on: (i) a demographic profile of the respondent, (ii) agreement with the CGL study hypothesis, (iii) opinion on the influence of environment correlates on an area's walkability and (iv) opinion on the influence of demographical and social correlates on an individual's likelihood of walking in their neighbourhood. The instrument development went through four stages.

Step 1 – Initial draft questions based on the literature review were presented to the research team for consideration where they were discussed (Column 1, Tables B.1 to B.10 in Appendix B1).

Step 2 – The amended questions (Column 2, Tables B.1 to B.10 in Appendix B1) were pre-piloted by a group of six professionals known to the researcher (2 male, 4 female) from the areas of spatial planning and urban design, engineering, traffic planning, sociology, geography and public health. They were a representative group of the intended sample. They were asked for their feedback and for suggestions on how to further develop the questionnaire. This was a face validity exercise, a casual assessment of item appropriateness (Litwin, 1995), but whilst casual, the feedback relating to the pre-pilot participants' suggestions proved invaluable when considering the format and wording of the questions. All correspondence was carried out by email.

Step 3 – Validity and reliability tests were carried out on the third draft of the questionnaire. These tests are outlined in section 3.2.2 of this chapter.

Step 4 – Final amendments were made to the questions, which are outlined on Column 4, Tables B.1 to B.10 in Appendix B1).

3.2.2.1 Validity Testing

It is important to test a new questionnaire for validity as it is an important measure of the survey instruments accuracy (Litwin, 1995) and to determine the extent to which an instrument actually measures the construct/concept/variable it intends to measure (Burns and Burns, 2008). To ensure the validity of the survey tool two techniques for validity testing, face validity and content validity, were employed during the questionnaire development. Criterion validity, a measure of how well one instrument stacks up against another (Litwin, 1995), was not applicable in this study as no previously constructed instruments are known to exist which measure the relevant perceptions of the targeted population.

Content validity, 'a subjective measure of how appropriate the items seem to a set of reviewers who have some knowledge of the subject matter' (Litwin 1995, p.35) was an integral element of the questionnaire design and was carried out at each stage of the instrument development process. Each draft of the instrument was presented to the research team who discussed the items inclusion and content validity. A face validity exercise was carried out at step two during the pre-pilot of the instrument. A second validity exercise was carried out on the third draft of the instrument (Column 3, Tables B.1 to B.10 in Appendix B1). Nine researchers evaluated the validity of the instrument, by completing it and then discussing the validity of each question and its corresponding responses. These discussions were facilitated by a single researcher (Leyden) and took place in face-to-face meetings or on the telephone. All of the validity testers, worked in relevant areas (universities or government), had PhDs and were based in Ireland (n=6), the United States (n=2), or Spain (but from France) (n=1). Most had considerable experience with questionnaire design and analysis and most had conducted research related to walkability or the influence of neighbourhood characteristics on behaviours. All input was discussed and recorded and used to improve the design, validity and quality of the instrument used in this study. Results and resulting amendments made to reflect the feedback obtained are outlined in tables B.1 to B.10 in Appendix B1.

It was important that this questionnaire was validated by both design professionals and individuals from identified groups with no streetscape design experience. This was to ensure there was an understanding of the physical situation or physical structure being presented in the question. A number of items included on the questionnaire related to specific design practices which some professions may not be familiar with, as previously highlighted by Ewing and colleagues (2006) and Brennan Ramirez and colleges (2006). Feedback from the pre-pilot study emphasised this point with two respondents noting that older engineers might never have been introduced to particular concepts although they are taught as part of an engineering degree in recent years. To prevent non-response or a forced response which a respondent may not be comfortable with, a 'don't know' option was included in the question response options.

3.2.2.2 Reliability Testing

Reliability is a measure of how reproducible survey instrument items are (Litwin, 1995). It refers to the consistency and stability of items which enable them to be replicated (Burns and Burns, 2008). A 7-day test - retest reliability analysis was carried out on the questionnaire (Litwin, 1995) with exercise science, transportation planning and spatial planning students (N=66, 58% male, average age 21.2yrs $\pm$ 1.28). Percentage agreement between test one and test two was assessed using Statistical Package for Social Sciences (SPSS) statistics software, version 17.0. The results are presented on column three of tables B.1 to B.10 in Appendix B1. The level of agreement for items was weak but acceptable ranging from 40% to 74% for environment items and 45% to 83% for social and demographical items (Litwin, 1995; Hume *et al.*, 2006). Items with low reliability were not excluded from the list of proposed walkability items but consideration was given to these reliability scores when analysing the returned study questionnaire data. While the questionnaire was tested on students of a sub-sample of the targeted disciplines not all relevant professions were accounted for in the testing. Also, the student sample had limited streetscape experience and therefore may not be well versed in the practical relevance of items, particularly the social and demographic correlates.

Environmental items on the survey were grouped into sub components (scales) based on the theoretical foundations of the survey items. Personal and demographic correlates were grouped using factor analysis. The homogeneity or internal consistency of the resulting sub-components and factors, how the different items within the sub components complement each other (Litwin, 1995; Field, 2009), were measured using Cronbach's alpha (α) and the interclass correlation coefficient (ICC). Negatively scored items were reversed for the reliability analysis of the sub components and factors. The alpha and ICC results are reported in the data analysis section of this chapter on tables 3.3 and 3.4.

3.2.2.3 Question development: Area of work

Respondents were asked 'which of the following best describes your area of work?' to identify professional groups within the respondents. Eleven options were provided with the option of selecting 'other'. Professions were listed as bodies of knowledge rather than a position, e.g. 'architecture' rather than 'architect'. In design and construction professions it is common for architects, engineers and others to progress to project management roles and drop their professional discipline from their title. Similarly, individuals may work within the profession or industry but not have the professional qualification attributed to the professional field or have academic training in one area of work (i.e. architecture) but work predominantly in another (i.e. urban design). For ease of reporting all those who select architecture as their area of work are referred to as architects, and similar for other professions in this study, although this may not be technically accurate.

3.2.2.4 Question Development: Agreement with CGL Hypothesis

Respondents were asked to what degree they agree or disagree with the CGL Study hypotheses by asking their level of agreement with two statements: 'human health is affected by the way we plan and design communities and transport systems' and 'carbon emissions are affected by the way we plan and design our communities and transportation systems'. The question was scored on a 5-point Likert scale from 1 – Strongly Agree to 5 – Strongly Disagree. The development of the questions is outlined on table B1.2 in Appendix B1. The question was re-worded for ease of understanding following the pre-pilot consultation. Initially the question was scored on a four point Likert scale. However, a fifth point was added to the scale to allow the respondent to give a neutral response if they wished. Pilot feedback pointed out that it was felt that this question forced a respondent to have an opinion when they may not actually have one. 'Climate change' was amended to read 'Carbon emissions', the product of traffic fumes, a contributory factor to climate change directly associated with traffic fumes, rather than the overall concept of climate change to give focus to the question.

3.2.2.5 Question Development: Environment correlates

The environment question (Tables B1.4 to B1.9 in Appendix B1) was designed to determine each respondent's rating on how good or bad individual environment characteristics (N=46) are for the walkability of an area. The listed environment correlates were derived from the literature review. Items responses were on a five point Likert scale from 1= very good to 5=very bad for walkability. The good to bad scale direction used for the question was consistent with the remainder of the questionnaire. For analysis items were reversed and scored as very good = 5 points and very bad = 1. Feedback from pilot respondents prompted the inclusion of an additional 'don't know' option on the Likert Scale. As correlates were derived from a literature review of a diverse knowledge base some of the terminology or concepts being investigated may be unfamiliar to some respondents. This diversity and complexity was identified as a research challenge by Brennan Ramirez and colleagues (2006). Participant non response because of a perception of irrelevance, given that some of the terminology may be unfamiliar, was a concern raised in the pre-pilot testing of the questionnaire. As a result a 'don't know' option was included.

Items are grouped into themes in tables B1.4 to B1.9. The survey template can be seen on the survey in Appendix B.2. Items on draft one reflect the headings from the literature review on walkability (Section 2.6). In draft 1 (column 1 of tables) the questionnaire asked for correlates to be ranked in order of importance but as the list grew in length this was no longer feasible. A Likert scale was introduced in draft 2, with a scale of how important each correlate is for the walkability of an area from 1 (not at all important) to 9 (very important). Draft 3, reduced the Likert scale to 5 points and introduced the 'don't know' option. A selection of items were reversed coded to counteract participant fatigue, a common practice in psychological research (Pallant, 2010). The Likert scale for environmental items allows for correlates to be interpreted as positive or negative for walkability. Footnotes are included on tables B1.4 to B1.9 to explain the rationale for changes to the questionnaire wording during the questionnaire design process. An increased awareness of relevant correlates through the process of development of the questionnaire meant that the list grew in length from 17 items to 46 over the four questionnaire drafts. An alternative description of 'walkability' is given as 'pedestrian friendly' to inform any respondent who may not be familiar with the term. The question was presented over three pages and at least five items had to be answered on each page to proceed.

3.2.2.6 Question Development: Social and Demographic Correlates

The socio-ecological model of behaviour (section 2.4) highlights the importance of an individual's physical and social environment and also an individual's personal characteristics on their behaviours. Physical activity and public health research place particular emphasis on the individual (Biddle and Mutrie, 2008) however little evidence was identified in literature from other professions (section 2.7). In light of this observed difference respondent opinion was sought on the influence of an individual's demographic or social characteristics on the likelihood of them walking in their neighbourhood. Items were identified from reviewed literature and exploratory items relating to the influence of desired appearance were also included. This question was introduced to the instrument in the second draft.

The format of the social and demographic correlates question is similar to the question on environment correlates. The question asks respondents opinion on how influential the identified items are on an individual's likelihood of walking in their neighbourhood. The question is scored on a 5-point Likert scale from 1 (far less likely to walk) to 5 (much more likely to walk). The question was designed to assess if respondents believe that there is a relationship between the listed items and to determine which direction (more or less likely to influence) they believe the relationship to be. To explore the items being investigated the second draft of the list expanded the correlates from 14 items to 23 to attribute particular contexts and direction (Table B1.10, Appendix B1).

3.2.3 Recruitment

Lists of potential research participants were generated from a number of strategies. The entire population of elected public representatives for urban regions of the Greater Dublin Area were targeted. The delegates attending relevant conferences hosted by the Department of Transport, the Irish Sports Council, the Health Service Executive and the Engineers Ireland were given the opportunity to sign up to receive an email about the study. A systematic identification of relevant third level courses was undertaken to identify academics. Individuals from the identified stakeholder fields were contacted from listings from the golden pages telephone directory and from an internet search using the Google^{TM} search engine. For local authorities, as public servants email addresses are not publicly available, telephone calls were made to relevant departments and a department head/ line manager's email was obtained and they were asked to distribute the email to their colleagues. A similar process was followed for relevant government agencies. When making telephone calls a request was made to speak to an identified key person, they were then asked personally if they would complete the questionnaire and distribute it to their colleagues. In instances where members of staff were known to the researcher a personal approach was taken. 'I know x who works in your department who can vouch for me' or 'I met you or a colleague at a seminar' or 'I worked with you on a project when I worked for x' etc.

Two recruitment methods were employed. Emails with the survey web link were sent directly to individuals. To facilitate a wider distribution of the questionnaire, emails were also sent to companies and institutions that we did not have individual email addresses for. This was done to cast a wider net, as we did not want to lose individuals from our study on the basis that we did not have their individual email address. Scope was allowed for professionals from other fields to become involved in the study through the nature of its design and dissemination. Recipients of the email were asked to forward the survey link to colleagues who they believe may be interested in partaking in the study. The initial question then allows the respondent to enter their profession if it is not on the list. Different web links were used for the two recruitment strategies so a response rate could be determined for the individuals' targeted. The links were to identical surveys. Every effort was made to prevent people getting multiple emails. Informed consent was obtained from participants by explaining on the recruitment email that by clinking on the survey link they were giving their consent. Participants were informed that their participation was voluntary and responses would be treated confidentially. Copies of the email texts used can be seen in Appendix B.2.

3.3 Data Analysis

All data was stored, cleaned and analysed using SPSS version 17. Means, standard deviations and proportions were used to describe the data where appropriate. 'Don't know' responses were removed from the dataset and replaced with a 'missing' code. All data was tested for normality by calculating skewness, kurtosis and using the Kolmogorov-Smirnov (KS) test. The KS test was suitable for this dataset as the sample size was small (n=216) (Field 2009**,** p.788). Levene's test for homogeneity was also carried out on the data. It was found that the majority of cases were not normally distributed.

3.3.1 Ranking of correlates

Correlates were ranked on their importance for walkability based on the mean scores attributed to the environment correlates by the total participant sample. Similarly, demographic and social correlates were ranked on the mean score of their influence on an individual's decision to walk in their neighbourhood. The top five highest scoring environment correlates (most influential on walkability) and the bottom five lowest scoring (least influential on walkability) for each professional grouping were determined.

3.3.2 Differences of professional opinion on correlates

Non-parametric tests were carried out to identify professional differences in 1) agreement with the study hypothesis, 2) the importance attributed to environmental correlates when considering the walkability of an area and 3) the perceived influence of social and demographic correlates on walking behaviour. The Kruskal – Wallis (KW) Test was carried out on each correlate/item to test for differences across the six professional groups. The KW test was followed by Mann-Whitney U tests to identify differences between two independent professional groups. As there were 15 individual U tests carried out for each correlate a Bonferroni adjustment of 15 was applied to the statistical score to control for Type 1 errors. One way ANOVA tests with Games-Howell post hoc tests were used to establish differences between professional groups for normally distributed correlates. Correlates found to be significantly different between groups have the means and standard deviations as opposed to medians reported. This is due to the short range in survey responses. The effect sizes for the KW tests determining differences between groups were also determined.

3.3.3 Factor analysis

Given the large number of environment (n=47) and social (n=23) items measured using the survey instrument it was desirable to reduce these items to generate a more parsimonious list of factors for comparison analysis. This is advantageous as using fewer variables in analysis improves power against Type II error (Thompson, 2004), this is when it is believed that there is no effect on the population when there actually is an effect (Field, 2009). The principle of factor analysis is to identify a smaller number of underlying factors which explain much of the variance in the original variables. Exploratory factor analysis is done on data when no assumptions are made on the relationships between items thus restricting researcher bias. The factor extraction method selected for this analysis was principal component analysis (PCA) because of its common use for factor extraction from social data, particularly in the construction of environment scales in behaviour research (Ogilvie *et al.*, 2008; Pallant, 2010; Field, 2009)**.** Varimax rotation with Kaiser Normalisation (eignevalue rule) was used to maximise the dispersion of loading within factors by constructing uncorrelated sub-components of the data and therefore producing more interpretable factors (Field, 2009; Pallant, 2010). Horn's Parallel analysis (comparing enginvalue size to a randomly generated dataset of the same size) was used to verify the number of sub-components as the Kaiser test can overestimate the number of sub-components to be retained (Pallant, 2010).

Before carrying out factor analysis the suitability of the data was checked for (i) adequate sample size and (ii) the relationship between variables. The environment correlates question variables were found to be unsuitable for PCA as the ratio of 1:4.6 (216 cases for 47 correlates) was lower than the accepted absolute minimum of five individuals to every variable. For the demographic and social correlates the ratio of 9.4 individuals per variable was low but acceptable for PCA and therefore met the assumptions of PCA. Recommended ratios are between 10 to 20 people per measured variable (Field, 2009; Thompson, 2004). The relationship between variables for the demographic and social correlates was determined using Kaiser–Meyer-Olkin (KMO) measure of sampling adequacy (a measure of degree of common variance between variables) and Bartlett's test of sphericity (a test of the null hypothesis that the variables are completely uncorrelated) (Pallant, 2010; Ogilvie *et al.*, 2008). The KMO measure was 0.63, mediocre according to Field (2009). A KMO value of close to 1 indicates that patterns of correlations are relatively compact and so factor analysis should yield distinct and reliable results (Field, 2009). Bartlett's test of sphericity ($\chi^2(253) = 744.4$, $\rho<0.001$), indicated that correlations between items were sufficiently large for the analysis. The PCA and Varimax rotation converged into eight components after 11 iterations. The factor loadings after rotation are shown on Table 3.1. Prior to the parallel analysis an interpretative observation was made by the researcher that the last three sub components did not have logical groupings. Horn's Parallel analysis was carried out to compare eigenvalues from a randomly generated dataset of the same size using Watkins' (2000) computer software to the sub components generated from the PCA and Varimax rotation. Five of the eight sub components generated were retained as their eigenvalues exceeded the corresponding data from the random sample (Table 3.2). This result reflected the researcher's interpretation of the generated sub components.

Factors were constructed using items with loadings of greater then 0.5. Table 3.3 shows the reliability analysis of the constructed scales. For factor 2, *the income and education level factor,* two items, *low income and low education level*, had to be reversed for scale construction and analysis as they had a negative correlation with the other items in the factor. The total variance explained by the five constructed factors was 50.3%. The percentage variance explained by each constructed factor and the reliability scores for the generated scales are outlined in table 3.10. The *Ability* and *Social* sub components both have alpha scores of over .7 which is ideal however as the number of items in the sub components is less than 10 the alpha scores for sub components can be small so the ICC should also be measured. The ICC scores for the sub components are within the optimal range of 0.2 to 0.4 except the *Social* sub component which has an ICC of 0.6 (Pallant, 2010). Considering this information the five generated sub components were deemed suitable by the researcher.

Table 3-1: Rotated Component Matrix for PCA on Social and Demographical Factors

	1	2	3	4	5	6	7	8
Having an intellectual disability	**.756**							
Having a mental illness	**.750**							
Being old	**.686**							
Having a physical disability	**.627**			-.367				
Having a high income		**-.747**						
Having a middle income		**-.724**					.304	
Having a low income		**.700**						
Low education level		**.669**						
Being a social person			**.833**					
Feeling part of the community			**.832**					
Enjoying exercise				**.767**				
Being fit				**.587**		-.332		
Owning a dog				**.526**				
Not having much time					**.740**			
Having a car					**.661**			
Being overweight/ obese	.432				.476			
Being a child						**.836**		
Having lots of children					.319	**.521**		
Being female							**.715**	
Having a young child			.364			.427	**.617**	
Having a sensory impairment	.506						**-.509**	
Wanting to look smart/ having an interest in fashion or makeup								**.782**
Being a single parent	.302				.362			**-.548**

Table 3-2: Parallel Analysis for Social and Demographic Correlates

Component No	***Actual Eigenvalue from PCA***	***Criterion Value from Parallel Analysis[1]***	***Decision***
1	3.61	1.64	Accept
2	2.60	1.53	Accept
3	2.32	1.45	Accept
4	1.68	1.38	Accept
5	1.36	1.31	Accept
6	1.24	1.26	Reject
7	1.14	1.20	Reject
8	1.06	1.15	Reject

[1]Determined using Watkins (2000) Monte Carlo software recommended by Pallant (2010)

Table 3-3: Social and demographical sub component properties

Factor	*# items*	*α*	*ICC*	*Variance Explained*
1 Ability	4	0.7	0.4	15.7%
2. Income & Education	4	0.4	0.2	11.3%
3. Social	2	0.8	0.6	10.1%
4. Exercise	3	0.5	0.3	7.3%
5. Time and Car	2	0.3	0.2	5.9%

3.3.4 Construction of environment sub components

The environment variables were found to be unsuitable for PCA as the ratio of correlates to individuals was lower than the accepted absolute minimum. Theoretical groupings of the environment correlates based on the literature and question development process informed the construction of environment sub components. Not all items grouped into reliable sub components. Tables outlining the correlates included in each of the sub components can be found in Appendix B.4. Functional and connectivity correlates were grouped together to form a sub component relating to the road and path network. Items which were not relevant or which reduced the α score of the constructed sub component were removed. One item, *day and night functions in an area*, which theoretically fitted under two sub component headings (*personal safety* and *destinations*) was tested for best fit under both headings. The item was included in the *destinations* sub component as it improved the α score of the sub component. The item '*route overlooked by occupied buildings, shops and residences*' was retained in the *personal safety* sub component despite its inclusion causing a reduction the α score of the sub component as it had a strong theoretical basis for inclusion. Three items did not fit into the theorised sub-components of the environment question but were retained as individual correlates because of the exploratory nature of this study and the correlates were deemed suitable for inclusion by both the research team and the questionnaire validation group. Cronbach's alpha (α), the most common measure of scale reliability according to Field (2009) and intraclass correlation coefficient (ICC) were determined for the constructed sub components, table 3.4. The results indicate that the subcomponents are suitable for further analysis.

Table 3-4: Environment sub component properties

Factor	# items	α	ICC
1 Destinations	9	0.8	0.6
2. Path Context	6	0.7	0.6
3. Personal Safety	7	0.6	0.4
4. Personal Comfort	11	0.6	0.5
5. Road and Path Network	12	0.7	0.6

Histogram plots with normality curves were observed to indicate a normal distribution for all sub-components, environment and social and demographical. Therefore, ANOVA tests and Games Howell post hoc tests were used to compare sub components between professional groups.

3.4 Results

3.4.1 Sample

The sample consists of 216 respondents, average age 39.7 years, 58% of whom were male.

3.4.1.1 Response rate

A response rate of 31% (N=171 out of 543) was obtained from the individual emails recruitment method outlined in section 3.2.3 (Table 3.5). The accuracy of this result cannot be confirmed as it was determined using the number of emails which had a positive delivery report. Therefore the result is conservative as these emails may not all have reached their intended recipient. An additional 46 surveys were completed by the second recruitment method, where companies and individuals were asked to pass on the survey link, giving a total of 216 responses. Independent sample distribution analysis was carried out to assess differences in the age, gender, profession or level of streetscape design experience between respondents recruited from both survey links. No significant differences were found between the samples on any of these variables, and so both datasets were combined for full analysis. All of the walking advocates contacted completed the survey but only 14% of the public representatives contacted completed the survey.

Table 3-5: Response rate by professional group

	Delivered	Responses	%
Spatial Planning	51	19	37
Transport Planning	69	32	46
Architecture	23	15	65
Landscape Architecture	6	2	33
Urban Design	6	4	67
Public Health/ Physical Activity Promotion	44	18	41
Advocacy	4	4	100
Public Representatives	270	38	14
Engineering	70	39	56
	543	171	

3.4.1.2 Area of work

The numbers of respondents grouped by area of work are shown on table 3.6. Geographers were grouped with spatial planners and environmental policy professionals were grouped with public health and advocacy professionals[37]. Discrepancies in the number of respondents from particular professions between tables 3.5 and 3.6 are because table 3.5 reports the assumed professions when distributing the survey link and table 3.6 reports respondents self-reported profession and includes responses from both recruitment methods.

Table 3-6: Survey response distribution by professional group

Professional Group	Number	%
Spatial Planning (SP)	33	15
Transport Planning (TP)	39	18
Architecture & Design (AD)	36	16
Public Health & Advocacy (PHA)	28	13
Public Representative (PR)	38	17
Engineering (E)	42	19
Total	216	100

3.4.2 Agreement with key hypothesis

The mean and standard deviation score for agreement with the study hypotheses were 4.66 $\pm$ 0.6 for human health, and 4.64 $\pm$ 0.6 for carbon emissions. The group statistics are presented on table 3.7.

[37] The environmental policy professional was known to the researcher and a decision was made on this grouping based on a knowledge of their work area

Table 3-7: Agreement with hypothesis statements

Profession Group	Human Health ($\rho<0.01$)	Carbon Emissions (ns)
	Mean (sd)	Mean (sd)
Spatial Planning (SP)	4.64 (.5)	4.70 (.5)
Transport Planning (TP)	4.62 (.7)	4.64 (.5)
Architecture & Design (A&D)	4.83 (.6) [1]	4.78 (.6)
Public Health & Advocacy (PHA)	4.89 (.3) [2]	4.71 (.5)
Public Representative (PR)	4.68 (.7)	4.68 (.5)
Engineering (E)	4.38 (.8) [1,2]	4.38 (.8)

Note: Values are means (standard deviations).

Kruskal-Wallis (χ^2), ns = not significant, [1] E < A&D, p<0.05, [2] E < PH&A, p<0.05.

A significant difference was recorded between professional groups on their level of agreement with the human health hypothesis ($\chi^2(5)$ =18.6, $\rho<0.01$), and post-hoc Mann-Whitney U tests revealed that this difference was due to the mean score of the engineering group being significantly lower than either public health and advocacy (U = 483.0, r =-.4, p<0.05), and architecture and design groups (U =365.0, r =-.4, p<0.05) (Table 3.7). No significant differences were observed between groups on the carbon emissions hypothesis (χ^2 (5) = 9.7, p> 0.05, ns)).

3.4.3 Hierarchy of environmental correlates

Correlates which were negatively worded in the instrument design process were reverse coded for analysis. These items are identified on table 3.8. Items were scored as 5 (very good for walkability) to 1 (very bad for walkability). After reverse coding negatively worded items all environment correlates had a mean score of between 3 (neither good nor bad for walkability) and 5 (very good for walkability). To reflect the reduced scale and mixed direction of items, results are reported as having little or no influence (3) to being very influential (5) on walkability. The top six most influential environmental correlates that contribute to the walkability of an area, according to the total sample, were: i) *well maintained footpaths*, ii) destinations (e.g. shops, schools) within walking distance of people's homes, iii) *well designed pedestrian crossings*, iv) *crime rate*, v) *access to parks or other green spaces* and vi) street lighting (Table 3.8). The top six correlates all have mean scores of greater than 4.5. The correlates reported as having the least influence were building height, residential density, pedestrian bridges, *street art* and the age of the area. Table 3.8 presents the 47 environmental items listed in order of their mean scores. The higher scores indicate a greater influence on walkability.

Table 3-8: Item mean score ranking for total sample (N=216)

		Mean (SD)
1	Well maintained footpaths	4.71 (.5)
2	Schools, shops, transport stops, recreation facilities and other services within walking distance of peoples homes	4.69 (.6)
3	Well designed pedestrian crossings	4.56 (.6)
4	Above average crime rate[1]	4.54 (.6)
5	Access to parks and other green spaces	4.53 (.7)
6	Good street and footpath lighting	4.53 (.5)
7	Friend/family's homes within walking distance	4.43 (.6)
8	Pedestrianised streets - no motorised vehicles	4.42 (.7)
9	Pedestrian Shortcuts	4.37 (.7)
10	Wide roads with multiple lanes of traffic[1]	4.36 (.7)
11	Dirty unkept local area[1]	4.35 (.6)
12	Other people walking	4.34 (.6)
13	Overlapping day and night functions in an area	4.30 (.6)
14	Unique areas with personality and character	4.29 (.6)
15	Proximity to the sea, river or canal	4.26 (.7)
16	Cul-de-sacs[1]	4.23 (.9)
17	Attractive gardens and trees along routes	4.22 (.6)
18	Long waiting time for pedestrians at traffic lights[1]	4.21 (.8)
19	Benches to stop and rest	4.21 (.6)
20	Poor air quality/ presence of air quality[1]	4.20 (1.1)
21	Low speed of passing traffic	4.20 (.6)
22	Mixed land use – variety of shops, residences, amenities and other uses	4.20 (.6)
23	Inviting local shops	4.20 (.6)
24	Friendly faces	4.14 (.6)
25	Loud noise[1]	4.13 (.7)
26	Route overlooked by occupied buildings, shops and residences	4.09 (.8)
27	Interesting architecture	4.06 (.7)
28	High walls surrounding properties[1]	4.06 (.7)
29	Sheltered routes from wind and rain	4.05 (.6)
30	People begging[1]	4.02 (.7)
31	Public spaces where people can gather	4.01 (.8)
32	Buildings and spaces designed to human scale	4.01 (.8)
33	Even slope/gradient along the route – not hilly	3.97 (.7)
34	Presence of a buffer between pedestrian and road – for example: grass verge/ parked cars/ barriers	3.97 (.7)
35	Congestion on footpaths[1]	3.96 (.7)
36	Bad weather[1]	3.93 (.8)
37	Shops and businesses with closed shutters at night[1]	3.89 (.7)
38	Large flat car parks[1]	3.89 (.8)
39	Street entertainment or buskers	3.81 (.7)
40	Mixed age profile of people living in the area	3.80 (.7)
41	Young children playing	3.74 (7)
42	Little or no graffiti	3.71 (.8)
43	Older area of the city	3.61 (.8)
44	Street art	3.61 (.7)
45	Pedestrian bridges over roads	3.60 (1.0)
46	Low residential density[1]	3.26 (.9)
47	Tall buildings[1]	3.19 (.7)

[1]reversed coded items; these items should be interpreted as having a negative effect on walkability

3.4.4 Professional differences between environmental correlates

A significant difference was recorded between professional groups on the contribution of 17 of the 47 environment correlates to the walkability of an area. These correlates and their statistical differences between professions are shown on table 3.9. Discussion of these differences is based on the mean ranking scores. Tables 3.10 and 3.11 present the top five and bottom five correlates for each of the professional groups respectively. Sample sizes were insufficient to check if there were any significant differences between individuals within professional groupings on the rated environmental and social items.

Spatial planners rated *destinations, pedestrian crossings* and *well maintained footpaths* as their top three influential correlates (Table 3.10). They rated *attractive gardens, people begging* and *footpath congestion* significantly lower in their influence on walkability than architects and designers, engineers and public representatives respectively (Table 3.9). Transport planners rated *well maintained footpaths, destinations* and *cul-de-sacs* as their top three influential correlates (Table 3.10). They rated seven factors significantly lower than architects and designers; these included *overlooked routes, unique characteristics of the area, attractive gardens* and *mixed age profile of people living in the area*. They rated four correlates lower than public health and advocacy professionals; these included the *presence of benches* and *mixed age profile of people living in the area*. They rated the influence of *pedestrian bridges* significantly lower than either public representatives or engineers (Table 3.9). Architects and designers rated walkability correlates higher, on average, than all other professional groups (Table 3.9). Specifically, they rated *destinations, well maintained footpaths* and *green spaces* as their top three most influential correlates (Table 3.10). On only one correlates, the presence of *pedestrian bridges over roads*, did they rate its influence significantly lower than any other professional groups (these were public representatives, public health and advocacy professionals) (Table 3.9).

Public health and advocacy professionals and public representatives rated *well maintained footpaths* and *destinations* as their top two. While these professionals placed *proximity to green spaces* as number three *Crime rate* was the third influential correlates for public representatives (Table 3.10). Both groups rated the *overlapping* *functions of an area* and if *walking routes were overlooked* significantly lower than architects and designers (Table 3.9). Engineers rated walkability correlates lower, on average, than all other professional groups. They ranked the *crime rate* of an area ahead of *well maintained footpaths* and *pedestrian crossings* in their top three correlates (Table 3.10). They rated eight correlates significantly lower than architects and designers, and four significantly lower than spatial planners. These correlates included *proximity to services, proximity to friends and family homes, availability of public spaces for people to gather* and *residential density* (Table 3.9).

Table 3-9: Significant differences in mean scores for environmental correlates by area of work

Walkability correlates	*Professional Groups: mean (sd)*						*Mann – Whitney test (U, r)*
	SP N = 33	*TP N = 39*	*AD N = 36*	*PHA N = 28*	*PR N = 38*	*E N = 42*	
Low residential density (reversed)	3.39 (.8)	3.29 (1.0)	3.63 (.8)	3.12 (.9)	3.03 (.8)	2.85 (.9)	**E<AD**^{2} (394.5, -.4)
Schools, shops, transport stops, recreation facilities and other services within walking distance from people's homes	4.85 (.4)	4.58 (.8)	4.92 (.3)	4.74 (.4)	4.68 (.6)	4.46 (.6)	**E<AD**^{2} (434.5, -.4) **E<SP**^{1} (436.5, -.4)
Over lapping day and night functions in an area	4.34 (.5)	4.11 (.7)	4.67 (.5)	4.04 (.6)	4.18 (.5)	4.20 (.6)	**PHA < AD**^{2} (211.5, -.5)) **TP< AD**^{2} (415.0, -.4) **E < AD**^{1} (469.5, -.4)
Large flat carparks (reversed)	3.91 (.7)	3.74 (.8)	4.19 (.8)	3.41 (.8)	3.91 (.8)	3.90 (.7)	**PHA < AD**^{2} (257.5, -.4)
Pedestrian bridges over roads	3.52 (1.1)	3.00 (1.1)	3.25 (1.1)	4.04 (.8)	4.04 (.9)	3.73 (.9)	**TP<PHA**^{2} (224.5, -.5) **TP<PR**^{2} (277.5, -.5) **AD< PR**^{2} (357.0, -.4) **TP<E**^{1} (467.0, -.4) **AD<PHA**^{1} (284.5, -.4)
Cul-de-sac's (reversed)	4.25 (1.0)	4.54 (.7)	4.50 (.6)	3.96 (1.0)	3.89 (.9)	4.17 (.9)	**PR< TP**^{1} (437.5, -.4)
High walls surrounding properties (reversed)	4.09 (.7)	3.94 (.7)	4.42 (.7)	3.89 (.8)	4.03 (.7)	3.83 (.7)	**E<AD**^{1} (449.0, -.4)
Route overlooked by occupied buildings, shops and residences	4.42 (.6)	4.16 (.7)	4.64 (.6)	3.70 (.9)	3.84 (1.0)	3.66 (.9)	**E<SP**^{2} (366.5, -.4) **E<AD**^{2} (293.0, -.6) **PHA <AD**^{2} (191.0, -.6) **PR <AD**^{2} (392.0, -.4) **TP < AD**^{1} (417.5, -.4) **PHA < SP**^{2} (238.0, -.4)

Table 3-9 cont.

Walkability correlates	*Professional Groups: mean (sd)* SP N = 33	TP N = 39	AD N = 36	PHA N = 28	PR N = 38	E N = 42	*Mann – Whitney test (U, r)*
Benches to stop and rest	4.24 (.7)	3.92 (.5)	4.39 (.6)	4.33 (.5)	4.25 (.6)	4.15 (.6)	**TP< PHA**[1] (342.0, -.4) **TP< AD**[1] (428.5, -.4)
Congestion on footpaths (reversed)	3.67 (.8)	3.89 (.6)	3.81 (.7)	4.08 (.6)	4.29 (.7)	4.00 (.8)	**SP<PR**[1] (353.5, -.4)
Public spaces where people can gather	4.18 (.5)	4.00 (.6)	4.31 (.8)	3.88 (.8)	4.11 (.7)	3.59 (.8)	**E< AD**[2] (418.5, -.4) **E< SP**[1] (436.5, -.4)
Unique areas with personality and character	4.24 (.7)	3.92 (.6)	4.51 (.6)	4.48 (.6)	4.19 (.7)	4.27 (.5)	**TP<AD**[2] (346.5, -.5) **TP<PHA**[1] (280.5, -.4)
Attractive gardens & trees along route	4.09 (.6)	3.95 (.6)	4.50 (.5)	4.25 (.6)	4.38 (.6)	4.17 (.7)	**TP<PR**[1] (480.0, -.3) **TP<AD**[2] (396.0, -.4)
Mixed age profile of people living in the area	3.74 (.9)	3.47 (.6)	4.03 (.8)	4.08 (.6)	3.61 (.6)	3.70 (.7)	**TP<AD**[1] (428.0, -.3) **TP<PHA**[2] (257.5, -.4)
Street entertainment or buskers	3.94 (.6)	3.50 (.6)	3.75 (.8)	3.81 (.6)	4.08 (.7)	3.18 (.8)	**TP<SP**[1] (397.0, -.4) **TP<PR**[2] (402.0, -.4).
Friends/ family's homes within walking distance	4.52 (.5)	4.32 (.6)	4.63 (.5)	4.46 (.7)	4.35 (.6)	4.24 (.5)	**E<AD**[1] (482.5, -.4)

Note: Values are means (standard deviations). [1]p<0.05, [2]p<0.01. Due to reverse coding range of scale 3-5, where 3 = no influence and 5 = influential.
SP= spatial planners, **TP**= transport planners, **AD**= architects and designers, **PHA**= public health and advocacy, **PR**= public representatives and **E**=engineers

Table 3-10: Highest Influencing correlates by professional group

	Architects & Designers (AD) N = 36 *Mean (SD)*	Transport Planners (TP) N = 39 *Mean (SD)*	Spatial Planners (SP) N = 33 *Mean (SD)*	Public Health & Advocacy (PHA) N = 28 *Mean (SD)*	Public Representatives (PR) N = 38 *Mean (SD)*	Engineers (E) N = 42 *Mean (SD)*
1	Destinations in walking distance[1] 4.92 (.3)	Well maintained footpaths 4.64 (.5)	Destinations in walking distance[1] 4.85 (.4)	Well maintained footpaths 4.89 (.3)	Well maintained footpaths 4.79 (.4)	Above average crime rate[2] 4.63 (.5)
2	Well maintained footpaths 4.72 (.5)	Destinations in walking distance[1] 4.58 (.8)	Well maintained footpaths 4.70 (.5)	Destinations in walking distance[1] 4.74 (.4)	Destinations in walking distance[1] 4.68 (.6)	Well maintained footpaths 4.60 (.6)
3	Access to parks and other green spaces 4.72 (.5)	Cul-de-sacs[2] 4.53 (.7)	Well designed pedestrian crossings 4.70 (.5)	Access to parks and other green spaces 4.71 (.5)	Above average crime rate[2] 4.68 (.5)	Well designed pedestrian crossings 4.48 (.6)
4	Overlapping day and night functions in an area 4.67 (.5)	Pedestrian shortcuts 4.50 (.8)	Access to parks and other green spaces 4.61 (.6)	Above average crime rate[2] 4.69 (.5)	Well designed pedestrian crossings 4.65 (.5)	Destinations in walking distance[1] 4.46 (.6)
5	Above average crime rate[2] 4.64 (.5)	Well designed pedestrian crossings 4.50 (.6)	Good street and footpath lighting 4.58 (.5)	Pedestrianised streets 4.64 (.5)	Good street and footpath lighting 4.57 (.5)	Good street and footpath lighting 4.45 (.6)

[1]Destinations: 'Schools, shops, transport stops, recreation facilities and other services within walking distance of peoples homes', [2]reversed coded item,

Table 3-11: Lowest ranking (having least influence) environment items by profession

	Architects & Designers (AD) N = 36 *Mean (SD)*	Transport Planners (TP) N = 39 *Mean (SD)*	Spatial Planners (SP) N = 33 *Mean (SD)*	Public Health & Advocacy (PHA) N = 28 *Mean (SD)*	Public Representatives (PR) N = 38 *Mean (SD)*	Engineers (E) N = 42 *Mean (SD)*
1	(Tall buildings)[1] 3.03 (.6)	Pedestrian bridges over roads 3.00 (1.1)	(Tall buildings)[1] 3.03 (.5)	(Low residential density)[1] 3.12 (.9)	(Tall buildings)[1] 3.41 (.9)	(Low residential density)[1] **2.85 (.9)**
2	Pedestrian bridges over roads 3.25 (1.1)	(Tall buildings)[1] 3.24 (.6)	(Low residential density)[1] 3.39 (.8)	(Tall buildings)[1] 3.16 (.8)	Street art 3.76 (.8)	(Tall buildings)[1] 3.26 (.8)
3	Street art 3.63 (.6)	(Low residential density)[1] 3.29 (1.0)	Pedestrian bridges over roads 3.52 (1.1)	(Large flat car parks)[1] 3.41 (.8)	Older area of the city 3.78 (.8)	Older area of the city 3.50 (.7)
4	(Low residential density)[1] 3.63 (.8)	Street art 3.42 (.8)	Older area of the city 3.64 (.7)	Older area of the city 3.58 (.7)	Little or no graffiti 3.82 (1.1)	Young children playing 3.55 (.7)
5	Little or no graffiti 3.69 (.9)	Older area of the city 3.47 (.7)	Street art 3.65 (.7)	Street art 3.62 (.6)	Mixed age profile of people living in the area 3.84 (.7)	Street art 3.61 (.6)

[1]reversed coded item

Professional differences between environment sub-components

In the environment section of the questionnaire there were a number of sub-components. These were 'Destinations' (N= 9 items), 'Path Context' (N=6 items), 'Personal Safety' (N=7 items), 'Personal Comfort' (N=11 items) and 'Road and Path Network' (N=12 items) which are outlined in Appendix B.4. Environment sub components were normally distributed. Table 3.19 shows differences in mean scores between professional groups.

Table 3-12: Differences in mean scores and standard deviations for environmental factors by area of work

	Professional Groups						
Environmental Factors	**SP N = 33**	**TP N = 39**	**AD N = 36**	**PHA N = 28**	**PR N = 38**	**E N = 42**	**Games Howell Post Hoc**
Destination sub-component	34.6 (2.7)	33.5 (3.0)	35.9 (2.5)	33.6 (3.1)	34.6 (3.7)	33.1 (3.0)	AD> E[3], AD>TP[2] AD>PHA[1]
Path Context sub-component	23.9 (2.5)	23.2 (2.3)	25.1 (2.4)	24.6 (2.3)	24.6 (2.8)	24.0 (2.6)	AD>TP[1]
Personal Safety sub-component	29.3 (2.4)	28.8 (2.7)	30.8 (2.7)	28.6 (2.5)	29.3 (2.9)	28.4 (2.4)	AD > PHA,TP[1] AD>E[2]

Note: Values are means (standard deviations). [1]p<0.05, [2]p<0.01, [3]p<0.001. **SP**= spatial planners, **TP**= transport planners, **AD**= architects and designers, **PHA**= public health and advocacy, **PR**= public representatives and **E**=engineers

Similar to item level analysis the architects and designers group scored significantly higher on the environments sub-components then other professional groups for all observed significant differences. The significant differences in the *destination sub-component,* F(df) = 4.1 95) , p=.001, were between the architects and designers groups and engineers, transport planners and the public health and advocacy group. The significant differences in the *path context sub-component*, F(df) = 2.4 (5), p=0.041, were between architects and designers and transport planners. On the *personal safety sub-component* the significant differences, F(df) = 3.9 (5), p=.002 are again between architects and designers and public health and advocacy, transport planners and engineers, similar to the *destination sub-component*. No significant differences were found between professional disciplines on their rating of the contribution of *personal comfort* and the *road and path network* to walkability (Table 3.12).

3.4.5 Hierarchy of social and demographic correlates

The social and demographical correlates (N=23) were ranked based on the mean score of the influence of each of the social and demographical correlates on an individuals decision to walk score attributed to the items by the whole sample, table 3.20. The top five items scored above 3.5 indicating a positive association with the likelihood of walking. Ten items scored between 2.5 and 3.5 which are at the mid-range of the scale (3 - no influence) suggesting a perception of little or no influence on the likelihood of walking. Eight items scored below 2.5 indicating a negative respondent perception of on the likelihood of walking. The three lowest ranking items were *being overweight/ obese, having a physical disability and not having enough time* (Table 3.13).

Table 3-13: Social and demographical item mean score ranking for total sample (N=216)

		Mean (SD)
1	Owning a dog	4.74 (.5)
2	Enjoying exercise	4.52 (.5)
3	Being fit	4.42 (.6)
4	Feeling part of the community	4.09 (.7)
5	Being a social person	3.86 (.7)
6	Being female	3.32 (.8)
7	Being a child	3.21 (1.1)
8	Having a low income	3.20 (.9)
9	Having a middle income	3.13 (.7)
10	Wanting to look smart/ having an interest in fashion or make-up	3.02 (1.0)
11	Having a young child	2.91 (1.2)
12	Being a single parent	2.91 (.7)
13	Hiving a high income	2.68 (.9)
14	Low education level	2.66 (.8)
15	Being old	2.60 (.9)
16	Having an intellectual disability (e.g. autism or downs syndrome)	2.21 (.8)
17	Having lots of children	2.14 (1.0)
18	Having a sensory impairment (e.g. blindness or deafness)	2.14 (.9)
19	Having a mental illness (e.g. depression)	2.11 (.8)
20	Having a car	2.07 (.7)
21	Being overweight/ obese	1.85 (1.0)
22	Having a physical disability	1.81 (.6)
23	Not having much time	1.81 (.7)

3.4.6 Professional differences between social and demographic correlates

Professional differences were observed in two of the 23 social and demographical items tested, table 3.14. Public health and advocacy professionals had a significantly lower mean score than engineers, public representatives, architects and designers and spatial planners for the *low education level* correlate all of whose scores are close to 3, i.e. no influence on the likelihood of walking. A similar result is observed for the '*having a middle income'* correlate where the public health and advocacy group mean score is significantly higher, and therefore suggesting a higher likelihood of walking, than spatial planners, engineers and architects and designers whose mean correlate scores indicate a perception of the correlate having no influence on the likelihood of walking. There was no significant difference observed between the other professional groups (Table 2.14).

Table 3-14: Mean scores and standard deviations for social and demographic factors by area of work

Social and Demographic Items	*Professional Groups: mean (sd)* SP N = 33	TP N = 39	AD N = 36	PHA N = 28	PR N = 38	E N = 42	Mann – Whitney test (U, r)
Low education level	2.90 (.5)	2.66 (.9)	2.78 (.7)	2.05 (.7)	2.68 (.7)	2.70 (.9)	**PHA< SP**^{2} (105.5, -.6) **PHA< AD**^{2} (132.5, -.5) **PHA< E**^{1} (222.0, -.4) **PHA< PR**^{1} (138.0, -.5)
Having a middle income	2.80 (.6)	3.13 (.7)	3.03 (.7)	3.64 (.6)	3.20 (.5)	3.08 (.6)	**SP<PHA**^{2} (114.0, -.6) **E < PHA**^{1} (234.0, -.4) **AD < PHA**^{1} (177.0, -.4)

Note: Values are means (standard deviations). ^{1}p<0.05, ^{2}p<0.01. Range of scale 1-5, where 1 = far less likely to walk and 5 = much more likely to walk. **SP**= spatial planners, **TP**= transport planners, **AD**= architects and designers, **PHA**= public health and advocacy, **PR**= public representatives and **E**=engineers

3.4.7 Professional differences between social and demographic factors

In the social and demographic section of the survey instrument there were a number of factors. These were 'Ability' (N= 4 items), 'Income and Education' (N= 4 items), 'Social' (N=2 items), 'Exercise' (N=3 items) and 'Time and Car' (N= 2 items) which are outlined in section 3.2.4.3. Social and demographic factors were normally distributed. The only factor to show a significant difference between professional groups was factor 2, 'Income and Education' ($F(df) = 6.4\ (5)$, $\rho < 0.001$). Games Howell post hoc tests showed a significant difference between the public health and advocacy group and all of the other professional groups.

3.5 Discussion

In a literature review of walkability research it was noted that researchers have observed differences of opinion on what constitutes a walkable environment (Southworth, 2005; Lo, 2009; Stonor *et al.*, 2003; Ewing *et al.*, 2006b; Foster and Giles-Corti, 2008). No literature was identified which investigated if observed differences actually exist between the identified professional groups. These groups, whose views are represented in this study, are numerous stakeholders from different professional groups involved in designing and building walking environments or promoting walking behaviour. The current study reports that while all of the group agree that the way we plan and design our communities and transport systems affects human health, the level of endorsement was significantly lower among engineers than other professionals. This is indicative of a potential lower priority of public health concerns for engineers when designing streetscapes. No significant group differences were recorded on the level of agreement on how we design our communities and transport systems affects carbon emissions. However significant differences reported between groups on items (within the heading of influence of environmental items on walkability) show a difference in opinion on what contributes to positive design to improve human health and reduce carbon emissions.

Responses indicated that a common understanding exists on the importance of well maintained footpaths which is consistent with the literature across disciplines (Southworth, 2005; Stonor *et al.*, 2003; Pikora *et al.*, 2003; Forsyth and Southworth, 2008; Cullen, 1964; Hoehner *et al.*, 2005; Frank *et al.*, 2008; Sallis *et al.*, 2009; Burden, 2010; Brownson *et al.*, 2009; Owen *et al.*, 2004; Ewing and Handy, 2009; Handy *et al.*, 2002; Cervero and Kockelman, 1997; Gehl, 2006; Burden and Florida Department of Transportation, 1995; Alfonzo, 2005). Analysis of data revealed that beyond the functional path, professional groups think differently about walkability. Professional groups ranked items in order of importance differently, with some statistically significant differences between groups. These differences in the applied item rankings were observed to be consistent with their professional descriptions, for example, strategic planners, architects and designers rated the proximity to services/destinations top of their list of influential factors for walkability, consistent with the central purpose of their professional descriptions (Southworth, 2005; American Planning Association, n.d.). Architects and designers rated more items significantly higher than any other profession, they also gave the highest mean score to the majority of items, which alongside their belief that neighbourhood design affects human health and carbon emissions, suggests a greater understanding of walkability consistent with statements by Forsyth and Southworth (2008) that urban designers have been advocating walkable neighbourhoods for decades.

Engineers' responses displayed a functional perspective on walkability which lends support to Lo (2009) who highlighted the tendency of engineers and traffic planners to treat pedestrians like motorised vehicles with little consideration for factors not relating to the functional route. Engineers generally rated environment items as having a lower influence on walkability than other professions. This would suggest that engineers are less aware of the impact that some environmental characteristics can have on an individual's decision to walk. Consideration of the fact that engineers and public representatives rated *day and night functions of an area*, *overlooked routes* and the influence of *high walls* significantly lower than architects and designers yet rated crime in their top three factors influencing walkability would imply a lack of understanding of the functional purpose of these correlates on the safety of an area. Additionally, engineers rated low residential density as marginally positive for walkability which contradicted other professional groups and is also contradictory to many studies (Pikora *et al.*, 2003; Hoehner *et al.*, 2005; Frank *et al.*, 2008; Sallis *et al.*, 2009; Brownson *et al.*, 2009; Owen *et al.*, 2004; Handy *et al.*, 2002; Cervero, 2002). In addition to this finding, the total sample mean score for *residential density* rated the second lowest on influence on walkability out of forty seven items. These studies suggest that higher densities result in closer proximities to services and results in higher walkability/ more walking for transport as a result. The high ranking of *proximity to destinations* and the low ranking of *residential density* would suggest that density itself is not the issue; rather the provision of services nearby would be more important according to the professionals who are involved in designing these areas. This represents a deviation from current thinking and further research to test this hypothesis is needed.

The ranked environmental items on table 3.15 show the walkability influence range scores for the 47 environmental items (mean score range 3.19 – 4.71). A clear gap of 7% of the range can be seen between the 6th (*Good street and footpath lighting*) and 7th (*Friend and family's homes within walking distance*) items. With the exception of the 4th item (*crime rate*) all the top items relate to functionality and land planning. The role of each of these six top ranked items can be clearly described, unlike some of the later urban design items which relate to overlooking or overlapping functions of an area, items which have a more subtle social or perceptual relationship with walkability (Southworth, 2005; Ewing *et al.*, 2006b). A breakdown of the reduced measurement scale into half point divisions shows this gap between the 6th and 7th items also reflects a division between the items with a mean score above 4.5, closer to 5 (very important for walkability) from the items closer to 4 (somewhat important for walkability). The next twenty six items (means scores 4 to 4.5), predominately relate to the social, aesthetic and comfort characteristics of an area. A further thirteen items can be rounded up to a score of 4, somewhat important for walkability, with two items remaining below 3.5 and hence considered not important. These two items both relate to the density of the area, low residential density and tall buildings. It must be noted that these two items scored two of the lowest reliability scores in the questionnaire development exercise, 40% and 48% respectively, and the low score may reflect a lack of understanding on the participant's behalf. However this is unlikely because of the professional profile of the survey sample. The contrast of this finding to the accepted norm in walkability research (Forsyth *et al.*, 2007; Sallis *et al.*, 2009; Brownson *et al.*, 2009) warrants further investigation.

Traffic planners scored the influence of *cul-de-sacs* (related to connectivity) and *proximity to destinations* higher for walkability, but aesthetic items (*unique areas, gardens and trees*) significantly lower than architects and designers, supporting the methods recommended by Frank and colleagues (2008) and Saelens and colleagues (2003) to measure walkability. This method prioritises a walkability index consisting of connectivity, density and land use mix measures but does not consider the streetscape. Public representatives rated the influence of *cul-de-sacs* on the walkability of an area significantly more positive than transport planners and designers. Again, this highlights a potential conflict of understanding, particularly for the influence of *cul-de-sacs*/ closed off estates, which have been popular methods of construction by developers in recent years, on the connectivity (a primary concern of transport planners) and hence the walkability of the area. This study's findings also highlight potential differences between ideal theoretical perspectives and the actualities that exist. Public representatives and public health and advocacy professionals rated the influence of *pedestrian bridges* significantly higher than transport planners, architects and designers on their influence on walkability. There is an accepted understanding among designers that *pedestrian bridges* do not always function as intended (Räsänen *et al.*, 2007). This study supports Räsänen and colleagues (2007) finding that the limitations with *pedestrian bridges* are known to some professions but are potentially not apparent to others. There is a need to understand these discrepancies further, and to establish how these differences might materialise in route choices or walking behaviours of pedestrians.

Owning a dog and *enjoying exercise* were the social and demographical items considered to have the greatest influence on the likelihood of an individual walking. Research has shown owning a dog has a relationship with the number of minutes walked (Coleman *et al.*, 2008; Cutt *et al.*, 2008). Enjoying exercise reflects a positive self efficacy towards physical activity and hence a higher probability of neighbourhood walking (Biddle and Mutrie, 2008). The lowest scoring items, indicating a far less likelihood of walking, were being overweight/ obese, having a physical disability and not having much time. A key difference in opinion was that the public health and advocacy group believed that higher incomes have little or no influence on the likelihood of walking but the architects and designer and engineering groups' opinion differs significantly, they believe individuals with higher incomes are less likely to walk. Group opinion was that almost half of the items investigated had little or no influence on the likelihood of walking in their neighbourhood. All seven professional differences observed were between public health and advocacy professionals and other groups. In these observations the public health and advocacy group assigned a greater directional score to items other professions scored as having little or no influence. This result suggests that the public health and advocacy groups, by the nature of their work with populations, have a greater understanding of the social and demographic items influencing neighbourhood walking behaviours. This observation suggests that the findings of studies relating to these behaviours may need to be better communicated with other professions with an interest in walking and walkability. The reduction of social and demographical items into factors further confirmed a difference in the knowledge between the public heath and advocacy professionals and the other walkability professions. The public health and advocacy professionals appeared to recognise the recreational and social aspects of walkability rating *green spaces* as the third most influential factor on the walkability of the area. The also rated social and aesthetic items *unique areas with personality and character, benches to stop and rest* and *a mixed age profile* as having a high influence on walkability. This is complementary to their professional description (section 3.1.3) which notes an emphasis on recreational walking.

The factor constructs for the environmental items and the demographic and social items do not have high internal consistency or reliability. This was not a primary concern for this study, the aim of which was to explore professional opinion on a number of theorised items. The items used for the questionnaire were correlated from a number of professional fields with some exploratory items suggested by members of the research team also included. A broad spectrum of potential environmental items was desired. Previous walkability exploration studies have focused on items familiar to the professionals groups who were involved in the research design, examples of which were outlined in chapter two.

A key strength of this study is the broad spectrum of professionals who were involved in the study. The extensive consultation with professionals with various backgrounds strengthened the validity process. Putting effort into ensuring the questionnaire was relevant to all those it was proposed for by using familiar terms, language and topics relating to their professional practices was critical to ensure their involvement.

Because of the identified diversity in practices the inclusion of a 'don't know' category was also considered important by the researcher so as to not alienate any participants. Limitations of this study are the relatively small sample size of the surveyed population and a potential bias in the population who selected to complete the survey. The low response rate from public representatives was expected. The achieved response rate for this study is positive and this is enhanced when consideration is given to the fact that removing public representatives from the response rate analysis would increase the response rate to 49%, a very positive result. The small size of the sample prevented exploratory factor analysis on environmental items. A smaller number of environmental items could have been used in a factor analysis but this would have taken from a key strength of the study which is the inclusion of items relevant to a diverse professional sample and their work practices which relate to the walkability of an area. The small sample size may also be because there is not a large population of relevant professionals in the Greater Dublin Area, particularly since the collapse of the construction industry in the recent economic recession. A large number of design and construction professionals have emigrated.

3.6 Conclusions

Study findings suggest that all professions agree that the presence of quality functional routes, destinations within walking distance and perceptions of safety have an influence on the walkability of an area. However the importance of aesthetic factors, the visual interest along a route, the presence of cul-de-sacs, the availability of benches, and having people of mixed age profile in an area received a higher priority for walkable areas for some professions than others. Ultimately, this difference in opinion could affect what is promoted in area design or what is excluded. Our challenge is how to communicate the key factors which are determined to influence walkability to the key decision makers who design and build our environments. Public health and advocacy professionals also rate the influence of education level and income on walking behaviour differently to other professional groups. In particular the influence of residential density and cul-de-sacs on walkability warrants further research from the findings of this study. Additionally, the diversity of the items which are perceived to influence walkability in this study deserve further exploration to inform the understanding of walkability and how walkable environments can be designed and constructed to encompass the range of professional views identified.

4 Study 2 - Focus Group Study

4.1 Introduction

The results of study one and the literature review established that the concept of walkability is complex, and that different views exist on what contributes to a walkable neighbourhood. Consequently, a more in-depth analysis to explore the concept of walkability was an identified research gap. The purpose of study two was to (i) further investigate an existing concept -walkability- among a professionally diverse set of professionals/participants and (ii) develop a list of walkability criteria to select high and low walkable areas for further study using qualitative research methods. This chapter outlines the study procedure, the methods employed, the content analysis findings and concludes with the development of a new list of walkability criteria.

4.2 Methods

Five common qualitative methodologies (Creswell, 1998) were reviewed for their usefulness to inform the methodology of study two. These included biography, ethnography, grounded theory, case study and phenomenology. Biography, which involves exploring the life of an individual, or an ethnographic study, which observes a cultural or social group, were unsuitable as this study will investigate understanding across professions and not just an individual or one professional field. Grounded theory, which is a qualitative method used to develop a new theory, was unsuitable as the concept being investigated is an existing one. A case study, which is the study of an issue through one or more cases, was unsuitable as the meaning and experiences of the walkability concept are being sought rather than a case study of its implementation (Creswell, 1998, p.65). Phenomenology is a philosophical approach to the study of lived experiences (Creswell, 1998; Smith *et al.*, 2009). Once we stop to self consciously reflect on an experience we are being phenomenological (Smith et al., 2009, p.13). The central underlying meaning of the experience is sought where 'experiences contain both the outward appearance and inward consciousness based on memory, image and meaning' (Creswell 1998, p.52). Phenomenology with a place based approach 'facilitates a holistic assessment of pedestrian conditions in specific places' (Stangl 2008, p.771). Thus, a phenomenological approach was ideal for study two as it permits the exploration of the concept of walkability within different geographical contexts using participant recall of personal experiences of place. It incorporates perceptions and context without generalising and categorising physical features, and therefore allows for discussion on built environment features either not generally discussed or disregarded when considering pedestrian perceptions and behaviours (Stangl, 2008). Socio-spatial recall was used to provide examples of high and low walkability within the Greater Dublin Area (GDA). This is a method where participants select and discuss environments which they have interacted with (Anderson, 2004) allowing for exploration of participant opinions on walkability from their perspective of familiar micro-geographies, while simultaneously grounding the findings in identified areas.

4.2.1 Focus Group Methods

Focus groups are group interviews of typically six to eight participants. A moderator guides the interview while participants discuss the topics the interviewer raises. Discussions are recoded and subsequently analysed by the researcher. A focus group method was used to collect the qualitative data because of the advantages it presents for investigating group diversity. This was essential in order to explore the differences in professional opinion on walkability (Morgan, 1997b). Focus groups by definition have elastic boundaries, yet there are limits. (Morgan, 1997b). This flexibility was important for study two as it allowed for an amendment to the traditional focus group format, permitting inclusion of research specific stimuli to generate focused discussion on the research topic.

4.2.2 Procedure

A map of the GDA[38] was given to each participant. Participant instructions were to select four high walkability and four low walkability areas. This selection had to be based on their own personal experience of their selected areas. Participants were given time and then asked to list their selections. Random areas were selected by the moderator and the participant who selected the area was asked to provide a rationale

[38] Ordnance Survey Ireland (2007), Scale 1:50 000

for their selection. Open discussion followed. This research design permitted dynamic discussion about a particular place and resulted in applied examples of the priorities attributed to walkability by the various professional groupings, bridging theory and practice. It also allowed for cross-comparison between groups as each discussion session had its own dynamic and direction, but usefully had a common external reference point (Kitzinger, 1994). Focus groups were repeated until data saturation was reached. This was when no new topics in relation to what makes an area high or low walkable were being raised in the focus groups (Sim, 1998) or no uniquely different areas were being selected by participants.

4.2.3 Pilot Study

The proposed focus group procedure was piloted on the research team (including a visiting professor), discussed, reviewed and amended. Four changes were made to the focus group method predominately to improve clarity and efficiency. These were:

(1) A map of the inner city of larger scale was also given to participants (Scale 1:15 000).

(2) Participants were given five minutes to select the high walkable areas and then given an additional five minutes to select the low walkable areas.

(3) The city was divided into three zones, the inner city, the outer city and the suburbs. The city zones were introduced to encourage the selection of a variety of neighbourhood types for discussion.

(4) The selections made by participants were written up on a flip chart at the beginning of the focus group session to save time later.

A second pilot test was then conducted on a group of postgraduate sport science and health students (N=8, 88% female, mean age 26yrs). No further amendments were deemed necessary. The focus group procedure and script used for the focus group study are outlined in Appendix C.

4.2.4 Focus Group Limitations

Focus groups are not without limitations and consideration was given to potential issues identified while designing the study methodology. The following are known issues that can occur in focus groups and how they were considered for in this project.

i) **Overpowering individuals**: The area selection exercise and associated questions were designed so each individual was given an opportunity to (i) speak early in the focus group to give a sense of inclusion, (ii) give an explanation for their area selections and (iii) contribute to discussion by giving their opinion on a selection through an adapted 'popcorning' method (Morgan 1997a, p.76). The rotational nature of the workshop allows the moderator to direct the conversation away from a dominant individual or invite a reclusive participant to comment if necessary.

ii) **Acquaintanceship issue**: It was difficult to overcome the acquaintanceship issue within these focus groups as the professional network of transport planners, urban designers, architects, landscape architects and spatial planners in the Dublin region is small. This was not considered a disadvantage.

iii) **Group contagion**: The exercise conducted at the beginning of the focus group also collects individual responses before discussion commences. This reduces the potential for a group polarisation effect where a strong directional view point is adopted by members of a group (Sim, 1998). It cannot be limited completely as participants may adapt a popular description given by another participant to suit their area selection. Sim (1998) also notes that having more than one focus group increases the reliability of the resulting data considering the potential for this group bias.

iv) **Selective participation bias**: It was suspected that elective participation would result in a biased sample of people with an invested interest in walkability; this was an accepted limitation of this study.

4.2.5 Data Analysis

Focus group recordings were transcribed verbatim and considered alongside notes taken by the assistant moderator during and post the focus group. Content analysis (Gibson and Brown, 2009; Creswell, 1998; Krueger, 1997; Pope *et al.*, 2000) was carried out on the data. This process involved:

Phase 1: All transcribed scripts were read in full and raw data codes were applied to the scripts using an inductive approach.

Phase 2: Raw data codes were then organised into first order thematic groups (themes)

Phase 3: Quotes within each theme were compared and contrasted to establish second order themes (sub themes).

Phase 4: Within some second order themes (sub themes), third order themes were identified. This resulted in three thematic levels. Illustrations were produced to show these thematic levels diagrammatically.

Phase 5: All second and third level themes were then subjected to a high or low walkable categorisation based on the descriptive content in order to answer the research question, to establish the attributes which were identified as having an impact (positive or negative) on walkability

Phase 6: Themes were explored with reference to the findings of study one and the literature.

Phase 7: Following thematic analysis of the qualitative data, considerations were given to how each of the identified themes related to the concept of walkability. Themes which were identified as integral to the concept as a whole were labelled as a ‘core theme’. Themes which related to individual influences and not to structural elements of the environment were labelled as ‘considerations’. Themes that consisted of grouped structural elements which were identified as contributing to walkability as a concept were left as ‘themes’.

Phase 8: Walkability criteria were developed with reference to the first and second order themes from the themes relating to groupings of structural elements with consideration for core themes and considerations.

Participant references are in the following format [focus group number, profession code]. For example [3, TP] denotes focus group three, transport planner. Codes are Arch = Architect, LA = Landscape Architect, UD = Urban Designer, TP = Transport Planner, TE = Transport Engineer, SP = Spatial Planner, PHA = Public Health professional or walking Advocate and PR = Public Representative.

4.2.6 Limiting Errors in Qualitative Research

While there is no easy way to limit errors in qualitative research, various steps can be taken to improve trustworthiness, credibility and transferability (validity), dependability (reliability) and conformability (objectivity) (Gibson and Brown, 2009; Krueger, 1997; Mays and Pope, 2000; Biddle *et al.*, 2001; Shenton, 2004). Steps were taken throughout the design process of the methodology and during the data collection and analysis to ensure the quality of the data. These steps were:

(1) The study rationale and the appropriateness of the study design to the research question were discussed at length by the research team.

(2) Questions and instructions were piloted on two focus groups to maximise clarity and ensure the questions were understandable to the proposed participants. Due to the professional heterogeneity of the focus group participants they were encouraged to seek clarification on any terms used they did not understand.

(3) A moderator profile linked to relevant skills, knowledge and background is often used by sports and exercise psychologists to imply legitimisation as a measure of trustworthiness, credibility and transferability (Biddle *et al.*, 2001). In this study the author, an experienced tutor and workshop facilitator, moderated the two pilot groups and all five focus groups. The author also has considerable knowledge of all of the professional disciplines represented in the focus groups. The other members of the research team took turns in the role of assistant moderator.

(4) The moderator and assistant moderator both listened to the conversation during the focus groups and sought clarification on areas of ambiguity.

(5) ‘Member checking’ or respondent validation (Mays & Pope 2000, p.51) was carried out at the end of the focus group session. This involved the assistant moderator reading out a summary of their interpretation of the discussion around each question and participants were asked it they agreed with the synopsis and given an opportunity to reply.

(6) Peer debriefing between the moderator and assistant moderator was completed after each focus group to review the data content and discuss any ambiguity in the group discussion.

(7) Content analysis began after the first focus group to assess if there was consistent patterns across focus groups and to identify items that should be probed in further groups

(8) Clear descriptions of the processes used in the planning, undertaking and analysis were recorded to facilitate transferability.

(9) Raw codes were applied to the first focus group script by four individuals of varying professions to assess the reliability of the coding process. This was particularly important in this study because of the previously identified complexity and difference in professional opinion of the topic. The codes applied by the author, a spatial planner also trained in urban design, an engineer and a physical activity researcher were compared. Differences were highlighted and a discussion was held between coders until a plausible explanation was agreed upon.

(10) Negative and deviant case analysis was carried out on the data highlighting contradictions and inconsistencies. In Figure 4-1, examples of positive and negative associations with walkability were noted under the second-order theme of biodiversity. Further examination of the content of the quotes indicates that trees in the city are positive, but consideration should be given to contextual design.

(11) Further investigation of the findings of study one (Chapter three) was undertaken using a mixed methods approach described in section 1.3 of this thesis. The assistant moderator had a list of identified topics of interest from the findings of study one. These were checked off the list as they came up in the focus

group conversation, any topics not mentioned in the group were brought up by the assistant moderator before member checking, for discussion.

(12) Particular emphasis was placed on the reflexivity of the account (Mays and Pope, 2000; Shenton, 2004) including using rich data description in the reporting of the study findings.

Example from Focus Group 1 re: trees in the city centre:

N: By the way, can I just mention that one negative quality, even in all those highly walkable areas is a lack of landscape and trees. I am thinking of biodiversity. You know, birds singing in the trees. Not only in the tress but the birds as well. That whole dimension seems to be missing. *(trees are positive, lack of trees are negative for walkability)*

J (*Assistant Moderator*): Can I ask if other people agree with that? Anyone feel it is important for the assumed walkability of a city?

B: I think for me it is if you are walking along and the architecture is nice is that it really does add and the same for well designed, well integrated, biodiversity or greenery or however you would go about. It is very nice but would not necessarily determine whether an area is walkable. It would certainly enhance it. *(trees positive, but not necessary)*

S: If it was raining it would make a big difference. It has a big impact on climate because it rains all of the time here and we don't have awnings and trees can actually really allow you to walk about the city. *(positive, provide shelter)*

A: ...big drops of water that fall off of them *(negative, not sufficient shelter)*

S: not big mature trees, well maybe, Oh, I dunno, well I have always found that anyway.

A: I always find that walking under trees after rain you still get wet. *(negative)* Laughter

S: Sometimes I think tress shouldn't be there like I don't think trees should be out there on college green for example. But in the general street trees can certainly enhance the quality, the perception of quality, of the place. *(Positive when contextual)*.

N: What I am getting confused about is why you said trees shouldn't be there around college green? Because I think we should pack college green with more trees and Dame St should all be tree-lined *(trees positive – opinion)*

S: See I think that it is a specific design issue with that and I didn't want to focus on that. That particular one I think is about the buildings in that case. I think that should be a complete civic space and should be all about the buildings. The trees are inappropriately placed. I think that is the case. *(Positive when contextual- opinion)*

Figure 4-1: Example from Focus Group 1 re: trees in the City Centre

Note: *Italics within parentheses* = raw data index codes

4.2.7 Sample and Recruitment

Respondents to the online stakeholder walkability survey (study one) were asked if they would be interested in receiving further communication relating to the CGL Study. Those that selected this option were emailed and invited to take part in the focus group study. A follow up email was sent to those who had not responded within 14 days of the original email. Thus, a purposive sampling procedure was adhered to

(Gibson and Brown, 2009). Participants represented identified professions and advocacy fields in order that the first aim of this study, to identify communalities and differences in stakeholder understanding of walkability, could be met.

A total of 97 individuals were contacted, 57 (59%) replied expressing an interest in participation, and 12 gave apologies that while they were interested they were unable to attend a focus group. One respondent requested no further communication from the study. Twenty six individuals took part in 5 focus groups; the mean age was 39.5 years (range 25 to 58 years), 58% male. Individuals who were unable to attend were asked to complete an online area selection exercise akin to the exercise undertaken in the focus groups. This data was used in study three.

Recruited groups were homogenous as all participants encounter design of pedestrian infrastructure, streetscapes or walking promotion in their area of work, yet heterogeneous as they consisted of professionals from various disciplines. A number of focus group participants had backgrounds that overlapped disciplines but indicated their current or dominant area of work. A breakdown of participant demographics and profession is shown in Table 4-1. The proportional split of professional disciplines in the study is shown in Figure 4-2.

4.2.8 Location and Time

All focus groups were conducted in a boardroom at Trinity College Dublin, a city centre location. The times, days and dates of the groups were staggered to increase the potential to suit peoples schedules (shown in Table 4-1). The first focus group took place ten days before the second to give time to review and make amendments to the procedure if necessary. No changes were made. Focus groups took approximately two hours each to complete.

4.2.9 Access and Ethics

Ethical approval for this study was obtained from the Dublin City University Research Ethics Committee (REC/2010/030). Each participant completed a written informed consent before data collection.

Table 4-1: Focus group participant summary

Focus group code and date	Work	Gender	Age
1 5th July 2010 4pm N=6	Architect	M	55
	Traffic engineer	F	33
	Landscape architect	M	43
	Spatial planner	F	29
	Traffic planner	M	38
	Urban designer	F	32
2 15th July 2010 4pm N=5	Architect	M	55
	Traffic engineer	F	25
	Landscape architect	F	33
	Public health and advocacy	M	50
	Public representative	F	51
3 16th July 2010 2.30pm N=5	Architect	M	43
	Traffic engineer	M	42
	Spatial planner	F	42
	Public health and advocacy	F	39
	Public representative	M	50
4 20th July 2010 2.30pm N=5	Traffic planner	M	39
	Spatial planner	M	32
	Spatial planner	F	25
	Public health and advocacy	F	39
	Traffic planner	M	36
5 22nd July 2010 4pm N=5	Architect	M	31
	Urban designer	M	38
	Public health and advocacy	M	58
	Spatial planner	M	32
	Spatial planner	F	35

Note. Code: first initial of participant

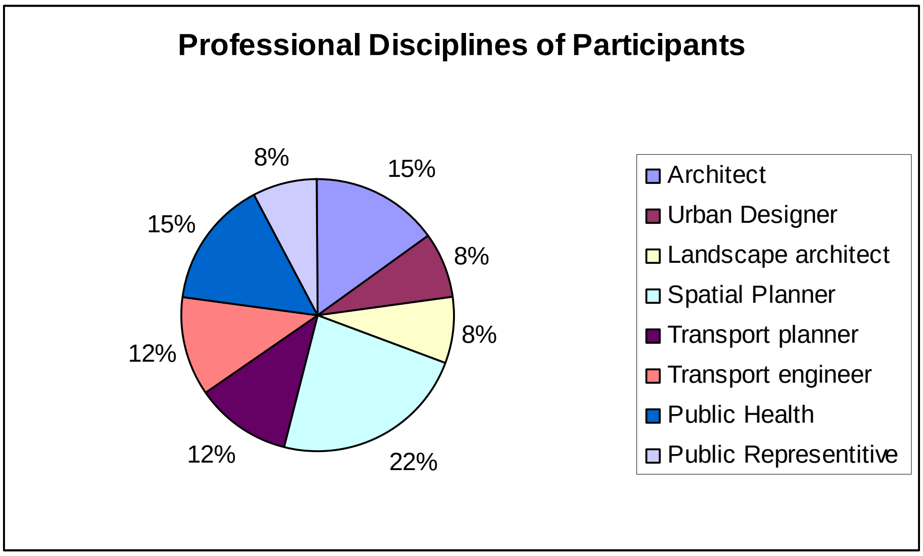

Figure 4-2: Breakdown of professional discipline

4.3 Results

The results of the qualitative thematic analysis are presented and discussed under the following headings:

(1) Influences on Participant's Views

(2) Considerations Relating to the Individual

(3) Core Theme – Scale

(4) Criteria one – The Village

(5) Criteria two – Permeability

(6) Criteria three – Path Context

The total word count for the five focus group scripts was 72,700.

Theme one, influences on participant's views, and theme two, considerations relating to the individual reflect the subjective nature of walkability and how walkability can mean different things to different people, both the study participants and the individuals using the areas. Theme three, scale, describes a core theme which was identified as an integral element of walkability throughout the data. Themes four, five and six outline specific elements of walkability. Criteria relating to these themes are developed at the end of each section. Themes two and three were considered during the development of each of the criteria. Figure 4-3 outlines the overall thematic structure of the qualitative findings of this study.

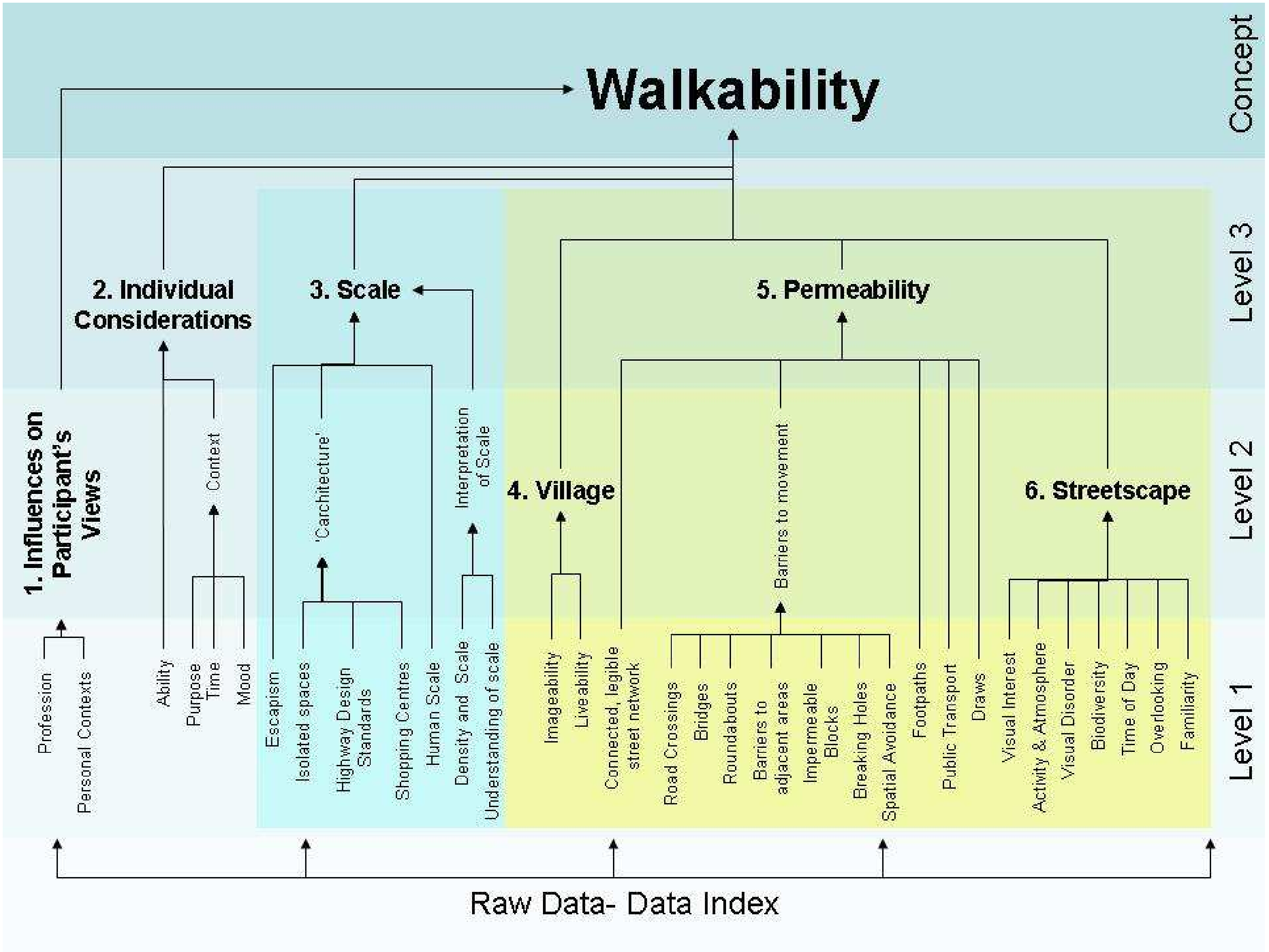

Figure 4-3: Thematic Structure of Qualitative Data

4.3.1 Theme 1: Influences on Participant's Views

Participants tended to respond to familiar micro-geographies, small scale areas, similar to what was found by Elwood and Martin (2000). *'I know because my son used to have an apartment right over it'* [5, PHA]. *'I used to live out there … so I used to walk in and out to work every day that way'* [2, TE]. This was a desired outcome of the research design. In addition, participant's profession and personal context were found to influence area selections (Figure 4-4).

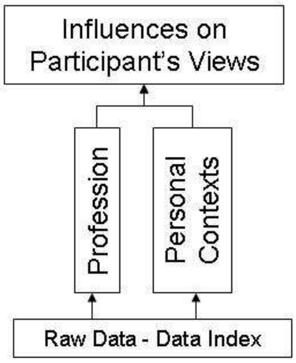

Figure 4-4: Theme 1 thematic structure

4.3.1.1 Profession (Sub theme 1.1)

Professional differences in the understanding of walkability, prevalent in study one, were also evident in data from this study '*I understood the question as a place to go for a* (recreational) *walk*' [3, PR], '*I was thinking livability more than walkability*' [3, Arch]. Public health professionals and public representatives tended to select areas they visited for recreational purposes or to visit friends, whereas design and planning professionals were more likely to discuss environments which they were involved in from a professional capacity. An observation was made to this effect by a participant '*One of the things that I think is interesting, I think our backgrounds have a bearing on how we address walkability... (how) we all introduced ourselves, how that is actually reflected in the answers that we gave'* [4, SP]. In group four, which was predominantly transport professionals including two spatial planners working in the transport field, a participant's observation was how traffic and transport had a significant impact on people's area choices in the focus group exercise. *'I think it is interesting that we seem to define walkability with reference to vehicular transport'* [4, SP]. This phenomenon, where a person's professional view influences their perceptions was also observed by Kusenbach (2003) in her street phenomenology study.

4.3.1.2 Personal Contexts (Sub theme 1.2)

Rather than limiting their answers strictly to professional aspects, participants reflected on the areas through multiple roles shaping their environment. For example as a parent: *'a lot of these places, even those that I would have said are walkable…, are when you are on your own. But as soon as you are going to bring your child in a buggy, some of these areas that people are saying are quite walkable, aren't walkable at all'* [1, TE]. The heterogeneous focus group forum was beneficial to explore the variety of perceptions of an area because 'individuals can overlook issues that do not figure prominently in their awareness' (Kusenbach 2003, p.462)

A bias was observed towards the more affluent areas of the city with lesser knowledge of suburban residential areas. It is acknowledged that this may be because our participants are a well educated group and thus less likely to live in deprived areas. Some low walkable area selections were acknowledged as being prejudiced by a perception of personal safety with no desire to go there. '*I think because I wouldn't set foot in it, just purely from a point of personal safety I suppose … that sounds very ignorant,* (some laughter from group), *but then its like that, if people have perceptions of places there not going to walk there you know'* [2, TE]. These area selections were considered in the context of discussion on perceptions but areas were not designated as low walkable unless further evidence, based on direct knowledge, was given of the impact of physical design on these perceptions.

Acknowledging these various views and perspectives in walkability discussion and investigation will greatly enhance the understanding of the concept as we can generate a more holistic view of the term. This is because professional views may be theoretical, but the research design for this forum introduced discussion of practical and personal considerations. This theme shows that professional training does influence how walkability is viewed by individuals. However, their views are also informed by their experiences in places familiar to them and personal roles, for example a parent or a carer.

4.3.2 Theme 2: Considerations Relating to the Individual

In the previous section the influence of an individual's profession and other factors on their perception of what makes an area walkable or unwalkable was addressed. During the focus group study a participant also noted that 'W*alkability means different things to different people and it also means different things to the same person under different circumstances'* [4, SP]. This section looks at how focus group participants highlighted key considerations relating to an individual's perceptions and motivations when considering walkability. These considerations were examined to a lesser extent in study one, personal factors.

4.3.2.1 Ability (Sub theme 2.1)

Participants presented elements of the built environment which limit the movement of people with disabilities or other restrictions. *'My uncle is a double amputee and I was taking him across the road one time and I had to go around all four sides because on the direct line, we couldn't actually get down on the kerb, even though there was a drop kerb there, it wasn't correct, so we had to take him around three sides to get across one arm'* [4, TP]. A consensus was agreed that design needs to consider people of all ages and abilities. However, this was not a frequently discussed element of the built environment in the focus groups.

Under theme one the impact of having a buggy or a child with you was noted. Narrow footpaths in older areas of the city, hailed as examples of high walkable environments, were no longer functional to their needs. *'I find walking around Exchange Street and Dury Street down the middle of the road with a car behind me, a child in one hand and a buggy in the other, there isn't anywhere to manage that (agreement) so when you look at very specific issues, all those areas have problems*' [1, TP]. Another example was cobblestone surfaces which are attractive but difficult to walk on. Further discussion of surfaces and paths are discussed under the theme five, permeability. This consideration is what Alfonzo (2005, p.819) describes as feasibility, 'a non-urban form variable, as the most basic need, for which fulfilment is necessary to even consider urban form within the decision to walk'. A person's life circumstance, age, health, children or dependants and physical mobility all form part of this consideration and design should consider all of these circumstances.

4.3.2.2 Context (Sub theme 2.2)

Environmental perceptions and personal factors were reported by participants as impacting on route choice. The purpose of the trip being undertaken, the time of day or time/route availability and the pedestrian's mood were all discussed as having an impact on route choice (Figure 4-5). A high walkable area is permeable with a variety of perceptually feasible route choices. Route choice is explored further under theme five, permeability.

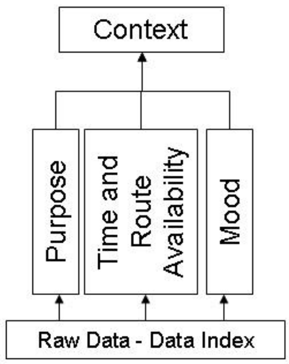

Figure 4-5: Sub-theme 2.2 thematic structure

4.3.2.3 Trip Purpose

Route choice does not only depend on the availability of a route but also the purpose of the trip being undertaken. *'If I am going to work I want to be sure of that direct route, if I am going for a walk on a Sunday afternoon I want to meander, I don't necessarily want to get to somewhere, so the activity of walking versus walking as a means to an end'* [4, SP]. The convenience of a route for a particular purpose may result in other features of the built environment generally associated with low walkability being overlooked. One participant illustrated this by first quantifying that the area '*may not conform to traditional models of high walkability… It's clearly got a lot going against it terms of the traffic and all of that, but it's just the fact that it's something that I do a lot, and am comfortable with'*. The familiarity of the route for a purposeful trip was important to him. *'I'll tell you what I think is important in terms of this, there's a* <u>*purpose*</u>*, … so I get my bout of exercise or a little bit of it, or a lot in terms of walking to the LUAS* (tram). *I'm comfortable with knowing that I'm going to be there in x amount of time and so I think it's the purpose part that makes it important, and that there's a time element involved that makes it important for me walking*' [2, PHA]. This routing decision was associated with directness, habit, familiarity and the proximity to the destination.

4.3.2.4 Time

In the above examples there was also a temporal aspect relating to directness and knowledge of being at their destination within a certain amount of time. A perception of barriers along the shortest distance route may result in an alternative route being taken: *'Clanbrassil Street will get me there quicker as the crow flies, but because of the amount of junctions that have no pedestrian phase… it's actually a much longer walk than walking up the Rathmines road to the quays instead'* [2, LA]. The time of the day may also impact on the routes available to the pedestrian (permeability): *'There're one or two obstructions at night time when the Westbury mall closes and the Powerscourt centre, but apart from those, you can always negotiate them with some small alleyway somewhere'* [2, LA]. This is further explored under themes five and six, permeability and path context.

4.3.2.5 Individuals' mood

Route choice was also observed to depend on the individual's mood. *'When I'm walking around the green I never know which route I'm going to take … And I find that just interesting, that little bit of unpredictability in terms of, let's just say your mood, you ask will I go straight across or will I go zig zag or whatever else'* [2, PHA]. The psychological influence of a vibrant or tranquil area was described to give context to the difference of opinion. *'It might depend on some other things too; if you want to be close to greenery then you need to be in area like Stephens Green. If you're psychologically up for it, you might want to be where there's loads of people,… you'd like to be in a bar that's full, make you feel like you're alive again, so there's that psyche dimension to it'* [2, E]. The vibrancy or tranquillity of a street is explored further under path context, theme five.

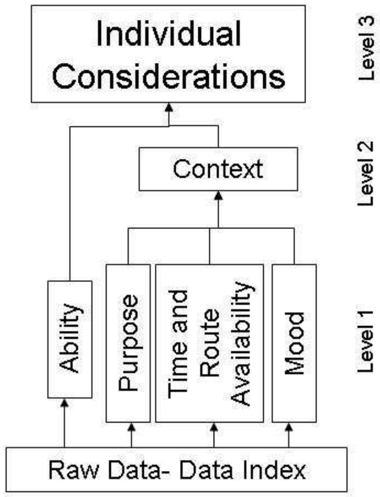

Figure 4-6: Individual Considerations thematic structure

Weinstein Agriawal and colleagues (2008) when investigating the routes taken by commuters when walking to a train station found that the shortest route was the pedestrian's top priority with safety issues also mentioned frequently. Aesthetic elements were rarely mentioned suggesting that in the context of this trip other walkability factors may not be perceived as important, similar to what was suggested by focus group participants in this study. The PQN[39] project consider trip purpose in their pedestrian model. An increased weighting to the quality of the route is given when 'the patient traveller' is on a leisure walk without time constraints compared to 'the impatient traveller' who is on a commuter trip with time constraints (Czogalla 2010, pp.184-185). Other individual considerations noted by the PQN study included gender, age and personal abilities, consistent with sub-theme 2.1 Ability. The availability of alternative routes, high connectivity, and a variety of atmospheric characteristics facilitates greater route options and would demonstrate that the needs of the pedestrian in many contexts are facilitated. Handy (1996) highlighted the importance of this aspect of walking behaviour, how elements of design influence certain types of choices about certain types of trips, for future research.

[39] Pedestrian Quality Needs COST project

4.3.3 Theme 3: Scale (Core theme)

A key urban design factor consistently mentioned and described when discussing high and low walkability was scale. Human scale refers to an environment scale which is perceptually comfortable relative to the size of, or distance to, the human body (Ewing *et al.*, 2006b; Gehl, 2010). This relative size or scale of an environment can influence feelings of comfort and belonging or isolation and vulnerability. In the focus groups, scale was discussed in three contexts illustrating how large or small scales can have a positive or negative impact on walkability depending on context. Participant understanding of scale as a concept and identified ambiguity between density and scale are also explored and discussed under this theme.

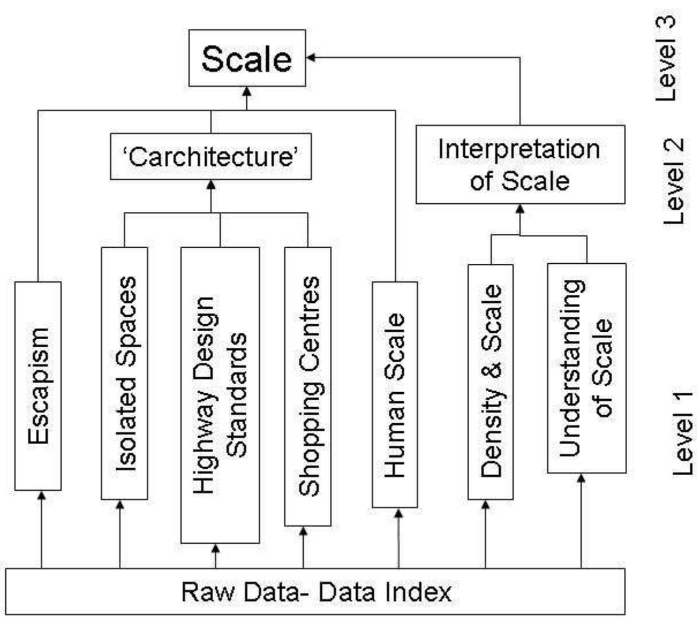

Figure 4-7: Thematic Structure of Scale

4.3.3.1 Escapism (Sub theme 3.1)

Positive enormous scale was linked to recreational walking destinations such as large urban parks, historic university courtyards and the seafront. They were positively described as being expansive *'the huge expanse makes it very attractive'* [2, PHA] and the *'sense of huge perspective you get walking out to the sea'* [5, SP] by the participants. King and colleagues (2002, p.19) describe these environments as 'restorative environments' which are associated with stress reduction and are characterised by a high prevalence of natural features which afford a sense of 'getting away' from usual work routines.

4.3.3.2 Carchitecture (Sub theme 3.2)

This sub-theme refers to negative enormous or large scale urban form and architecture which was described as *'Carchitecture'* [2, LA] by a participant. Carchitecture scale describes wide roads, large box buildings, long distances between services and isolated cul-de-sac suburban housing estates (Figure 4-8). The concept was predominately related to suburban areas built since the 1960's where there is a '*presumption is that this is an area where homes have 2/3 cars*' [4, SP]. The resulting roads and associated large developments were described as being '*Enormous in scale, I feel I should be in a car... and as a pedestrian you're just a tiny little ant making your way through these broad avenues and big block buildings'* [2, LA].

Figure 4-8: Suburban Distributor Road 'Carchitecture'

Urban inner city areas where historic roads were upgraded to large distributor roads to facilitate the movement of traffic, and historic city blocks which were replaced with large new developments, similar to those typical in the suburbs, were also discussed as being bad for walkability. An example was given of a village with a wide distributer road built through it: '*The village is a little short for the size of the space… the scale of road is too large... it cuts the area*' [3, TP]. The distortion of the streetscape scale to facilitate the movement of motorised vehicles jeopardised the relative scale to pedestrians, the human scale, and created a negative environment for the pedestrian.

The carchitecture scale also encompasses the speed of the traffic relative to a person walking alongside these large roads. *'It was just so uncomfortable, with cars whizzing by, and you just feel very vulnerable as a pedestrian and there was just really no pleasantness to it at all'* [2, TE]. The social aspect of an area can be impacted on by a fast road severing the area: '*There is a lot of traffic, it's a place where people tend to drive through… you don't really stop off there so people aren't really as considerate as other people would be in a place like Sandymount where you tend to know everybody there. I think it is a rushed sort of place'* [3, PR].

Distance to destinations is often used as a measure of the walkability of an area (Brownson *et al.*, 2009; Leyden, 2003) with long distances frequently associated with suburban areas. According to this spatial planner, distance alone is not the issue in the suburbs *'not even that it's just the distance* (between destinations)*, the scale is too big in my viewpoint'* [5, SP].

This relationship between car dependency, or the assumption that residents have cars, and negative scale is what Jan Gehl (2010, p.164) describes as '60km/hr architecture', not slow architecture to be enjoyed and interacted with at human pace. He describes it as being 'too large and amorphous' which is 'too cold and too dismissive' for human activities. Frank & Engelke (2001, pp.201-211) echo this observation adding that road design standards which favour high speed motorised travel and neglect streetscape complexity, favoured by pedestrians, impact on the desirability of walking or cycling. Gehl and Frank and Engelke's descriptions of this concept are in agreement with the examples given in this carchitecture sub-theme.

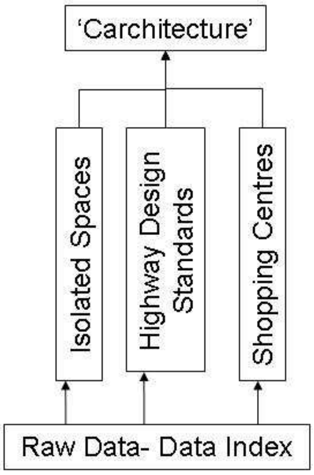

Figure 4-9: Thematic Structure of Carchitecture Sub theme

4.3.3.2.1 Isolated Spaces

The expanse of space at attractive recreational walking areas (escapism) was described as favourable for walkability. However, a contradictory view was given relating to open areas which are not well connected. If you wander along this open space: *'you suddenly realise that you are completely cut off … you have a vast expanse of sand in front of you… It is very daunting … it is (a) noticeably empty'* [1, LA]. While the vastness encourages exploring, feeling cut off from other areas is an undesirable emotion and threatens the sense of safety in these spaces triggering environmental stress (King et al. 2002). An agoraphobic feeling can be generated by uncomfortable open spaces.

Similar to large unconnected recreational spaces which can leave someone feeling isolated large green spaces within housing estates in low density suburbs were also perceived as negative by participants. These areas were sometimes described as badly maintained or without landscaping. The descriptive terminology used was depressive. *'I'm thinking of (*the*) residential area which is very **bleak** and a lot of very open space which on the one hand makes it very permeable but at the same time makes you feel **isolated** in spaces'* [1, LA]. Some suburban housing estates were also described as '*physically **disorientated**… feel quite **expansive** so you feel a bit **agoraphobic** …, **not** particularly **pleasant**'* [2, LA]. *'Just an absolute massive urban sprawl, just **chaotic**… I* *always used to feel quite **threatened** going out there… That old description of old bandit country springs to mind, you were always waiting on somebody to ride up on me, and take my purse!'* [2, PHA] (my emphasis) (Figure 4-9). This perception of vulnerability and isolation forms from a culmination of elements, not just scale, however the vast scale amplified the difficulty in providing, for example, overlooked routes which provide surveillance for an increased perception of personal safety (King *et al.*, 2002). Overlooking and surveillance are discussed further under theme six.

Figure 4-10: Example of Isolated Space given by participant

4.3.3.2.2 Highway Design Standards

An element of carchitecture frequently mentioned were the large distributor roads which form the functional skeleton of suburbia. In areas built post 1940's, and particularly those built since the 1970s/80s, design prominence was given to the road network required to provide for forecasted trip demand. The magnitude of space required for the larger roads conforming to design standards result in areas with expansive scale as a result of their morphological process. Road Design standards have different consequences on areas depending on the age of the area. Narrow roads in areas built before the prevalence of the car upgraded to conform to highway standards can require increased carriage (road/lane) widths to meet minimum standards. This can result in little space left between buildings for footpaths and other street amenities (Figure 4-11). The provision of car parking on these streets further impacts on the space available.

Figure 4-11: Narrow footpaths as a result of meeting highway design standards

In all focus groups blame for the negative impact of roads on walkability was attributed to transport professionals and their use of highway design standards, which prioritise the movement of vehicles over people. The application of these standards to urban and residential areas results in disproportionate scales and a perception of dominance of traffic. The lack of standards for street design, similar to the UK Manual for Streets (Department for Transport UK, 2007), and an unwillingness to deviate from the auto-centric highway standards were the key issues raised by participants. Belief among some participants was that the unwillingness to diverge from the highway standards was to avoid being sued in the absence of street design guidelines, Figure 4.12.

'What they do is up-design (roads) *to motorway standards. Lane widths are in excess of those on a motorway in a lot of cases. It is a 50kph* (speed limit*)* *but* (roads) *are built so you can do 70/80 k's so most people will do so. Nothing fronts onto it because the engineers won't let you, even though all the current guidelines tell you (that) you can, but it up-designed to motorway so you can't. Everything focuses on the movement of vehicles with less risk involved. There are no other standards to work with, so, because they are worried about getting sued, they just say 'I just did what the manual told me'. They design roads to be much faster as they perceive them to be safer because there are less junctions, there is no frontage, there are no driveways, there is little pedestrian activity so all the things that could potentially create a conflict are designed out'* [5, UD].

Figure 4-12: Up-design and Highway Design Standards

Considering the preference of participants for slower streets to enhance pedestrian comfort it was pointed out that the function of a road within the road hierarchy may require car-centric design and a larger scale may be necessary. *'The thing is, for certain roads like the N11, it is a horrible route to walk out there, I agree… But, it is an arterial route, and you have to sacrifice pedestrians* (in design) *at that point. … I agree that when you get into town … they should be forced to stop because at some point there is going to have to be a prioritisation of somebody else'* [5, SP].

4.3.3.2.3 Shopping Centres

The relative scale of new developments to streets and other buildings within older areas of the city was associated with disruption of the historic human scale of an area: the '*big new development not sympathetic to the scale … (*the street*) is a little bit incoherent in terms of old development and new development*' [3, SP]. One participant praised one recent large shopping centre development which was built to link with a village street '*What I like about Swords is that the main street links to the new shopping centre and that you can easily walk between them … it does retain the* *connection to the town centre and it keeps the town centre a little bit alive whereas others couldn't say that'* [4, TP]. Another attempt to link a new shopping centre to a historic village drew a long debate in one group. A negative view of this project was the apparent lack of consideration for the different scales and access: 'The *old village is in no way connected to the new shopping centre … the different scales as well, they are just so vastly, so completely different. The shopping centre is monstrous and the village is very small'* [5, SP].

While recent attempts to integrate large shopping centres to existing town or village centres drew debate there was clear distain for the shopping centres which were built '*completely segregated from the existing town centres'* [1, LA]. Segregated shopping centre areas were listed as having low walkability in every focus group. The difficulty in getting to them on foot or by public transport and the illegible layout of areas surrounding them were highlighted as problematic for walkability. *'That whole expanse of big block stuff where you get out on a bus you have to walk for ages to get to wherever it is that your trying to go and your never quite sure…Bad public transport access… disorientated. Large car parks… that block, where it's kind of surrounded by very large roads and again the scale is very big'* [2, LA] and '*huge car parks, different retail centres separated by carparks… drive between… awful for walking*' [4, SP]. While the external environments of the shopping centres were perceived as hostile the internal environments were described as being very comfortable for walking around. While the focus group conversations centred on shopping centres these structures are typical of new-suburb developments.

4.3.3.3 Human scale (Sub theme 3.3)

Participants referred to this positive small scale by citing examples of a number of older areas of the inner city, which have narrow streets, frequent junctions and small individual shops were selected by the focus group participants as highly walkable areas. They were described as having a *'lovely scale, a <u>really</u> nice sense of enclosure, it does feel quiet continental'* [1, UD] (Figure 4-13). Enclosure is an urban design quality relating to a sense of location or position, a 'hereness' in a place, I am 'in it' (Cullen, 1964). In this enclosed space the '*scale feels quite human, there are still cars there but they have to go very slowly, feel that people have priority, it feels more buzzy. It is* *tucked away from the main roads so you get that feeling that you have disappeared into somewhere that, that is more human scale'* [5, SP]. Historic (pre 1940) outer city and suburban residential areas were also described in a similar fashion.

Figure 4-13: Human Scale City Centre Area

Traffic moves slower on the narrower historic roads: *'As far as form is concerned for areas designed when people were walking… traffic speeds are very slow and volumes area low because the streets are narrow and not particularly straight. And on occasions that you do find cause to drive through there, you realise that it's a bit awkward. But it seems to strike the right balance between pedestrians and vehicles'* [1, LA]. *'it's a heavy trafficked road …(but) it has to slow down so much getting into Ranelagh you don't notice it as much'* [5, SP].

Small shops at regular intervals are preferable to large shopping centres and their expansive car parks. '*Those little nodes, none of them are too huge and none of them attracts massive amounts of parking'* [2, LA]. The most frequently selected highly walkable residential neighbourhoods were all villages. *'They all have a small village nucleus and then it doesn't mean that there is no development then after that, it's in little pockets. It all has that small nucleus to go to and then side streets off that. More incidental commercial, residents etc'* [1, SP]. These small pockets, or nuclei, service local populations and are easily accessible on foot. Village scale is explored further in theme four.

The relative nature of scale was explored in a discussion about the Georgian areas of Dublin City Centre which have grander buildings and wider roads. *'There is a lot of traffic around Merrion Square … but because the roads are wide and the paths are deeper as well, the noise doesn't have the same effect... because Merrion Square* (urban park)*, and the area around there is very pleasant'* [2, PR] *'Greenery, quiet & footpaths wide enough to see the other people that are using them, still a little bit of life going on, because there's painters there and other events on the weekends, but its not crowded or anything'* [2, E]. The larger scales of these areas are all designed relative to each other but with street trees and lamposts which detract from large tall buildings and maintain a human streetscape scale. The wider, busier roads are compensated with wider footpaths, bio-diversity and visual interest to counteract the traffic.

When discussing the attributes of the streetscape an urban designer stated that she believed the scale of the area to be of greater importance than architecture (theme six: path context). *'It's funny, I think that as long as you have the scale right and you have your right street width to building height it's almost more important than the architecture. The architecture is extremely important but it is the proportions and the sense of spatial enclosure that is the big difference'* [1, UD]. Similarly a landscape architect outlined how walkability *'needs to be a whole urban design thing, not just individual buildings'* [2, LA].

4.3.3.4 Interpretation of scale (Sub theme 3.4)

4.3.3.4.1 Density and Scale

The dominance of residential density as a key element of walkability (section 2.8.1.1) and a low importance attributed to residential density for walkability by Irish neighbourhood creators (section 3.4) meant that density was a concept of interest in the focus groups. Unprompted, density was only mentioned twice. The first mention was in the context of describing a badly designed residential development. '*It was an attempt to be high density and modern*' [2, LA], suggesting that high density design is/was fashionable. The second mention of density related to a discussion about pedestrianised streets. A comment was passed by a participant that he was unsure if they would work in a low density environment. Initially, the research team suspected that density was not frequently mentioned as Dublin is a low to medium density city. However, when prompted, focus group participants focused on the importance of density for the provision of services. '*The higher the density the more facilities would be provided in closer locations, closer distances, short distances'* [4, SP]. But this was put into context by highlighting that one of the most popular high walkable areas close to the city centre has a '*low residential density'* [4, SP]. This spatial planner continued by putting the neighbourhood scale, discussed throughout the focus group, into the context of macro-level density: '*but it is density of the area as a whole and the spread of uses it seems to me, judging on what we have all said today, that the best places, we are talking about villages* (human scale). *Whereas in low density areas like parts of West Dublin* (discussed as carchitecture scale) *are the total opposite of that – so density is mixed with the scale … you might have a housing estate, a park and then a massive distributor road and then another bit of parkland and then a car park for about half a kilometre. I think that makes a huge difference on walkability'* [4, SP]. Examples were given of new high density developments which are not walkable because of bad design and their isolated locations away from village cores. Acknowledgement was made by and urban designer that *'the most successful walking areas will always be denser but I don't think they are mutually exclusive at all. I think that you can have a low-density environment where people will have to walk… If it is a pleasant walk, you will walk that bit extra, 200 metres or so'* [5, UD].

The degree of compactness of an area which facilitates the daily needs of the residents without having to rely on personal motor transport, described as 'the right kind of density' by Jan Gehl (2010, p.65) is preferable to an area which just has a high residential density. Also, as mentioned by a participant, density and walkability are not mutually exclusive as a certain density is required to facilitate this compactness and the desirable small village scales when macro planning. This preferable compactness may be mistaken for high density and caution must be exercised when considering density in walkability. Macro walkability indices which combine density with other measures such as connectivity, public transport access and land use mix such as Sallis and colleagues (2009) WI composite index (section 2.7.6) consider density with the desired context. However, a high density score may compensate for an area with low service provision (land use mix) and therefore lose the desired context and give a biased 'walkability' result.

4.3.3.4.2 Understanding of Scale

Scale and its associated terminology was present in the vocabulary of urban designers, architects, landscape architects, planners and some of the other participants. These participants used urban design terminology when describing scale '*there is a lovely scale … it's just it's a really nice sense of enclosure'* [1, UD], others described their emotional response to relative size or distance *'you have a vast expanse of sand in front of you…it is very daunting'* [1, LA]. Those that did not use specific terminology described their perceptions and emotional responses to convey their general comfort in human scale environments and discomfort in car-centric environments.

While recent studies in New York have used human scale in their walkability measurement tool (Purciel, et al. 2009) it is a notably absent concept in walkability research. It is a finding of this study that scale is a central concept of walkability, hence it has been designated 'core theme' status. In the development of Ewing and colleagues (2006) measure of walkability, human scale was found to have the strongest relationship with overall walkability out of the urban design features tested (section 2.7.7). A weighting of over 40% was assigned to the measure in their walkability regression model yet no other studies were identified which adopted scale as a consideration in site selection. Scale as a concept should be promoted to walkability stakeholders outside design professions, including transport professionals and engineers.

4.3.4 Criteria

A secondary aim of this study is to generate a list of criteria which can inform the identification of high and low walkable areas in the GDA. The following sections develop the criteria reflecting walkability themes with consideration for themes two, consideration for all individuals, and three, scale.

4.3.5 Theme 4: The Village (Criteria one)

In the concluding stages of the final two focus groups summation comments were volunteered, unprompted, by participants. Both noted that their interpretation of a walkable neighbourhood, following the group discussion, was a neighbourhood which facilitated walking to carry out daily needs and for a means of recreation or leisure. '*I suppose what I would pick as high walkable areas are ones that can manage to combine both… like walking to the shops, … but there is also pleasant places to go for a stroll'* [4, PHA]. '*All the places that people were coming up with, it's that village atmosphere, it's the sense of vibrancy and destinations and something that you can actually go and do… go for lunch and walk around. …and off to the seaside or up the hill* '[5, UD]. The concept of a village neighbourhood, theme four, had two subthemes livability and imageability.

4.3.5.1 Livability (Sub theme 4.1)

All focus groups agreed that highly walkable residential areas tended to be centred around a village core or were within close proximity to the city centre with small local service nodes. These self contained '*liveable*' areas are where you can '*spend your weekend there quiet easily without going into town*' [5, Arch] or '*the fact that everything is within walking distance that you could possibly need over the course of a week*' [2, LA]. A key characteristic of these liveable villages was that they were '*built when people walked*' [1, TP] which results in facilities and destinations being spaced at distances which can be walked: *'Houses, shops and church, pub, they are close together. And there are a lot of houses close together. So the majority of people would be able to walk everywhere…(it has) a nice villagey sort of feel to it*' [3, Arch] and *'Parks* *spaced at distances that you would comfortable walk to*' [1, TP]. The age of the area also influences the connectivity and street scale outlined in themes five and three.

Within the greater city context these villages give a sense of identity to areas which due to their grain, street layout, and scale feel removed from the higher density big block city centre areas. '*I suppose the little village as well, it's the heart of it, you've a little sort of a self sufficient village, so close to the centre of the city and suddenly when you're in that village and you sort of feel removed from the city*' [2, E]. An interesting comparison was drawn between Dalkey and New York City where, despite the substantially higher density, areas within the city are referred to as villages. 'W*hen you're in New York, you generally live in a little sort of commune, shall we call it – in the West Village, the East Village, Soho, the nicer parts, so it's the fact that you have that close knit village in its own context with everything else…, you still have the sea and you have nice little shops and everything is in pretty good nick so it's that kind of fact that you have a little village, I thought, within I suppose, a big environment'* [2, E].

The 'village' concept is an area which supports the needs of the people living in its proximity. Services are accessible on foot, regardless of the residential density. It is a consideration for the maintenance or replication of a village in design practice. Villages, rural or urban, have operated for centuries without the need for motorised vehicles. Spatial planners are required to zone for the provision of amenities and maintain or make public transport systems viable in residential areas. Higher densities are desirable to support these services. However, higher densities play a supporting role for existing villages rather than a necessary one. New urbanist theory design principles call this village concept the 'traditional neighbourhood development unit (or TND)' (King et al. 2002, p.22) where a unit of development is scaled to a five-minute walk.

4.3.5.2 Imageability (Sub theme 4.2)

A noticeable characteristic of the highly walkable areas selected was that all these areas were easily identified by many participants. In contrast, low walkable areas were either an identifiable place with a specific issue or regions/vast areas of single use without a particular identifiable place or landmark. Other participants frequently asked for clarification as to where these difficult to identify areas were. One such area was described as: *'I mean it is one of those areas that has experienced a huge amount of development in the 80s and in the 90s and even then again, incoherent and a lot of housing … it seems very car dominated … no significant facilities or character'* [3, SP]. The participants are describing 'imageability', an urban design concept that describes the quality of a place that makes it distinct, recognizable, and memorable (Ewing *et al.*, 2006b; King *et al.*, 2002; Lynch, 1965). A place has high imageability when specific physical elements and their arrangement capture attention, evoke feelings, and create a lasting impression (Ewing *et al.*, 2006b). High walkable site selections suggest that a positive imageability is an element of walkability as they evoke strong and vivid memories among individuals (King *et al.*, 2002). Low walkable selections which had strong imageability were associated with negative attributes which would deter pedestrians from that area. It can be concluded that positive imageability is associated with high walkability. Similarly, negatively associated or absence of imageability is associated with low walkability. Therefore it can be concluded that imageability is a consideration for walkability but is contextual.

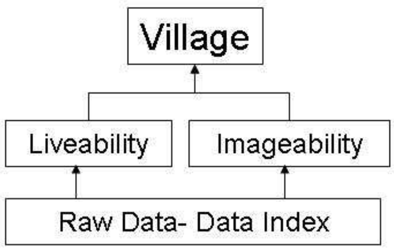

Figure 4-14: Thematic Structure for 'Village' sub-themes

In summary, Criteria 1: The village

A walkable area is identifiable and unique. Areas are of suitable scale for everyday neighbourhood functions with alternative routes to suit vibrant/energetic or quiet/calm moods and have access to a recreational walking route or destination nearby.

Converse of Criteria 1 for a low walkable environment: Agrophobic, large, expansive area with no identifiable 'core' and/or is built beyond reasonable walking distance to a 'node' and/or recreational walking destination.

4.3.6 Theme 5: Permeability (Criteria two)

The primary function of roads and paths is to facilitate the transport of people, whether it is in a car, on a bicycle or on foot. As identified in the literature review ambiguity exists between the terms connectivity and permeability (section 2.8.1.2). For the purposes of this discussion the connectivity of an area will describe the street layout and the theoretical catchment area that can be walked to. Permeability will relate to the ease of movement, without barriers (actual or perceived) through an area.

The sub-themes of permeability deduced from the transcripts are:

1) A connected, legible (perceptually coherent) street network

2) An absence of barriers, physical or perceived

3) Sufficiently wide and well maintained footpaths

4) Links to the greater city area on public transport

5) The 'draws' that keep you moving through the area

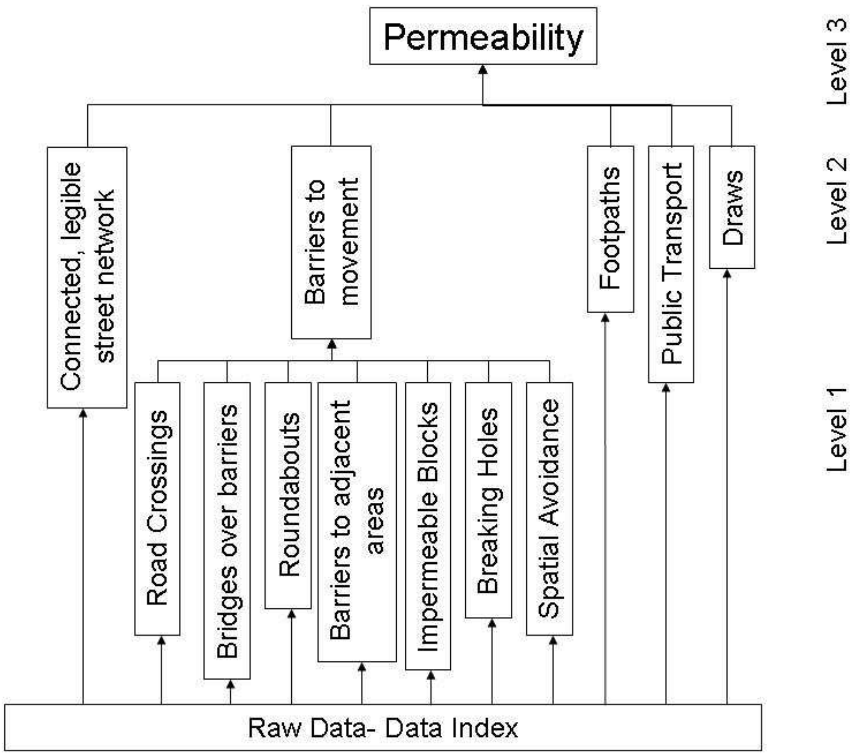

Figure 4-15: Thematic structure of 'Permeability' sub-themes

4.3.6.1 A connected, legible street network (Sub theme 5.1)

Alongside density, land use mix and access to recreational facilities, connectivity is one of the most frequently used measures of the built environment for physical activity research (Brownson *et al.*, 2009). Areas identified as highly walkable were associated with high connectivity. Where '*you can walk around in any and every angle and get through to where you want to go*' [4, SP]. High connectivity facilitates a variety of route choices: *'Where you can get off the busy street and into a quieter area that has footpaths. If you want, you can walk on the busy part, which would be Camden Street, or you can walk along alternative route through housing'* [3, SP]. This structure is built on having '*small blocks so that you can turn corners regularly'* [1, UD] where '*the side street areas are interconnected'* [2, LA] so that you can *'come in and out of it* (the area) *from almost anywhere'* [1, TP]. This variety of routes is a characteristic of connectivity and was also identified in high walkable residential areas: *'What I particularly like about that area in general is that you can weave and meander your way in any direction'* [5, UD]. Universally, highly walkable connected streets were associated with being built in a time when people walked, which is consistent with the views of Handy and colleagues (2002). Connectivity provides the functional structure of an area facilitating permeability.

These highly walkable areas were also described as being legible. Walkable '*because it is a very legible area and I suppose the Victorian grid system has a lot to do with that'* [1, UD]. The perception that on *'turning left here to meander through and now I know where I come back out'* [1, SP]. The legibility of an area is an urban design term to describe the perception of the ease of navigation and sense of orientation within an area (Handy et al. 2002). Legibility enables pedestrians to reliability identify areas that are safe and secure and avoid those which are not (King *et al.*, 2002).

Large scale suburban (carchitecture) areas were described as illegible due to low connectivity *'Where when you get out of a bus you have to walk for ages to get to wherever it is that your trying to go, and you're never quite sure … don't know how to orientate yourself'* [2, LA]. The factors that made areas illegible according to participants included incoherent junctions (pedestrian crossings). *'It's really about trying to navigate the many different bits of roads. It's not really that clear how to get* *around. It's a mish mash of road interchanges and the LUAS* (tram) *and again traffic lights, pedestrian lights don't really favour the pedestrian, the cars have the priority on most of these junctions so you don't feel particularly important. Or at least you are at the whim of the traffic'* [5, SP]. A legible, connected street network presents opportunities for alternative route choices to suit an individual's mood, ability or trip context.

4.3.6.2 Barriers to movement (Sub theme 5.2)

Barriers to movement through an area or into adjoining areas can be physical or perceptual. Some physical structures built to increase connectivity were identified as actually hindering movement and reducing permeability because of their subjective interpretation. In these cases a connectivity measurement is a misrepresentation of the permeability of the area. This therefore presents a case for permeability considerations, rather than solely connectivity, in high and low walkable site identification. This section identifies the barriers to movement identified by participants.

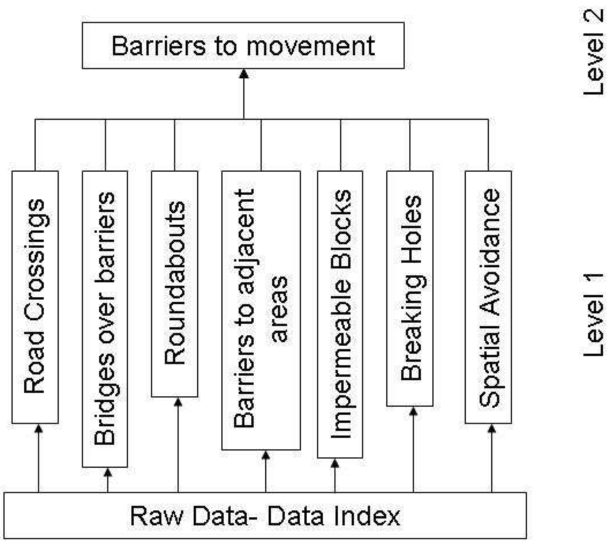

Figure 4-16: Thematic structure of 'Barriers to movement'

4.3.6.2.1 Road crossings

The picturesque College Green area of Dublin city centre was cited as an example of badly designed road crossings which detract from the attractiveness of the area: '*It's so hard to … get across those traffic lights …(but) It looks like a nice place to walk*' [1, TE]. *'It's the fact that you can't cross in one movement and you can't cross at your desire lines*[40]*'* [1, UD]. *'You see people running all the time to cross [agreement] and it has been like that for as long as I can remember [agreement] and yet it is something so simple to fix'* [1, TP]. Non compliance with pedestrian crossings was attributed to bad design where pedestrians are forced to cross away from their desire line (preferred route/ crossing point) and wait a significant amount of time to do so. Pedestrian crossings, which are positively associated with walkability in research literature (section ref 2.8.1.3), are well provided in many areas. But inappropriately placed crossings were perceived by the focus group participants as a barrier to movement and therefore permeability.

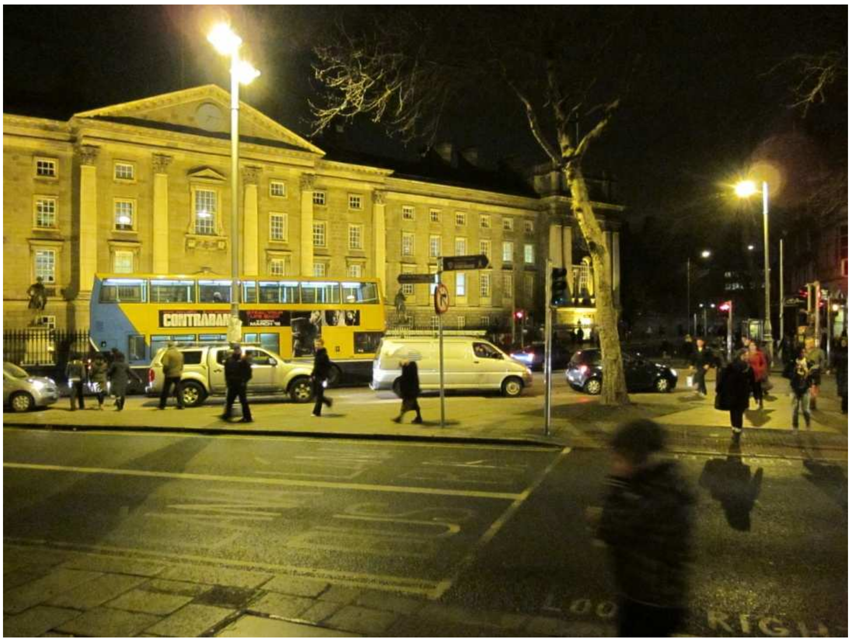

Figure 4-17: Pedestrian crossing at College Green

Not only can a bad pedestrian crossing affect the attractiveness of an area it can also isolate an area from neighbouring areas. *'The way the traffic flows at the top of O'Connell Street. You cannot get across there easily. It really seals off the top of the*

[40] This is the route that the users subconsciously desire to walk

city. … I don't think anyone walks any further. You get to the AIB, turn around and come back down again. I think that is purely down to traffic movements. I'm not part of the road. I suppose' [5, SP]. The perception that the pedestrian movement was not considered in the design of the crossings was present throughout all focus groups. Where the '*pedestrian lights don't really favour the pedestrian,* ***the cars have the priority*** *on most of these junctions so you don't feel particularly important. Or at least you are at the whim of the traffic'* [5, SP] (my emphasis). The pedestrian feels vulnerable.

Figure 4-18: Junction at the entrance to the Phoenix Park with no pedestrian crossing

4.3.6.2.2 Bridges over barriers

Rivers flowing through an area and railways and large fast roads traversing an area at grade (at ground level) are barriers to movement. Participants described them as such: '*The river itself is an impediment'* [1, TP] and the area '*has been cut off by the railways'* [1, TP]. Bridges can provide crossing points over these barriers to extend movement into areas: *'In fact it's drawn quiet well across the new pedestrian bridge into some areas in the north side'* [1, TP].

Examples were given of pedestrian over-pass bridges which theoretically facilitate the movement of pedestrians but actually act as a barrier: *'We increased the walking* *distance … from half a kilometre, to a kilometre and a half just because of the extra over-pass with its enormous long ramps that are not even accessible'* [2, LA]. These structures leave pedestrians vulnerable where they cannot see the other side to assess potential threats to their personal safety and result in non-usage: *'You have got footbridges which then get caged in because people are throwing things off them and even the lads throwing stuff off them don't particularly want to cross them. A lot of people would take their chances on the road. It is the affect they have on the surrounding neighbourhoods as well. It encourages that car based mentality'* [4, TP]. Examples were given by participants of times they ran, or contemplated running, across a large motorway rather than use a pedestrian bridge: *'I was in a hurry and I felt that I wouldn't take my life in my hands and I would do the right thing. But I seemed to have had to walk all the way around this loop (lots of enthusiastic agreement from group) and it was quite a long walk to get down the other side. There probably isn't an easy way to get around it but if I thought it was that much hassle I would have run across'* [5, PHA]. Pedestrian bridges are barriers as they are '*inconvenient for people'* [5, UD], particularly for elderly or vulnerable people '*I think that if I was anyway elderly I would be totally put off… you couldn't push a wheelchair up there I would think'* [5, PHA]. Despite the limitations the concept of providing a crossing over a motorway seemed like a good idea to one participant *'But I think the concept is good … you know the idea of having an overpass, seems like a good idea'* [5, PHA]. These findings are consistent with those found by Räsänen and colleagues (2007) who concluded that pedestrian bridges are more likely to be used when the convenience and safety benefits outweigh crossing at street level (at-grade) without considerable time loss.

Underpasses or subways were discussed in a similar manner with personal safety cited as the main reason for non usage. Pedestrian bridges were '*better than something waiting for you at the bottom of the subway'* [5, SP] but if there was a significant number of people using the subway they feel safer. A number of examples were given of good international practice. '*I suppose it can be down to patronage, and the footfall that is going to be there'* [5, SP] '*yeah, I would generally steer away from them myself unless it was a particularly busy, busy like, city centre or bus station or something* *where you could just go up, 24hr footfall. They do become areas for anti-social behaviour*[41]*'* [5, UD].

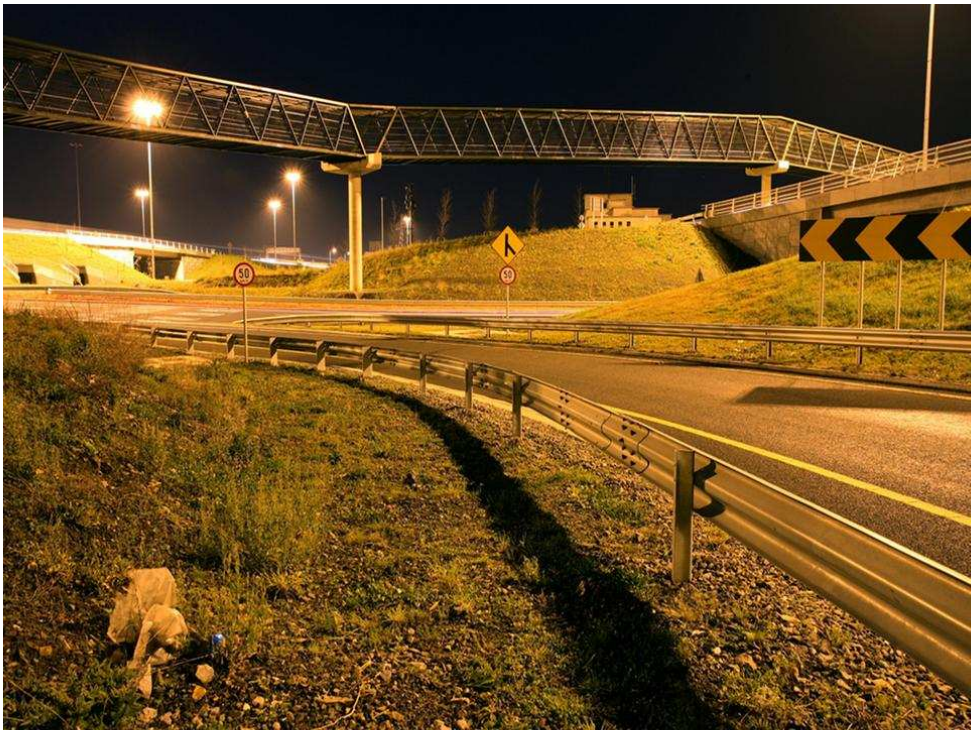

Figure 4-19: Pedestrian overpass at M50/N2 Junction (Source: csd75 on Flickr)

4.3.6.2.3 Roundabouts

Another structure constructed to facilitate the movement of vehicles identified as a physical barrier to pedestrian movement were roundabouts. The reasons for this were described by one participant: *'When you see people every morning sort of standing on the edge (laughter from group) getting ready to step in to try and anticipate a vehicle. It's hard enough for the car driver to anticipate what people are doing around roundabouts as a pedestrian it is even harder. And no matter what is said you cannot design a pedestrian friendly roundabout. The only way to do it is to put the crossings 30 meters down the road and then guard rail it all to force people to go down it because we know people will take the shortest route. I am sure that it is much harder to walk 50 meters as a pedestrian than it is to drive 15 meters* [5, UD]. One focus group

[41] Anti-social behaviour is behaviour that lacks consideration for others and may cause damage to the society, whether intentionally or through negligence.

mentioned that Walkinstown roundabout had the lowest accident rate of pedestrians and cyclists but noted that is probably because there are no pedestrians or cyclists using the roundabout [4]. Pedestrians are exposed and vulnerable to traffic at roundabouts and therefore roundabouts are not conducive to walkable environments.

4.3.6.2.4 Barriers to adjacent areas

Large roads and railways can isolate an area and make them difficult to access but the area remains connected inside. One of the most frequently selected highly walkable areas, Sandymount, was described in this manner. *'The sea front promenade is fantastic but to get to it you have to cross Strand Road… it is a pain to cross; it is unpleasant to walk along. … (Sandymount Village is) an island of calm between two busy roads with amenities outside them and so we need to cross the roads to get to them and they are not particularly well provided for pedestrians at the crossings.'* [4, TP]. An area which has a core that is not cut down the middle by a heavy road but has main roads around it to facilitate traffic movement, with multiple entry points to the area was preferable to a heavily trafficked core-area. However, pedestrian friendly links to facilitate trips into adjoining areas are required.

The impression of cul-de-sacs as low walkable areas was debated by participants. Areas dominated by long cul-de-sac estates were frequently selected as low walkable areas. Connectivity was given as one of the reasons for this. Low connectivity and isolation was forced upon some of these areas because of the adjacent roads' categorisation which does not allow for frontage onto the road or for more than one entry point. The impact that this has on traffic is that: '*Going to public consultations in places like Lucan … what I constantly hear is I can't get out of my estate in the morning… What they mean is that the traffic is so backed up on the main distributor road they can't actually leave their current estate road network'* [2, LA]. Despite this people seem to be happy to live in cul-de-sacs. One public representative's statement in the third focus group to this effect drew debate, figure 4-20.

Other groups also acknowledged this desire to live in a cul-de-sac for an increased perception of safety and sense of community. One highly walkable area was selected because it had an *'Interesting mix of cul-de-sacs and permeable roads – people like both to live on a quiet cul-de-sac and be able to move through the area*' [4, SP].

Facilitating some short cul-de-sacs, some of which are also permeable to walkers and cyclists, with wide overlooked connections rather than narrow lanes, within a connected area was considered a satisfactory compromise.

'If you live in that area though you don't want people to be going through – you are quite happy with the cul-de-sac'. [3, PR]

'Why don't you want them to go through? If people are walking' – [3, PHA]

'They don't'. [3, PR]

'Driving, they are driving. It's from a driving perspective. A cul-de-sac is nice for children to play in'. [3, SP]

'But also depending on the area, if the area is prone to anti-social behaviour you know main ways give people escape routes. It's another argument where people can cut through'. [3, PR]

'People make their own shortcut – if you are living in a housing estate and your cul-de-sac is there and your road goes around like that and there's the cul-de-sac, you hop the wall – you will make your own path and then that causes more social problems because natural instinct is I want to go on the shortest route from a to b and I can't so I will make my own. [3, PHA]

Darndale was designed with all the best planning notes at the time and it had all gone in neat and the doors where all cul-de-sacs basically and 20 years later it all has to be rebuilt. So, sometimes the theory doesn't always work. … I say we get more requests for transfers for closed lane ways at every single meeting than any other single other item. Particularly in a lot of poorer estates that have been built in the last say 40 years. And yet there is an argument that the more people there are… [3, PR]

Sometimes they are just horrible places to be. They are like tunnels or narrow – people feel intimidated [3, PHA]

In the dark. Not overlooked [3, Arch]

'Yeah. If it was more open in the first place and need now access to places' [3, PHA]

'I would say don't close them because… and cyclists would often say that they are safe through routes for them' [3, PR]

' I live at the end of a cul-de-sac and it's lovely because you feel anyone coming in there – in terms of crime – kids just play out in the middle of the street. Just across. Everybody knows everybody else. Cul-de-sacs can be good but then if I want to cycle out there to go around I have to go around. So there are pros and cons'. [3, TE]

Figure 4-20: Cul-de-sac debate

4.3.6.2.5 Large impermeable blocks

Some barriers are impermeable and operate as edges to an area. Examples include historic institutional blocks such as hospitals, schools and convents, which are often walled, effectively sectioning off an area. The result is that the block has to be circumnavigated as there are no paths which allow pedestrians to pass through the lands: *'It's a big institutional block that impacts on movement through that part of the city. It's almost like a cancer in the city as it kills that corner as there is no movement through it'* [1, TP].

Similarly, large shopping centres and developer built cul-de-sac housing estates have the same effect on an area: 'The shopping centre is fenced off from the outside world except for the car parking. So, it's walkable for you to go from the car-park to the centre, but outside… The tram stop for the hospital is at a railing. Now, you could walk a mile and a half around to the other side of the railing but there is no gate that allows you to walk straight through into the hospital. I don't know what the thinking behind it is, the hierarchy of design, but you end up with the network of lands that are fenced or walled … they are isolated'. [1, TP]. Figure 4.21 illustrates this form of isolated 'suburban sprawl' development. While these blocks may be walkable within their boundaries, poor connections to adjacent areas or services may result in an increased dependency on motorised vehicles.

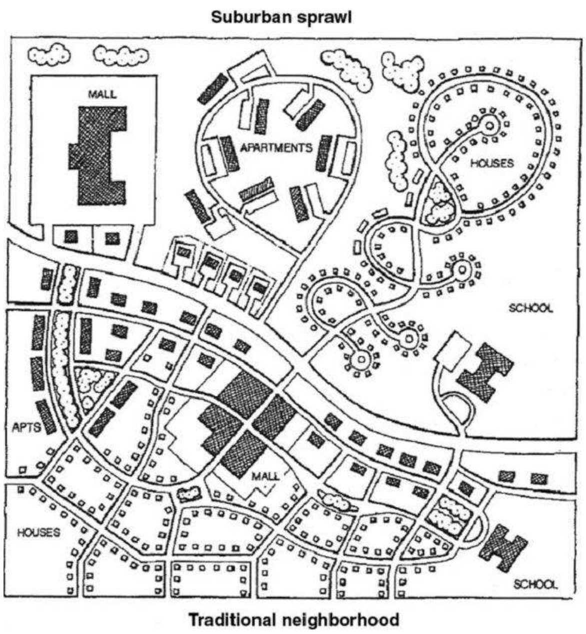

Figure 4-21: Isolated development blocks in 'suburban sprawl' development (Spielberg, 1989)

4.3.6.2.6 Breaking holes

When people want to cut through a barrier they will create their own shortcuts (Figure 4-22). An example was given by a participant of a relatively new development where '*The access isn't good, permeability isn't great. It is very cut off from surrounding areas … It is a reasonably new area that has come together piecemeal. They built a new road into the area and the first thing they did was build fences that people then break holes in because the movement of people wasn't considered. … and what happens over time is that people will carve their way through and these walking routes materialise everywhere'* [1, TP]. Another participant in this group lent their support to this stating that '*contributing to all of that is a misunderstanding of risk and this misunderstanding of safety. Those fences are going up because they want to protect people from the road. It all derives from there'* [1, UD]. In a recent audit of the Blanchardstown area Fingal County Council observed a substantial amount of evidence that people have been jumping walls, some as high as 8 foot, and cutting through fences in order to take a shorter route (unpublished internal report).

Figure 4-22: Knocked fence

4.3.6.2.7 Spatial avoidance, perceived risk

As mentioned under theme two, considerations relating to the individual, spatial avoidance can be as a consequence of a perceived risk to safety. Focus group participants cited prejudice based on the deprivation of the area, a legacy of crime in the area, visual deterrents, a personal risk assessment of the area, a feeling of isolation or no lighting at night as reasons for spatial avoidance. One highly walkable area was described as '*you can weave and meander your way in any direction, every street felt safe*' [2, LA] with no perceived risks. This impacts on the permeability of an area as the true permeability of the area is reduced if some routes are not considered or are avoided. Spatial avoidance is when a pedestrian takes an alternative route or does not walk as a result of a perceived risk based on the individual's perception of the area from visual cues and historic knowledge (Bell *et al.*, 2001). Coakley's qualitative study of women's fear of violent crime (FOVC) in public spaces in Cork (2003), Ireland's second largest city, found the top precautionary measures adopted by women is general spatial avoidance (43.7% of sample). A second reason given for alternative route choices by focus group participants was to avoid inconvenient road crossings or other discomforts such as those outlined under this barriers sub-theme.

4.3.6.3 Sufficiently wide, well maintained footpaths (Sub theme 5.3)

In this section the term 'footpath' relates to the designated surface for walking upon. This is predominately the footpath (sidewalk) as typically observed, but includes the whole street where areas are pedestrianised. Footpaths were classed as low walkable by participants when there was a perception of insufficient space or of vulnerability. A perception of insufficient space for the pedestrian because of clutter (street furniture) or stationary crowds (waiting for buses etc) impacted on pedestrian comfort. Street furniture refers to the bus shelters, litter bins, seating, lighting and signs adjacent to the road (Cowan & Rodgers 2005, p.375) (Figure 4.23). The position of street furniture is often dictated by the highway standards as it relates to the movement of vehicles, with little or no consideration for pedestrian movement: *'The clutter on the streets themselves, there's abandoned poles and there's bollards to help the traffic flow (laughs) but they put it over the pavement! (laughter from group)'* [5, SP]. '*yeah (with a* *sigh), its probably one of the most pedestrianised areas of the city yet the pedestrians are given so little'* [5, UD].

Figure 4-23: Street furniture blocking footpath

The South Quays and Nassau Street were both classed as low walkable areas because of crowding on the footpaths by people waiting for buses: *'The reason I chose Nassau Street is the footpaths, they are just tiny. All the space is given to vehicles and loads and loads of people are crammed onto footpaths which are probably only a meter and a half to two meters at best… people queuing for the bus'* [5, UD]. '*I jaywalk all the time, I'm going to get killed by a bus someday stepping off to try and get around people'* [5, PHA] (Figure 4.24). Crowded streets were described as '*closterphobic*' [1, UD] and '*aggressive*' [2, LA]. The presence of other people was generally perceived as positive, while isolated, empty areas contributed to low walkability. As discussed under theme two, considerations for the individual, ability and mood can influence how these busy or quiet paths are perceived.

Figure 4-24: Narrow footpaths on Nassau Street

References to narrow footpaths were generally coupled with a perception of a threat from fast or heavy traffic in low walkable areas: *'It has narrow footpaths, the traffic is beginning to funnel in. It's dangerous enough. I wouldn't walk along it at night or with younger kids* [3, PR]. An area became unattractive because of the threat from traffic because of the narrow footpath. High walkable areas often had reference made to wide and/or comfortable footpaths where the impact from traffic was minimised.

Maintenance of footpaths was considered weak in Dublin: '*Forget about the quality of the footpaths, it's just unbelievably bad and are not maintained at all. And even if they go in perfect and they never do, they are never maintained'* [1, Arch]. Uneven surfaces cause concern for vulnerable users who fear tripping or falling. *'The quality of the footpaths can be poor and generally can be uneven … for older people when I think about it it's a real disincentive'* [5, PHA]. Cobbled areas were associated with a risk of falling. *'The cobblestones, I'm always afraid of spraining my ankle while walking on them'* [1, Arch]. *'The cobbles… were very rough, they capsized a load of people actually'* [1, UD]. While cobbles are difficult to walk on they were considered aesthetically pleasing. Cobbles were also considered to send the message that this area is for pedestrians. A recent event where a cobbled area was resurfaced with asphalt was brought up in three of the five focus groups. All were disgusted as '*tar sends one message and that's this place is for vehicles other surface street would send another* *message that it's a most likely it's a place that has more balance, priority, between or shared between different users but black tar says one message'* [1, UD].

Narrow footpaths and bad footpath surfaces were frequently mentioned in high walkable inner and outer city area descriptions. Contradictions were highlighted by the moderator and acknowledgements that older areas of the city had footpaths that were quite narrow were noted. However, despite the bad/narrow footpaths the areas were still considered walkable. When questioned whether footpath functionality was important considering these contradictions an urban designer replied: *'Oh, I think that it is so important. I find it so difficult to think we don't value the quality of the public realm at all. See, I don't know if it would affect people walking or not … in the city centre it is a little bit different as there are different reasons for being in there. But I think that (footpath quality) is so important. I think it is a major problem'* [1, UD]. This comment suggests that the functionality of surfaces is important. However their influence on trip choices is unclear. Pedestrians walking in the area may consider the functionality of the area when making route choice decisions, or on where they will visit, based on their individual abilities and perceived personal comfort. Only twice in the study was the absence of footpaths mentioned, both examples related to large national routes in suburban locations. This may be because footpaths are well provided in the city. Walkability studies which consider micro scale attributes all consider the presence of quality maintained footpaths as a primary consideration in walkable areas (Pikora *et al.*, 2003; Alfonzo, 2005; Lo, 2009; Southworth, 2005; Moudon *et al.*, 2007; Brownson *et al.*, 2009). However, while the width may be considered the appropriateness for the context of the street and the footfall is not always.

4.3.6.4 Access to public transport (Sub theme 5.4)

While some of the selected high walkable areas were in the outer city and suburbs they remain connected to the greater city through good public transport systems: '*It is very accessible via other means as well (bus and rail). It works very well, particularly for people that live and work in that part of the city you know they can move through their environment very easily and they can get to other places easily without jumping into a car*' [1, LA]. The opposite situation was a common thread when discussing recently built areas where new developments overlook public transport but have no accessible routes to them: *'Long cul-de-sacs with views of the LUAS (tram) but can't get there… very poor connections … Cut off from the rest of the city because of a lack of permeability due to design'* [4, TP], '*There is a bus stop there. You can be literally be on the other side of that fence from that bus stop and it is 600 meters to get to*' [5, UD]. A feature of public transport trips is that they require additional trips on foot at either end of a journey in order to connect an origin to a destination. This overall trip depends on other accessible travel modes or walkable areas for a trip to continue comfortably and conveniently. The absence of one link destroys the sustainable trip chain: '*If you have one part and you don't have the second part well then it's no good and you might as well bring the car …you can get as far as the train station, but how are you supposed to get the next mile home as there is no bus to bring them there*' [2, PR]. Access to public transport is a central consideration in urban and transport planning and a central focus in sustainable transport management. A walkable area will facilitate public transport trips by connecting potential users to the transport system.

4.3.6.5 The draws through the area (Sub theme 5.5)

A term frequently used by participants to describe the invitation an area presents to a pedestrian to continue walking was the 'draw' or the 'draws'. '*It's a route that draws people in. It makes it a very interesting street'* [1, UD]. Draws also include the destinations that attract people to go there: *'I think it has very much to do with the draws that are along Wexford Street itself in terms of facilities and shops … and it's within very short distance of both of the sides of residential community and a more transient type of working community. And I think it is a very successful interface between the two…The transition from… the commercial areas around the green, and you got the concert hall and things like that. Hardcourt Street itself is quiet commercial and you have night clubs there, and then you go to Wexford Street it's much more, it's almost boutique-y type shops and things like that, and residential community and it's fairly seamless and I think it is a pleasant experience to pass through all of those'* [1, LA]. Environments which invite people to continue walking through an area are the opposite to barriers to movement and increase the permeability of the area. These draws also contribute to the imageability and legibility of an area (Section 4.3.4 & 4.3.5).

The following walkability criteria were developed by considering the sub-themes under theme five, permeability, along with the general considerations outlined in themes two, considerations for the individual and theme three scale:

In summary, Criteria 2: Permeability: A walkable area is permeable, legible and easy to move through. It has high connectivity for pedestrians with appropriately designed road crossings for people of all abilities at locations which reflect pedestrian's desire lines. The area has good public transport links to the greater region. Footpaths have an appropriate level of service and surface finish. Streets are designed to slow traffic to walking speed in busy pedestrian areas. A walkable area does not have fast traffic and/or crowded footpaths and/or barriers to movement through an area.

4.3.7 Theme 6: Streetscape (Criteria three)

'Permeability on its own isn't enough it has to be of interest as well' [1, TP].

This theme, the streetscape, addresses the micro level street environment. This includes visual interest of the street, the atmosphere and the perception of safety and how that is provided for by the streetscape design and features of the built environment. The functional elements of the street have been covered under theme five, permeability.

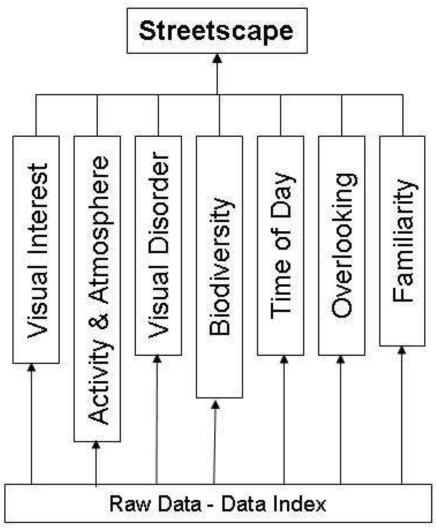

Figure 4-25: Thematic Structure of Streetscape

4.3.7.1 Visual Interest (Sub theme 6.1)

High walkable areas were described as having visual interest. Visual interest is provided by diversity in architecture, different forms and scales: '*It is quite diverse … space for different scales and sizes of shops so it has a bit more character than some of the main high street areas'* [5, SP]. Another urban design quality, variety, which relates to this diversity was highlighted: *'As you move through them the scale drops, the widths drops and the heights increase and that's what makes it interesting, and that part of walking is attractive, visual, your eyes being entertained*' [1, SP]. Descriptions of low walkable areas reflected the converse. Monotonous land uses (housing or industrial): *'Loads of houses but there is nothing else'* [3, Arch], '(Design is) *so clinical that it is uninteresting for people'* [3, PR], *'no significant facilities or character'* [3, SP]. Hugely different scales can result in incoherent vistas that change the character of the area, predominately caused by large new developments in older areas: '*Just so completely different. The shopping centre is monstrous and the village is very small... there is a total disconnect'* [5, SP]. A participant described the difference between areas that were selected as high and low walkable in his focus group as: '(high walkable) *are interesting and if you want to they are engaging as you go through them, whereas those areas* (low walkable) *have nothing to give and time begins to stretch out'* [1, TP]. Visual interest and variety can also be provided by biodiversity, outlined in sub theme 6.4.

Figure 4-26: Visually interesting area of the Dublin Docklands

Good neighbourhood aesthetics are frequently associated with higher levels of neighbourhood walking (Brownson *et al.*, 2009; Hoehner *et al.*, 2005; De Bourdeaudhuij *et al.*, 2003; Humpel *et al.*, 2002; Owen *et al.*, 2004; Panter and Jones, 2008) and feature on street audits used in public health research (Pikora *et al.*, 2002; Day *et al.*, 2006; Brownson *et al.*, 2004b). Natural features are usually emphasised in these measures rather than the design of the built environment (Purciel *et al.*, 2009). Urban design texts emphasise the importance of visual interest to entertain the eye while interacting with the streetscape (Cullen, 1964; Lynch, 1965; Bentley *et al.*, 1985; Gehl, 2006). The frequency of change of the visual detail is of particular importance to a pedestrian moving at walking pace to ensure they continue to be entertained (Gehl 2010). This variety in the streetscape is referred to in urban design as 'complexity' and was objectively measured by Purciel and colleagues (2009) using variety of buildings, colours, presence of outdoor dining, people and public art. Similar to other walkability themes which emerged from the focus group data the concepts are established in urban design literature but frequently generalised into greater concepts (i.e. aesthetics) without particular description or indicators in public health research.

4.3.7.2 Activity & Atmosphere (Sub theme 6.2)

Signs of activity and the atmosphere of the area also contribute to the social interest and the walkability of the area according to the focus group participants. Social interest refers to opportunities to interact with other people. Active shop fronts overlook the street and are a cue for social interaction. Continuous active frontage shows signs of life in contrast to derelict buildings and deserted areas with no sign of life: *'I think they have a kind of charm that when you are walking in them that you feel you are in somewhere where there is activity around. … I like the diversity of activity that is on it. … It has a bit of character'* [3, SP]. *'What I liked about the area was there was this continuous active frontage … Every part of the street had something going on or there was something to do that was interesting'* [5, UD]. Homes facing onto the street suggest the same: *'The vibe there... every street felt safe, everything as well overlooked, there are front doors on every street, it is a real living neighbourhood'* [2, LA]. The social interest of one high walkable area was described as: '*hard to walk down without meeting people you know, it's a friendly sort of a street'* [3, PR]. Entertainment provided by buskers and artists and opportunities to play (i.e.MUGA pitch) also add to the diversity and charm of an area.

Figure 4-27: Street Activity

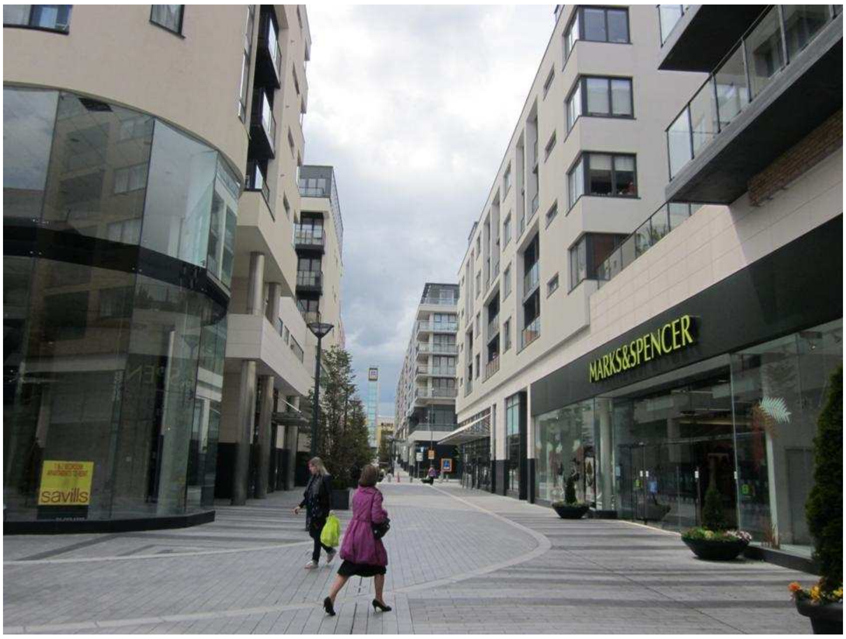

Figure 4-28: Atmospherically uninteresting street

The social street aspects of identified low walkable areas were that the areas were atmospherically dead, miserable, unloved and sad: *'I felt like, It was just a pointless area! … it was very very quiet, very dead'* [5, Arch]. '*Just miserable there, it's really off the charts nasty*' [2, LA]. *'It's just very unloved part of the city … so many derelict buildings, a very sad part of the city'* [5, Arch]. Areas with no diversity or with no significant facilities or character were atmospherically unappealing. In contrast high walkable areas were described as vibrant and lovely, with a nice pace of life where it always felt sunny: *'It's got all the attributes that a village needs to be self sufficient and summery and I like that vibe'* [2, Arch]. '*It is one of those places that always feels like it is pleasant, like it is sunny there or something'* [5, SP]. But not everyone agreed that the vibrancy was always positive in the city centre, it depended on the individual's mood. *'I wouldn't be crazy about Grafton Street I think its too crowded…its almost aggressive on very busy days'* [2, LA] *'if you're in the mood to stroll actually and you just take in the street then it might be different'* [2, PHA]. Gehl (2010, p.63) notes that the invitation to engage with the city is a positive element of city life but needs to present a variety of opportunities. He also states that it is not the number of people using the space but the 'sense that the city space is inviting and popular that creates a meaningful place'.

4.3.7.3 Visual disorder (Sub theme 6.3)

Under subthemes 6.1 and 6.2 visual interest, activity and atmosphere and their anti-thesis' visual disinterest and unatmospheric areas were discussed. Under this subtheme visual disorder refers to elements of the streetscape which evoke a negative response rather than a disinterest. Visual disorder was predominately associated with low walkable inner city deprived areas. This visual disorder also can induce a perception of negative atmosphere and a perceived threat to personal safety. Perceptive atmosphere is difficult to measure objectively. While street activity can be measured objectively, the presence of people alone does not determine positive street activity as groups of people who present a perceived threat can make an area seem unpleasant. Visual cues from people such as drug users and homeless people were highlighted as negative examples: *'No matter what time of the day or night you went there at there was always people lying around out of their heads …people vomiting and stuff like that … I have felt threatened in those kinds of environments. So that's what makes it unwalkable for me'* [5, PHA]. Acknowledgements were made that these people were not really a threat: *'the reality is , these people, if you leave them alone are not really a threat but there is a kind of a sense that there could be a danger'* [5, PHA]. *'I don't feel remotely threatened … they generally won't come near you – but you don't get that feeling unless you know the area particularly well. … It looks slightly dodgy and I think people permeate the area as a result of that. You are as likely to get mugged on Grafton Street as you are on Talbot Street. So, I think – while it may not be a rational foundation for thinking; it certainly is a legitimate response to visual view of the environment. So, it is subjective safety'* [4, TP]. Physical visual disorder sends a message to the pedestrian that the street is '*unloved*' [5, Arch] and they are areas where '*the lights have gone out*' [2, Arch] and where there is '*a lack of pride*' in the area [2, LA]. Examples given of visual disorder, other than people engaging in anti social behaviours, were graffiti, litter and unkempt gardens and common spaces.

Figure 4-29: Visual disorder

In their study of walkable route perceptions Brown and colleagues (2007, p. 45) describe the feelings evoked by the number, type, appearance or activities of people around as 'social milieu'. Negative social milieu reflects what is described here, the negative social environment, and positive social milieu was outlined under sub-theme 6.2, activity and atmosphere. Both are highlighted by participants as having an influence on the walkability of an area. Brown and colleagues (2007) concluded that in addition to physical features the social climate emerged as one of the most important features people noted when walking in an area. This finding prompted the team to highlight the importance of understanding subjective experiences of walkability (Brown et al. 2007). Physical reasons given by participants for people congregating in areas and engaging in anti social behaviour were that the areas were not overlooked or lit or were not being used so these groups moved in and claimed ownership of the areas. All of these aspects are by products of bad neighbourhood or streetscape design.

4.3.7.4 Biodiversity (Sub theme 6.4)

Biodiversity, or natural features, contribute to both visual interest (subtheme 6.1) and atmosphere (subtheme 6.2) by providing spaces which were described as an '*oasis*' within the city centre [4, SP & 5, PHA], '*a piece of country there in the middle of the city*' [2, PHA] and 'a *haven of tranquillity*' [5, PHA] giving respite from the bustling city centre: '*The trees just make it enclosed and slow, just a nicer pace of life'* [5, SP]. Trees and planters in particular contribute to the streetscape by making the space more human scale, particularly where there are tall buildings. A similar point on scale was made by Purciel and colleagues (2009). Trees were also noted to have a filtering effect: '*More tree foliage helps the physical atmosphere of a broad street that tends to funnel the wind and especially in the summer months it may filter out some of that dust'* [2, LA]. It was noted however that street trees alone do not fulfil the need for biodiversity in an urban environment. Their location and context are also important. Within the city attention to detail and appropriateness of design were highlighted by one participant with regard to an area where large trees block the dominant architecture of the area: '(Trinity College façade blocked by trees on Dame Street) *I think is about the buildings in that case. I think that should be a complete civic space and should be all about the buildings. The trees are inappropriately placed'* [1, UD].

Throughout the study the focus group selected high walkable areas that had a recreational walking amenity nearby. While some parks and sea front promenades were selected as destinations to go for a walk, a review of the selection reasons showed a preference for neighbourhoods with a natural, outdoor destination for walking nearby. Coastal areas were frequently selected by participants both as a place to walk and a place to live. The sea is positive all year round '*It's just the being near water'* [2, PR] and the spray is '*invigorating*' in winter [2, PHA]. Access to green space has been the subject of a number of walkability studies (Brownson 2009).

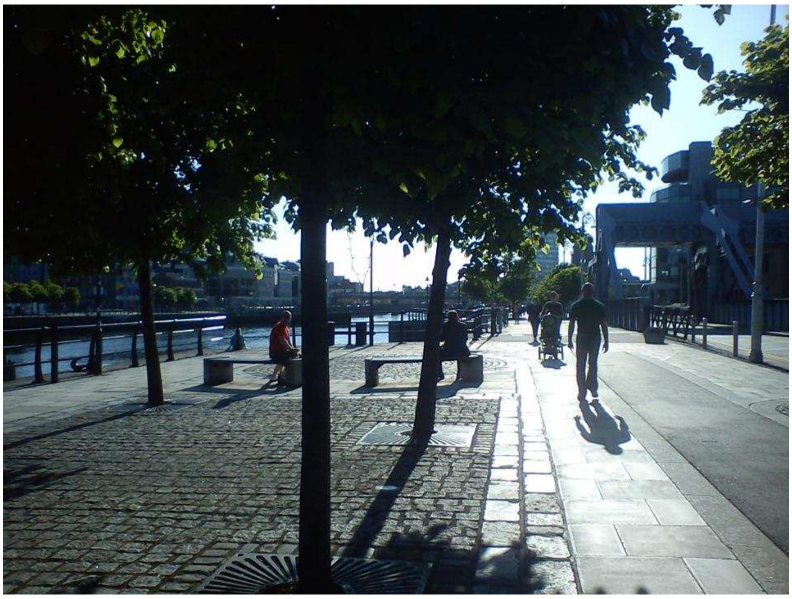

Figure 4-30: Biodiversity

4.3.7.5 Time of day and the street (Sub theme 6.5)

Another sub theme of streetscape identified from the focus group data was that the built environment has a temporal aspect. The functions, landscape and character of an area can change depending on the time of day. Areas which were high walkable could become low walkable at night. One example given was Henry Street, a pedestrianised shopping street in the city centre: '*6 o clock and it is just steel, for the entire length of it, there is just nothing going on, even though it's actually it should be very pleasant. Yet, it's just a big long line of shutters'* [1, TP]. Agreement was given by another participant who mentions another shopping street which is not pedestrianised: *'It almost transforms into a bit of traffic sewer then because all you see then is the traffic, your not focusing on the shops anymore, it almost changes your perception of it'* [1, UD]. At night the visual interest and overlooking functions of the active shop fronts become passive when the shutters come down. Recreational areas are also subject to temporal limitations, '*the park, it is a place that you would go to during the day but in the evening time you would be less reluctant to'* [4, SP]. These areas were unattractive at night and people fear for their personal safety. Both the covered shop frontages and the empty park are considered unsafe as there is no people in a position to overlook the area. In general streets with mixed uses throughout the day and evening with some residential units were considered the most walkable.

4.3.7.6 Overlooking and eyes on the street (Sub theme 6.6)

Throughout all of the focus groups a key factor in low walkable areas was that areas were not overlooked. Other people using the street, houses facing onto the street and active shop fronts contribute to the concept of overlooking. It was highlighted that the ground floor interface is critical: *'Residential areas that have the original village cores etc., what makes a huge difference, I think, is that you have every inch of the street overlooked by adjoining buildings. One of the difficulties with for example estates, build around the 60's was that there are large sections of road which are sometimes not overlooked and there are a lot of blank walls. That in my mind makes an enormous difference in terms of how walkable those streets area in terms of the sense of security and safety'* [1, LA]. '*The ground floor interface is extremely important'* [1, UD]. Consistently throughout all the focus groups the lack of activated frontage or potential for people to overlook onto streets from their homes and blank walls alongside footpaths was the primary reason given for feeling unsafe from personal crime in any area discussed. Laneways, large walls, buildings facing away from the street and shutters on shop fronts all remove the opportunity for overlooking. '*its that lack of an activated work front, or shop front that you could, like even if you don't use the shops, they just feel that there more overlooked and secure and from a personal safety point of view'* [2, LA]. This concept is known as transparency in urban design. It 'refers to the degree to which people can see or perceive what lies beyond the edge of the street or other public space and, more specifically, the degree to which people can see or perceive human activity beyond the edge' (Ewing et al. 2006, p.S226). A measure of transparency developed by Ewing and colleagues (2006) was found to have a significant relationship with walkability in their regression model with a weighting of 0.14, third in magnitude after human scale and enclosure. Transparency and overlooking provide a comfort to the pedestrian that they are not alone.

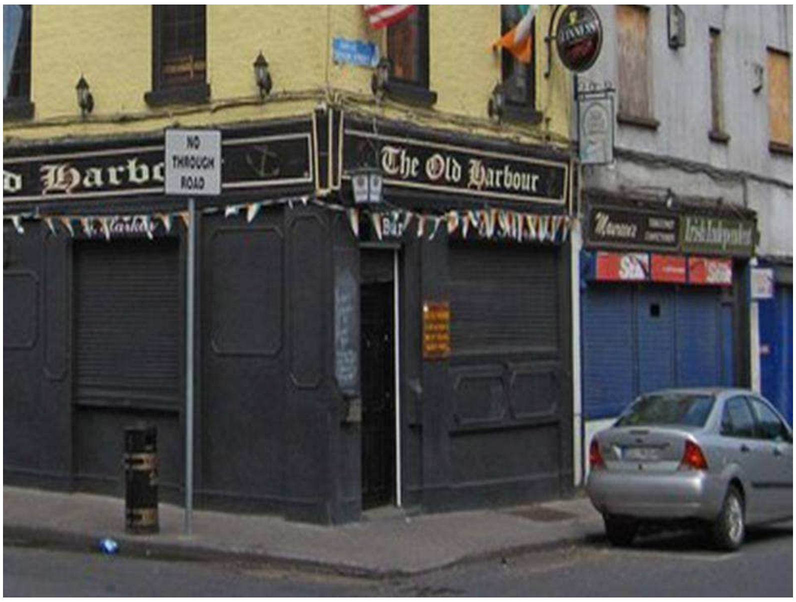

Figure 4-31: Shutters

4.3.7.7 Familiarity and personal safety (Sub theme 6.7)

Several participants suggested that an area should be classed as 'low walkable' because of perceived risks: *'Yes you can walk around it but you would think very carefully, if you are not from that area, about where you would go'* [1, LA]. *'That's probably what stands out to us and we don't want to walk down that road but as you say, people from the area probably do. They say 'oh yeah, if I go down this laneway it brings me to x'. Whereas we don't know [agreement] what is on the other end as we can't see it'* [1, SP]. Participants openly acknowledged that this was possibly due to their own prejudice but they would feel threatened walking in those areas. The areas mentioned were predominantly deprived suburbs. Some city centre areas were mentioned but as one participant noted *'I think the suburb here is more to do with people being afraid of what they don't know and afraid of walking down a lane in case. Whereas in the city, you may be more observant because certain places have a name for bad behaviour so you just don't go there at all'* [3, PR]. In all of these areas deprivation and risk of crime influenced the perception of a threat to their personal safety. However design features were also identified which influence this insecurity, most commonly visual cues such as graffiti and overlooking. Lynch (1965, pp.4-5) describes familiarity as giving an important sense of emotional security. Lysaght and Basten (Date Unknown) in their qualitative study investigating spatial practises in

Belfast concluded that unwritten rules create geographical divisions on a micro scale where fear of violence curtails spatial practises and residents feel obliged to re-negotiate routes in times of heightened tensions. Subjective local knowledge, incidents and personal experience were found to contribute to spatial practices similar to Coakley's (2003) findings in Cork.

In summary, Criteria 3, Streetscape: A walkable streetscape is built to human scale, has active frontage on buildings facing the street, shop fronts or front doors with day-long usage. Attractive routes with a variety of uses. In a walkable area there are other people using the street and every inch of the street is overlooked. The appropriate use of natural features is encouraged. A walkable area does not have narrow laneways or blind corners or streets that people avoid or fear crime.

4.4 Discussion

The first purpose of this study was to facilitate in-depth analysis of the multi-dimensionality of walkability in Dublin using a qualitative study incorporating a variety of professional opinions and personal experiences. As suspected, based on the findings of study one, this study confirmed that professional training does influence how walkability is perceived. While the reasons for selecting high and low walkable areas varied based on an individuals views there was little disagreement on the areas selected. Acknowledgements were made to influences on perspectives under themes one and two. The use of the generalised term 'walkability' for studies which just consider specific micro or macro environments or behaviours with specific purpose (i.e. recreational walking) can result in conflicting results and non-transferable research (Section 2.10). The inductive approach taken by this study exploring walkability with particular reference to familiar geographies embraces perceptions which may be influenced by both professional and personal factors. This results in a deeper exploration of walkability and perceptions of the environment. A consideration for the range of perspectives given in the focus group study to ensure a holistic definition of walkability is a key strength of this research. A lack of disagreement within the focus groups may be due to a participation bias with only those concerned or interested in pedestrians welfare attending.

The importance of human scale in the design of pedestrian friendly environments is a key finding of this study and is consistent with Ewing and colleagues urban design walkability index (2006). Previous research has focused on density as a key determinant of walkability with predominantly positive but some contradictory results (Brownson *et al.*, 2009; Forsyth *et al.*, 2007; Frank *et al.*, 2008, 2010). While high density areas facilitate the provision of services there are also negative associations with high density at a micro level such as crowding (Schurch, 1999; Gehl, 2010). Further research on the contextual relevance of density at a micro scale and its relationship with human scale is required. The walkable village concept encompasses the provision for everyday services at an accessible scale. The importance of a liveable village structure or frequent, accessible service nodes within a comfortable urban structure took priority over the density of the area, in the focus groups. Suggestions were made that the two elements are related but are not mutually exclusive. It is proposed that some walkability research (Sallis *et al.*, 2009; Van Dyck *et al.*, 2010) may be confusing density for scale but using residential density as a proxy as it is easier to measure.

A number of issues were identified in the focus group study which divided the term connectivity from its commonly used synonym permeability. Identified barriers to movement were both physical and perceptual. Perceived barriers were often facilities constructed by engineers to aid movement such as badly designed pedestrian crossings or overpasses. In future studies, facilities which increase permeability scores on existing audit or objectively measured scales, need to be reviewed in context of desire lines, ease of use and functionality. Focus group findings suggest individual historic spatial associations with familiar micro-geographies similar to previous research in environmental psychology (Anderson, 2004; Kusenbach, 2003; Brown *et al.*, 2007; Gustafson, 2001; Coakley, 2003). A pedestrian's perceptual response to an area may have greater influence on the decision to walk or not than auditable objective built environment characteristics. Further research is required to explore the differences between objectively measured features of the environment and how they are perceived and what influences these perceptions.

The streetscape or path context plays a particularly important role in walkability. However a desire for variety and diversity on streetscapes means that conventional streetscape audits which do not consider street context can misrepresent the walkability of the area. Recent research that encompasses urban design measures such as scale, transparency and variety (Ewing 2006) and identifiers of visual cues through qualitative data combined with recall questionnaires (Brown 2007) have been very informative. However further investigation is required on the psychological responses to area characteristics.

The results of this study and this discussion highlight limitations in current physical activity and built environment research. This was achieved by returning to first principles and examining perceptions of the environment informed by professional knowledge from complementary fields. Studies have engaged professionals in their walkability research but never in such a comprehensive manner. Using a socio-spatial methodology where the selected areas were common reference points facilitated discussion with multi-disciplinary perspectives.

The second purpose of this study was to develop a list of walkability criteria to select high and low walkable areas for further study. The developed criteria are comparable to previously produced scales, summaries and constructs for walking or walkability published under a variety of professional disciplines. Table 4-2 shows how the developed criteria complement published scales and encompass considerations from the various professional fields, some of which are not considered in discipline specific scales.

One criterion, which is represented differently on the scales, is safety. Lo (2009) describes safety as being from traffic at road crossings. Southworth (2005) and Pikora (2003) describe safety as being from both traffic and social crime. Alfonzo (2005, p. 827) describes safety as a lack of fear of crime from visual disorder, particular land uses and the presence of certain groups. Content analysis undertaken in this study did not generate/identify a safety theme or sub-theme but the concept was integral in almost all of the themes produced. Threats to safety highlighted by the participants were directly related to bad infrastructural design which that can leave a pedestrian vulnerable to passing traffic or from an absence of eyes on the street. Areas where bad design, particularly not overlooked disconnected areas with low or no passing foot traffic, resulted in groups of people taking ownership of the area and engaging in anti-social behaviour presented a perceived threat. Under the produced criteria safety from traffic is integrated into ‘connected street network’, ‘pleasant atmosphere’ and ‘sufficiently wide good quality footpaths’. Safety from social crime is integral in the ‘routes overlooked’, ‘no visual disorder’ and ‘atmosphere’ criteria. Foster and Giles-Corti (2008) found many inconsistencies in research relating safety from crime, disorder and overlooking/surveillance with neighbourhood walking. However, they noted that neighbourhood maintenance and visual cues for disorder warrant attention in research on neighbourhood level perception of safety and physical activity behaviours.

Table 4-2: Comparison of built environment scales, summaries and constructs for walking/ walkability

Developed Criteria	Schurch 1999	Southworth 2005	Lo 2009	Handy 2002	Sallis 2009	Ewing 2006	Gehl Architects (Van Deurs, 2009)	Pikora 2003	Alfonzo 2005	Cullen 1971	Moudon & Lee 2003	Urban Design Compendium (2000)
1. human scale	Human scale and Pedestrianisation			Street scale		Human scale Enclosure						
2. identifiable place	Place - meaningful to events in daily lives		Visual interest and a sense of place as defined under local conditions			Imageability	Local character					Convivial
3. accessible facilities – Village	Density - attainment of compactness which promotes mixed use	Fine grained land uses	Land use density	density and intensity	Residential density		Density			Place	Origin/ Destination	
4. recreational walk facility nearby	Mixed and compactable uses - rather than isolation by zoning practices		Building mix and land use diversity or mix	Land use mix	land use mix and Retail floor area		Mixed use	Destination				
5. connected street network **9. seamless connections to adjacent areas** **10. no major barriers to access the greater city area**		Connectivity	Path directness and street network connectivity	Street connectivity	Intersection density		Connectivity		Accessibility	Serial vision	Route	Connections Conspicuousness (legible) Convenience
6. not severed by large fast through road			Absence of heavy and high speed traffic						Comfort			

Table 4-2 cont.

Developed Criteria	Schurch 1999	Southworth 2005	Lo 2009	Handy 2002	Sallis 2009	Ewing 2006	Gehl Architects (Van Deurs, 2009)	Pikora 2003	Alfonzo 2005	Cullen 1971	Moudon & Lee 2003	Urban Design Compendium (2000)
8. good public transport access		Linkage to other modes		Regional Structure								
7. sufficiently wide, good quality footpaths	Built environment - consideration for place and scale etc	Quality of Path	Presence of continuous and well maintained footpaths Universal access characteristics					Functional	Comfort			
12. pleasant atmosphere contextual to area characteristics	Human culture - Sense of community						User participation			Content	Area	
11. visual interest along routes	Public Realm Natural environment	Path context	Street trees and landscaping	Aesthetic qualities		Transparency	High quality public realm	Aesthetic	Pleasurability			Comfortable
13. no visual disorder						Tidiness						
14. routes overlooked with doors onto the street		Safety	Safety of at-grade crossing treatments					Safety	Safety			
Considerations							Adaptability		Feasibility			
Understanding walkability							User participation					

The limitations of this study were that the length of the exercise to identify areas and the related discussion varied between focus groups and on occasions not all identified areas were discussed due to time constraints. All groups took approximately twice the time outlined on the original invitation. While the research group suspected this may happen it was decided to invite participants for a one-hour group to ensure we would get participants. Some participants had to leave before completion of the exercise as a result. There was a potential bias in the site selection based on our participant sample. Our sample was an educated group who are more likely to live and be familiar with affluent areas of the city. This may have influenced why only two high walkable deprived areas were identified. Another limitation was that participants only contributed to the discussion about areas which they were familiar with. Conducting this focus group exercise in a mobile unit which visited the areas being discussed would have further enhanced the research (Kusenbach, 2003). However, this would have been time consuming and costly. Alternatively a video or images could have been shown similar to Ewing and colleagues (2006) of areas being discussed. This was also unfeasible as it would have involved preparing materials for the whole city.

Strengths of the current study included using a structured focus group approach which allowed interaction between all the participants. Asking people to identify and discuss areas they are familiar with facilitated discussion on actual areas rather than theories being discussed without context. The use of familiar environments also allowed for discussion on the perceptions of comfort and sense of safety and what environmental characteristics impacted on these perceptions. Macro, meso and micro scale characteristics which influence walkability were identified and incorporated into the developed criteria. No example of this was identified in public health walkability research.

Safety as an element of walkability was considered within the contexts of the structural elements of the built environment which could cause a pedestrian to feel unsafe. In the case of threats to personal safety the structural aspects of the environment which contributed to these threats were noted.

4.5 Conclusions

Identified themes were grouped into appropriate categories. Three categories became apparent, with positive walkable aspects and negative low-walkable aspects, and two sub themes common to all three categories.

1) The village scale, a liveable neighbourhood with a recreational walking destination nearby
2) A permeable area easy to move through and easy to move into other areas of the city from either on foot or using public transport
3) The path context with active street fronts that provide eyes on the street

The two sub-themes that ran through all three criteria were considerations for the individual and scale. The fourteen key criteria constructed from the analysis of the focus group discussion are outlined in table 4.3.

Table 4-3: Walkability Criteria

A walkable area…

Core Theme	1.	is built to human scale
Village	2.	is an identifiable place
	3.	has accessible facilities in a village centre or frequent nodes
	4.	has a recreational walk facility nearby
Permeability	5.	has a connected street network within the area with various routes available
	6.	is not severed by a large, fast through road
	7.	has sufficiently wide, good quality footpaths
	8.	has good public transport access
	9.	has seamless connections to adjacent areas
	10.	has no major barriers to access the greater city area
Streetscape	11.	has visual interest along routes
	12.	has a pleasant atmosphere contextual to area characteristics
	13.	has no visual disorder
	14.	has routes overlooked with doors onto the street

The current study provides a comprehensive insight into key factors influencing the walkability of an area contextual to Dublin. Using the criteria constructed from this study to select study sites should ensure high and low walkable areas are selected which incorporate elements of macro and micro scale area characteristics which has not previously been done in physical activity research. Further work is required to develop these criteria to ensure their transferability to other cities, towns, villages, climates and cultures.

The benefit of this research for public health is that merging research from a variety of disciplines facilitates the production of recommendations relevant to a variety of stakeholder groups. This research also highlights discrepancies identified in heath science research particularly around the contextual nature of environmental perceptions. This study highlights the importance of trip context and pedestrians mood on route choice. Previously, links to socio economic status and demographics were the primary considerations in research on perceptions.

4.6 Future Work

Future research should utilise qualitative methodologies within the areas being studied to increase the reliability of the information rather than relying on memories of areas which may have undergone improvement or development.

Areas of high and low walkability should be selected to reflect the developed criteria and a population study should be carried out to determine if the residents of the areas agree with the views of the focus group participants.

Further research into the relationship between walkability, human scale and density should be carried out to determine the relationship between the three concepts.

5 Study 3 - Site Selection and Validation using Objective Measures

5.1 Introduction

The most commonly used method for selecting sites in city-wide walkability studies is using GIS datasets and census data to stratify areas using walkability and socio-economic status (SES) measures (Brownson *et al.*, 2009). In a review of walkability studies, a gap was identified between GIS objective environment measurements which contain little or no street level context and audit tools which emphasise aesthetic features. In the review of literature a need for a site selection method which encompasses both was identified (Section 2.9). While Ewing and Handy's (2009) walkability model based on urban design principals considers more street level variables than other GIS site selection methods, developmentally it is still in its infancy and also requires numerous detailed GIS datasets to implement it (Purciel *et al.*, 2009). Given the complexity of walkability, as revealed in study two, to create an accurate as possible representation of high and low walkable areas a site selection method should include as many identified characteristics of walkable communities as is feasibly possible given the data available to researchers.

The purpose of this chapter is to outline the methods employed to select sites for the CGL population study. The aim of the CGL study is to investigate the relationship between the built and social environment, and walking and motorised transport behaviour in the GDA. The aim of this study is to select high/ low walkable and deprived/not deprived neighbourhoods for a cross-sectional population study. The methods used consider both the neighbourhood structure and the street level characteristics and encompasses urban design principles including imageability and scale. The 5-step process to identify sites used a novel method which encompasses local professional knowledge, objective GIS measurements and a holistic working definition of walkability developed in the previous study (study two).

The method used in this study is complementary to the IPEN international projects (Brownson et al. 2009; Sallis et al. 2009, Section 2.7.6) as it includes the WI constructs in the objective analysis of selected areas to allow for international comparison. The WI index comprises of objective measures of residential density, connectivity and land use diversity. Limited availability of GIS datasets of relevant environmental and social measures at representative neighbourhood scales for the GDA was a research challenge. A recent review of walking measurement in Europe, concluded that evidence suggests reliable, rigorously collected and spatially compatible data about walking and the quality of public space for walking is still widely missing (Sauter and Wedderburn, 2008; Sauter and Tight, 2010).

Some walkability studies undertake street level audits on areas shortlisted using the WI GIS Index to collect further information on the selected areas (Brownson *et al.*, 2009; Badland *et al.*, 2009; Van Dyck *et al.*, 2010). Relationships between neighbourhood audit scores and physical activity behaviours are analysed to investigate relationships. However, as these attributes were not considered in the assignment of a walkability status to the area, for example negative aesthetic scores or perceived barriers to movement, they do not alter the walkability status of the area. Excluding street level information on the physical realm through which a pedestrian moves, taints the validity of the assigned walkability status. Barriers to walking, both physical and perceived, which effect pedestrian route and modal choice, were identified as being crucial to the walkability of areas by participants in study two. A walkability score which reflects the true street level characteristics along with the functional structure of an area would give a better reflection of the walkability of the area, making the assigned 'walkability' score more relevant by acknowledging the multidimensionality of the term.

The density, connectivity and land use mix of the selected sites are objectively measured using GIS measures for comparability to international studies such as the IPEN project. Street level site visits for verification of criteria scores and ground truthing were also carried out to include street characteristics in the assignment of a neighbourhood walkability rating. The steps taken in the site selection process are described and the shortlisted areas remaining after each stage are outlined at end of each section. The purpose of this study is to identify and categorise twenty neighbourhoods in the GDA in four categories (high walkable not deprived, high walkable deprived, low walkable deprived and low walkable not deprived) where walkability ratings reflect the findings of study two of this thesis.

5.2 Procedure

The procedure used involved five stages which are presented as individual methods in this chapter. By applying each successive method the number of areas on the shortlist of potential study sites was reduced. The methods used to apply each method area outlined in detail, they were:

1. Focus Group Site Identification
2. Deprivation Assessment
3. GIS Assessment
4. Expert Review & Ground Truthing
5. GIS Review

5.3 Site Selection Method 1: Site Identification

5.3.1 Introduction

Following study one an identified need for a qualitative investigation to further explore the understanding of walkability among identified stakeholders presented an opportunity to enlist the expertise of these individuals for the site selection process, study two.

5.3.2 Procedure

Study two, section 4.2, outlines the process used in the focus groups. Participants in each focus group were asked to select six high walkable and six low walkable areas in the GDA. Two high and low walkable areas in each of the inner city, outer city and the suburbs were required to ensure a geographic dispersion of areas. Region boundaries were marked on maps (Ordnance Survey Ireland 2007, scale 1:50 000 GDA & 1:15 000 inner city) given to participants to assist in their area selections. Examples of participant's maps from the focus group exercise are shown in Figures 5-1 and 5-2. In the focus groups, the reasons for area selection were discussed. This method facilitated both the investigation of the characteristics of high and low walkable areas informing walkability criteria, study two, and short listing potential areas for further study. An advantage of this method is that validation of the area selections can be carried out by referring to the focus group scripts.

The focus group study comprised of five groups with a total of 26 participants who were identified professionals involved in the design and construction of the built environment, public representatives, physical activity advocates and public health professionals. There were a number of inclusion criteria for the purpose of this study. These were (i) participants were required to have personal experience of walking or spending time in the area, (ii) recreational destinations or areas predominately referred to because of a recreational destination in the neighbourhood were excluded and (iii) areas must have a residential population of sufficient size and density relative to the area to survey[42]. This was a particular concern in higher density areas where the morphology[43] of an area could change significantly within a few streets.

Individuals who expressed an interest in participating in the focus group study but could not attend were sent a weblink to a survey asking them to select areas, in the same categories selected in the focus groups, with their reasons for selection. This supplementary information was collected via a weblink on an email to a survey host website (www.surveymonkey.com). No definition of walkability was given to participants before the exercise. This data was considered alongside the data collected in the focus groups.

Focus group recordings were transcribed verbatim. A frequency count of identified areas was carried out on the qualitative data. In this analysis areas were (i) grouped geographically, (ii) area selections were reviewed for inclusion criteria and (iii) the data results were compiled to produce a summation of why areas were selected as high or low walkable. Tables were produced summarising these grouped areas and the reasons for their selections. An example of these tables can be seen in appendix D.1. It was necessary to group areas as inner city as references were often as localised as a single street. The converse occurred in suburban areas where areas were frequently selected as generalised regions requiring the moderator to seek clarification on the particular area being discussed. Summary tables outlining the frequency of valid area

[42] This means that in an identified area there needed to be a sufficient population within an area which reflects the characteristics which make the area high or low walkable.
[43] grain and character

selections were produced using information from these tables, Tables 5-1 & 5-2. This list of areas formed the short list of areas for consideration.

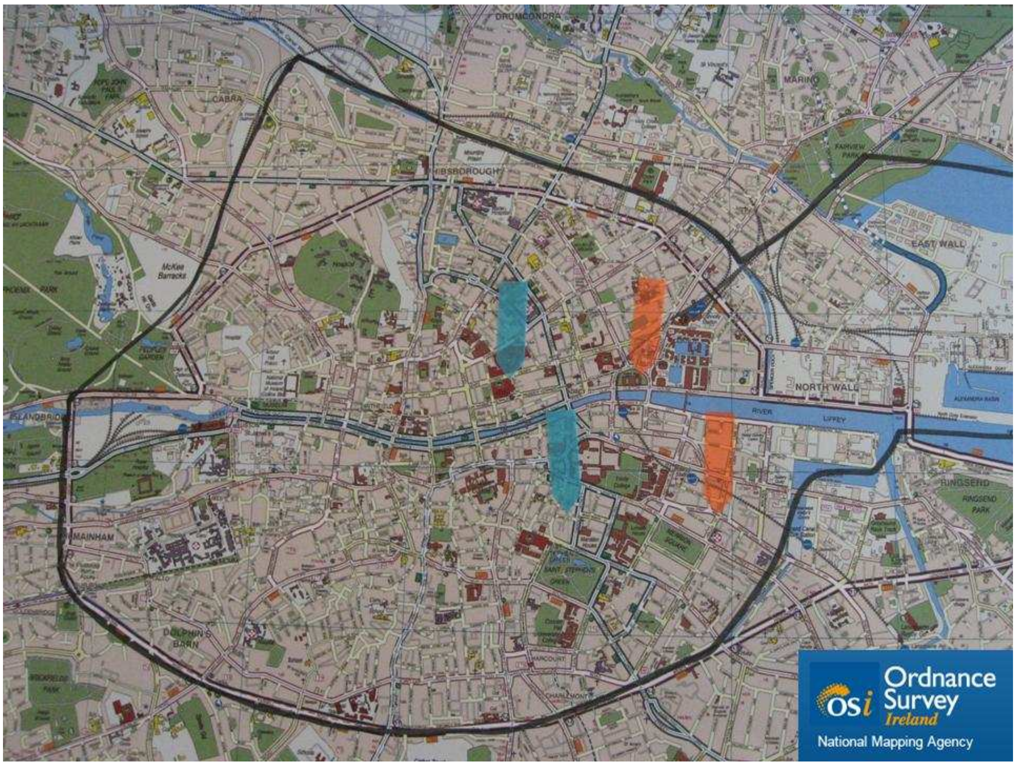

Figure 5-1: Site selections made by a focus group participant for inner city areas (mapping scale: 1:15 000, image not reproduced to scale) © Ordnance Survey Ireland/ Government of Ireland Copyright Permit No. MP 0009612

Figure 5-2: Site selections made by a focus group participant for outer city and suburban areas (mapping scale: 1:50 000, image not reproduced to scale)© Ordnance Survey Ireland/ Government of Ireland Copyright Permit No. MP 0009612

5.3.3 Results

A total of 316 area selections were made during the focus group study, 156 high walkable and 156 low walkable selections. One hundred site selections were made by individuals who expressed an interest in being involved in the study but could not attend a focus group. Following analysis, 39% (n=61) of the high walkable focus group area selections remained valid across 14 geographic areas (Table 5-1). This low percentage was because a high number of selections did not meet the study's inclusion criteria, for example, recreational destinations such as seafront promenades and urban parks which have little or no residential populations. The walkability criteria developed in study two of this thesis, chapter four, take account of the importance of the proximity to recreational walking facilities in walkable areas. Therefore the importance attributed to the availability of recreational facilities was not lost. These developed walkability criteria are applied to areas in method four (section 5.6) of this chapter. Table 5.2 shows the 110 (71%) valid low walkable focus group area selections across 15 geographic areas. An additional two areas were included on table 5.2 from the online selections.

Table 5-1: High walkable areas from focus group study

Area (Zone)	Frequency of Focus Group Selection	Frequency of Online Selections
Ranelagh/ Rathmines (O)	10	3
Dalkey (S)	12	0
Sandymount (O)	8	2
Portobello/ South Circular Road (I)	8	1
Malahide Village (S)	5	2
Drumchondra Iona (O)	3	3
Blackrock (O)	4	0
Swords Village (S)	2	1
Maynooth Village (S)	2	1
Rathfarnham/ Bainteer (O)	2	0
Monkstown (O)	2	0
Adamstown (S)	1	0
Stoneybatter village (I)	1	0
Blessington St (I)	1	0

Zones: I – inner city, O – outer city & S – Suburbs

Table 5-2: Low walkable areas from focus group study

Area (Zone)	Frequency of Focus Group Selections	Frequency of Online Selections
Blanchardstown Environs (S)	16	3
Tallaght Environs (S)	11	3
Quays (I)	12	1
Summerhill, Sherriff St, Amiens St (I)	8	2
Clondalkin Area (S)	8	2
Thomas St/ Cork St (I)	9	0
Stoneybatter/ Smithfield/ Phibsboro Environs (I)	8	1
Swords Suburbs (S)	8	1
Walkinstown (O)	7	2
Coolock, Darndale, Artane, Omni, Beaumount (O)	6	1
Crumlin (O)	6	1
Sandyford Industrial Estate (O)	6	0
Ballyogan/ Stepaside/ Cabinteely (S)	5	0
Lucan housing estates (S)	0	1
Balgriffin (S)	0	1

Zones: I – inner city, O – outer city & S – Suburbs

5.3.4 Review

This first method provides a solid foundation on which to begin to build the site selection process. The advantages of this method are that the selected areas have been validated by professionals who are familiar with the city. Prioritisation for the areas which received the most nominations also further strengthens this validity.

A limitation with objective site selection methods highlighted by research is that areas selected using GIS stratification techniques may not reflect real communities (Badland *et al.*, 2009; Van Dyck *et al.*, 2010; Lovasi *et al.*, 2009; Lee *et al.*, 2006; Brennan Ramirez *et al.*, 2006). This was also highlighted as a limitation in this study when considering the spatial geographies of available GIS data (Section 2.6.7). The short listing of areas identified by city residents and people with knowledge of the city increase the likelihood that these areas are functioning communities. This is particularly true of distinguishable high walkable village areas with high imageability. The converse is true of low walkable areas identified where suburban regions identified were large areas without a core. Methods to identify operational communities in these large sprawling areas were needed. The further methods used and outlined in this study facilitate this functional community/ area identification.

The cleaner, greener, leaner study hypothesis includes that walkability is influenced by socio-economic status. To investigate this hypothesis, sites of varying socio- economic status as well as varying walkability needed to be identified. The next step in the site selection process, method two, applies a deprivation score to the selected areas.

5.4 Site Selection Method 2: Deprivation Assessment

5.4.1 Introduction

The purpose of this second method is to assess the SES classification of the remaining short listed areas. SES is a strong and consistent correlate of physical activity and is a major source of health inequalities (Cerin *et al.*, 2009b; Brownson *et al.*, 2009; Van Dyck *et al.*, 2010). However, the associations of SES with walking for transport are less clear (Cerin *et al.*, 2009b). Evidence suggests that the SES of a neighbourhood can impact on how walkable it is perceived by its residents. In particular, perceptions of aesthetical features, evidence of social disorder and perceived neighbourhood safety can have a negative impact (Cerin *et al.*, 2009b; Brown *et al.*, 2007; Kamphuis *et al.*, 2010; Giles-Corti and Donovan, 2002). Research has identified that neighbourhood SES moderates the relationship between walkability and physical activity. However this moderation is context dependant and requires further exploration (Van Dyck *et al.*, 2010).

International walkability studies which have investigated the walkability/ SES link, have used single (income) or composite (including education level, job status and home ownership) measures derived from census data (Van Dyck *et al.*, 2010; Cerin *et al.*, 2009b; Sallis *et al.*, 2009; Kamphuis *et al.*, 2010; Kingham *et al.*, 2007; Lovasi *et al.*, 2009; Hoehner *et al.*, 2005). Income information is not collected in the Irish census of population because of low response rate to a piloted question on income (CSO Central Statistics Office, 2004). Demographic information which could be used for this study to construct an SES composite measure was only available at ED level.

Limitations presented by the size and boundary positions of ED areas have been outlined in section 2.6.7. RAPID[44] areas were identified in the GDA. However, the geographies of the RAPID areas did not correspond to census electoral district (ED) maps or data and as a result acted only as guidance to where the most deprived regions were within the GDA. The publication of the Haase Deprivation Index on census small areas facilitated the progression of this study (Haase and Pratschke, 2008).

5.4.2 Haase Deprivation Index and Census Small Areas Mapping

The Haase deprivation index (Haase and Pratschke, 2008) and census small area boundaries became publically available on a web-based GIS interface hosted by Pobal[45] in May 2011 (www.maps.pobal.ie). The 'Haase' deprivation index, developed by social and economic consultant Trutz Haase, is a relative index derived from three dimensions, i) demographic profile, ii) social class composition and iii) labour market situation. It has been applied to census data since 1986 to compare deprivation scores of ED areas over time (Haase and Pratschke, 2008). The relative index score is calculated, against the national average, to standardise the measurement of relative affluence or deprivation in a given area at a specific point in time. The national mean score is set to zero. Results are presented on interactive GIS mapping, colour coded at ED or small area level[46]. The scale has eight points, ranging from extremely disadvantaged (red) to extremely affluent (dark blue/purple) (Haase and Pratschke, 2008), Figure 5.3.

In order for this study to control for SES, information at small spatial scales was needed. Figure 5-3 shows the Pobal Deprivation Mapping with representation of the relative deprivation scores and small census areas on OS street mapping in a city centre area. From this map it can be seen that the relative affluence/ deprivation can

[44] Revitalising Areas by Planning, Investment and Development. These are areas of high deprivation identified for priority investment by the National Development Plan (Government of Ireland, 2007).

[45] Pobal is an intermediary company working on behalf of the Irish government to support local social and economic development in Ireland (Pobal 2010).

[46] Small areas are the new census geography developed jointly by the OSI and the CSO for the publication of the Small Area Population Statistics (SAPS) arising from the 2011 Census of Population. Small areas are sub divisions of EDs. Small areas have a minimum of 65 households, a mean of 92 and a maximum of 900 households. Pobal deprivation mapping displays relative deprivation scores at the new small area level (Pobal, 2010).

vary greatly within a few city blocks. Access to relative deprivation scores at small area level facilitated the identification of deprived and non-deprived neighbourhoods, particularly in city centre areas, where affluent and disadvantaged areas were previously within the same ED, influencing the mean deprivation score of the ED, Figure 5-4. These small area site geographies and associated deprivation information facilitated the final site selection.

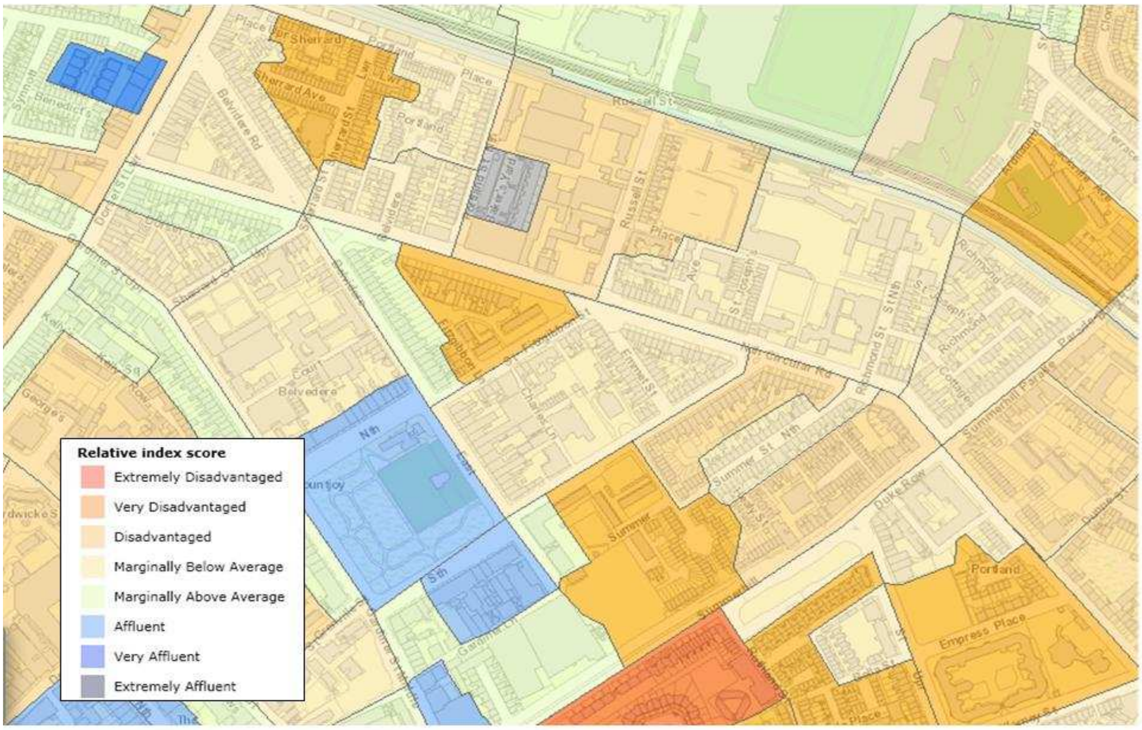

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Figure 5-3: Pobal deprivation mapping (reproduced with permission from Pobal)

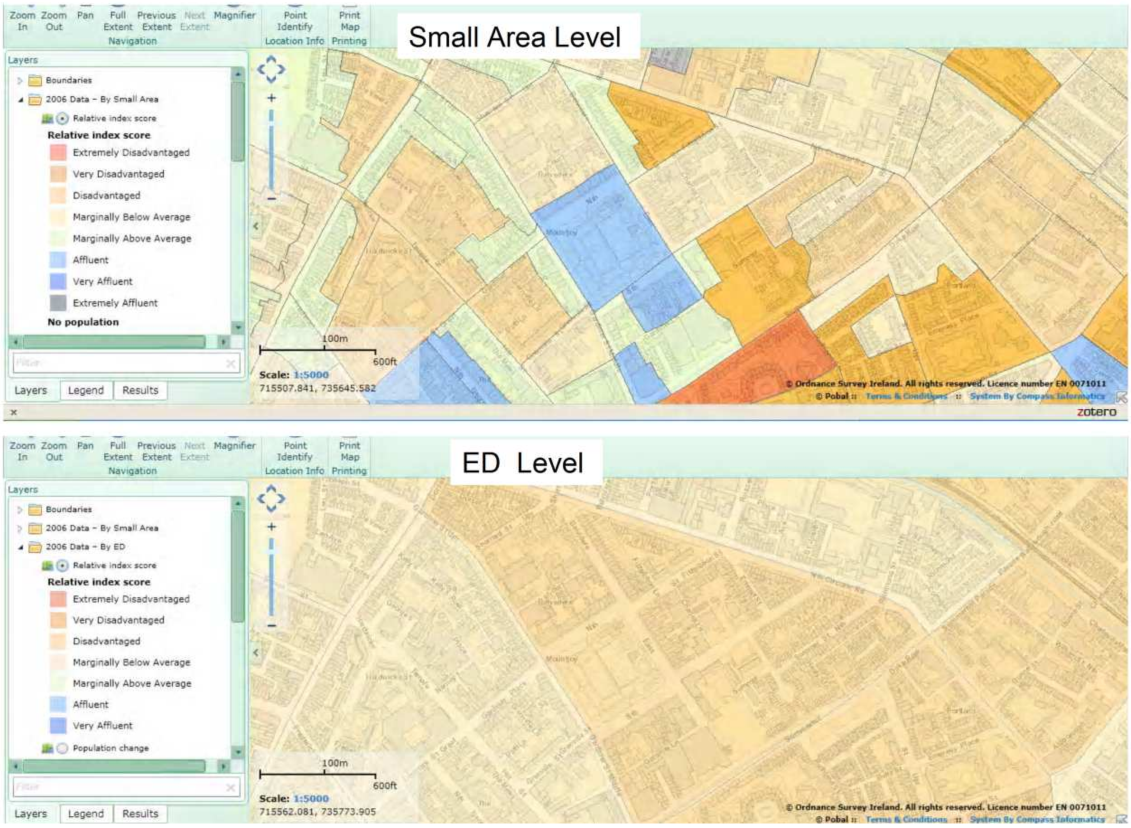


Figure 5-4: Small area deprivation mapping data versus ED level data (reproduced with permission from Pobal)

5.4.3 Procedure

The procedure used to assign SES/ deprivation scores to shortlisted areas used the Pobal Deprivation Mapping to establish if areas were deprived or not deprived. The interactive mapping was consulted in a desktop study.

5.4.4 Results

Tables 5-3 and 5-4 outline the deprivation scores of the shortlisted areas. Some areas have sections of the area which are deprived and sections which are not deprived as shown in Figure 5-4 above. The predominant rating (PDM) was assigned to the area. Areas where a relatively even divide was observed were assigned a ‘mixed’ status.

Table 5-3: High walkable areas from focus group study with deprivation scores

Area (Zone)	Selections	PDM
Ranelagh/ Rathmines (O)	13	Not Deprived
Dalkey (S)	12	Not Deprived
Sandymount (O)	10	Not Deprived
Portobello/ South Circular Road (I)	9	Not Deprived
Malahide Village (S)	7	Not Deprived
Drumchondra Iona (O)	6	Not Deprived
Blackrock (O)	4	Not Deprived
Swords Village (S)	3	Not Deprived
Maynooth Village (S)	3	Not Deprived
Rathfarnham/ Bainteer (O)	2	Not Deprived
Monkstown (O)	2	Not Deprived
Adamstown (S)	1	Not Deprived
Stoneybatter (I)	1	Deprived
Blessington St (I)	1	Deprived

Zones: I – inner city, O – outer city & S – Suburbs

Table 5-4: Low walkable areas from focus group study with deprivation scores

Area (Zone)	Selections	PDM
Swords Suburbs (S)	9	Not Deprived
Sandyford Industrial Estate (O)	6	Not Deprived
Ballyogan/ Stepaside/ Cabinteely (S)	5	Not Deprived
Lucan housing estates (S)	1	Not Deprived
Balgriffin (S)	1	Not Deprived
Blanchardstown Environs (S)	19	Mixed
Tallaght Environs (S)	14	Mixed - Deprived
Walkinstown (O)	9	Mixed
Coolock, Darndale, Artane, Omni, Beaumount (O)	7	Mixed - Deprived
Summerhill, Sherriff St, Amiens St (I)	10	Deprived
Clondalkin Area (S)	10	Deprived
Thomas St/ Cork St (I)	9	Deprived
Stoneybatter/Smithfield/ Phibsboro (I)	9	Deprived
Crumlin (O)	7	Deprived

Zones: I – inner city, O – outer city & S – Suburbs

A percentage agreement of 97% was observed between high walkable and not deprived areas. Low walkable areas selected by focus group participants showed greater SES diversity than high walkable selections and included deprived and non-deprived areas. This method was applied to streamline the site selections into four categories, one of which was incomplete (high walkable deprived) following this method. High walkable areas tended to be closer to the city centre or the coast whereas low walkable areas were predominantly in the outer city or western suburbs. Inner city areas listed as low walkable areas were areas along major traffic thoroughfares with high concentrations of social housing.

5.4.5 Review

An unavailability of consistent SES data for the GDA at a sufficiently small spatial scale which could reflect operational neighbourhoods presented a challenge to this research. The Haase Deprivation Index (2008) provided the solution, permitting the identification of deprived and not deprived areas at local small scale. The particulars of the deprivation index were not critically investigated as the SES of the selected areas will be verified using the population study. The primary reason for this is that the deprivation index is based in data from 2006 which was subsequent to the recession which has recently happened in Ireland, therefore making the data potentially invalid. It did however provide useful spatial data on which to base our study areas.

Walkability studies have identified that individuals with low incomes/SES show a less favourable neighbourhood satisfaction score, higher perceived danger from crime and lower aesthetic/attractiveness scores (Kamphuis *et al.*, 2010; Sallis *et al.*, 2009; Zhu and Lee, 2008; Neckerman *et al.*, 2009; Hoehner *et al.*, 2005). These studies selected their neighbourhoods using GIS indices of macro measures of density, connectivity and land use mix. Street level data is not considered in the assigned neighbourhood walkability score with the exception of Hoehner who identified areas with higher reported minutes of walking as walkable. The low number of deprived areas categorised as high walkable in this study was interesting and reflected these previous findings of negative perceptions of the environment in deprived neighbourhoods. While this association was interesting, this finding presented a challenge for this research. Additional areas needed to be identified for the high walkable deprived category. Section 5.4.7, researcher reflection addresses this limitation.

5.4.6 Researcher Reflection

Walkability studies have used census based data was used in conjunction with objective GIS measures of the environment to identify areas of varying walkability and SES (Frank *et al.*, 2010; Van Dyck *et al.*, 2010; Cerin *et al.*, 2007). This methodology assured that areas would be identified in each of the categories. Tables 5-3 and 5-4 outline the deprivation scores assigned to the selected high and low walkable areas. It was noted that only two deprived areas were listed in the high walkable section and only one low walkable not deprived area was not in the suburbs. Following further discussion one of the two areas selected, the Blessington Street area, was also deemed unsuitable for survey by the research team as the size of the residential area was small. The second high walkable deprived area Stoneybatter village's immediate surroundings also had more selections as a low walkable area than a high walkable area.

It was also noted at this point in the study, before proceeding to the next method, that suburban regions such as Clondalkin, Tallaght and Blanchardstown needed to be sub-divided into smaller areas. The small area mapping used in the deprivation study facilitated with the identification of smaller geographies within these regions. The next method, applying objective measurements using GIS, could not be carried out on a large number of areas as the outdated databases which were being used needed to be updated by the researcher. This task was time consuming and unfeasible for a large number of areas. Therefore only the top six areas in the high walkable not deprived category were examined.

Due to these limitations additional areas had to be identified. Section 5.4.8 outlines the process used to identify areas which were then, similar to all sites, subjected to the remaining site selection methods.

5.4.7 Addition of new areas to shortlist

Additional deprived areas that met the high walkable criteria established by the focus group study were required for sampling purposes. These included the inner city villages of Stoneybatter, Rialto and Eastwall, and the residential communities bordered by Mountjoy Square, Dorset Street and the Royal Canal along the North Circular Road. The three villages are areas similar in layout, age and character to Sandymount, Ranelagh and SCR/Portobello.

The deprived areas selected by the research team were all within close proximity to areas selected as low walkable by the focus groups. Two of these areas, Stoneybatter and Eastwall (selected as Sherriff St/ East Wall Road), were two of the four low walkable inner city areas selected by participants. The areas were reviewed using the developed walkability criteria and subsequently moved to the high walkable list.

Mountjoy Square is close to Summerhill which was listed as low walkable because of its heavily trafficked road and seedy atmosphere. Eastwall village is close to Eastwall road, Sherriff Street and the Docklands. These areas were selected as low walkable because of high concentration of industrial uses, no overlooking, an association with drug users, heavily trafficked roads and poor quality of the pavements. It was suggested that the residential area 'was not bad' [1, TP] in terms of overall walkability compared to the low walkable areas describe in its vicinity but was cut off by old railway lines and heavily trafficked roads. The scale of the new development around the village has a negative impact on the surrounding areas [1, LA]. The majority of negative areas listed near East Wall are at the Docklands side of the village and not between the village and the greater city. East Wall village is within walking distance, less than 1 kilometre, of Fairview Park and Clontarf seafront which was listed as a high walkable recreational walking destination.

Rialto village is close to Cork Street, Clanbrassil Street and Dolphins Barn. These areas were listed as low walkable because of high trafficked roads with bad crossings where priority is given to vehicles. Cork/ Thomas Street areas were described as having a 'depressing atmosphere' [5, Architect] with associations of anti-social behaviour and deprivation. A derelict, 'sad part of the city' [2, PHA]. Large institutional blocks in Dolphins barn were described as a 'threat to personal safety by design' [1, UD]. Rialto village is a quaint well connected red bricked Victorian village with a mixture of locally owned businesses. It is linked to the greater city by frequent bus services and a LUAS (tram) stop. While the surrounding areas have fast heavily trafficked roads the South

Circular Road which runs through Rialto village moves at a much slower pace and the scale of the road does not impact negatively on the area, similar to the North Circular Road in the Mountjoy Square area. Rialto is within walking distance of both the Royal Hospital in Kilmainham and the Grand Canal, both listed as high walkable recreational walking destinations by the focus groups.

Stoneybatter village was described by one participant as having 'a nice villagy feel to it', 'an area which is both liveable and walkable' [3, Arch]. By reviewing the focus group summaries it was observed that two female participants noted a sense of a threat to personal safety in the area which is why they selected the area as low walkable. Stoneybatter village is within walking distance of the Phoenix Park, Europe's largest urban park. Similar to Rialto and Rathmines it has a heavily trafficked road going through it which moves slowly and does not impact greatly on the area because of its relative scale. Stoneybatter has diverse shops and amenities, the majority of which are locally owned.

All of the deprived high walkable areas have large institutional blocks of social housing nearby and while they have good connectivity within their immediate communities the areas are all cut off from the greater city on at least one side by these blocks or a large busy road. Mountjoy Square, Rialto and Stoneybatter all have busy roads going through them which move at a slower pace, similar to the Rathmines or Ranelagh Roads. While these roads are busy they do not impinge greatly on the areas. The North Circular Road (Mountjoy Square area) was used as an example of a good road by a focus group participant because of its trees and high visual interest in contrast to a road he considered low walkable. All areas have good public transport links and are within walking distance of the city centre.

In the low walkable suburban areas smaller geographies needed to be identified within the large suburban sprawl areas identified in the focus group study. A variety of sample areas were subjected to objective GIS measurements and further methods. The newly identified areas were considered in all further site short listing methods.

5.5 Site Selection Method 3: GIS Assessment

5.5.1 Introduction

Analysis of GIS spatial information datasets is the most common method used to identify study neighbourhoods for city-wide or international walkability studies (Brownson *et al.*, 2009). From the literature review (Section 2.6.4) it was concluded that the primary advantage of GIS datasets is to objectively analyse data relating to individuals or neighbourhoods dispersed across large areas, the results of which can be spatially displayed (Leslie *et al.*, 2007; Brownson *et al.*, 2009). This is a cheap and efficient method for citywide analyses; however effective GIS analysis relies on the assumption that the information provided is constant over the sample area and is therefore limited by the quality of the data available.

The most frequently assessed variables listed in Brownson and colleagues' review (2009) of measurement of the built environment for public health are population density, land use mix, access to recreational facilities, street pattern/ connectivity, vehicular traffic, crime and others including building design, public transit, slope and greenness/vegetation. Composite variables/ indices are also used. This information is usually obtained from city authorities and census databases. Due to the nature of the data used (i) little consideration is given to the streetscape when assigning walkability scores to areas, (ii) its suitability for macro studies of the environment may not translate to meso (neighbourhood) and micro scale studies and (iii) the data used can be biased depending on the purpose of its initial collection (Section 2.6.4).

Comparability to international studies was considered beneficial so the initial proposed site selection methodology for the CGL study was the WI walkability index methodology which has been used by the international IPEN projects (Section 2.6.5). This methodology involves stratification of areas into high and low walkability and high and low SES based on an assigned walkability score derived from GIS data, of residential density, intersection density, land use mix and retail floor area, and a SES score based on income or another measure of SES relevant to the region (Frank *et al.*, 2005; Leslie *et al.*, 2007; Badland *et al.*, 2009; Van Dyck *et al.*, 2010). When faced with data limitations these projects selected their areas based on the composite GIS measure using the data available to them (Section 2.6). A list of favourable GIS datasets which included measures of population density, land use mix, intersection density, retail floor area and proximity to public transport stops and recreational facilities for the GDA, based on our literature review (Section 2.7), were requested from relevant government departments and research centres. Additionally, GIS data on footpath coverage, vehicular traffic, pedestrian traffic, crime statistics, slope/ gradient of route, registered dogs, street lighting, regional accessibility, cycle paths, home age and socio-economic determinants (such as income, employment status and educational attainment) were requested as it would also contribute to the validation of sites selected for the population study. However consistent and reliable datasets for street (micro) level information were not available.

The Dublin Transportation Office (DTO), now the National Transportation Authority (NTA) (www.nationaltransport.ie), made GIS datasets available to the researcher. Proxy measurements of residential density, connectivity and land use mix were calculated using the Dublin street network and the Dublin Transportation Model (DTM). The DTM incorporated data from the CSO census of population 2006 POWCAR dataset which contained responses from the 2006 census 'mode of travel to work or school' question. This included geocoded origin and destination address points for regular work trips (Caulfield, 2012). GIS analysis was conducted at small area level as necessary updates to mapping and connectivity measures were practical which were unfeasible at a city-wide level. The DTM summarised selected POWCAR data into a 250 metre grid to anatomise results in a suitably small scale, however the data was not available at small area level. Population densities for ED's could be calculated from census data but these areas were large and contained a variety of neighbourhood structures and green spaces. This variety within the EDs made the information unreliable. Objective GIS measurements were calculated for the remaining shortlisted areas to inform further methods.

These limitations posed significant research challenges. The purpose of this study was to apply the data available to calculate objective measures of the environment which could be used to validate area selection and/or compare area selections to international walkability studies.

5.5.2 Procedure

Following the initial short listing and categorising of selected areas as a result of the focus group study into high/low walkable and deprived/not deprived categories (Tables 5-1 to 5-4) and the acknowledgement that more areas would be required, 27 areas underwent initial objective connectivity measurement using GIS[47].

The population density and land use mix measures reported under this method were calculated from merging the 250 metre DTM grid layer with a 1 km radial buffer from an identified point. The connectivity measurement, Pedshed (section 2.7.1), was also taken from this point. The areas used were to establish a general snapshot of the area as the actual study areas were not finalised. Buffer areas were cropped to reflect coastlines. In shortlisted areas which had no identifiable core or were dispersed over a large suburban area a number of potential study locations were identified by considering if the area comprising of adjacent census small areas (i) had a sufficient residential population, (ii) adjacent small areas had similar deprivation status, and (iii) area characteristics were consistent with the reasons why the areas were selected in the focus group study, and were subsequently assessed using GIS. This resulted in there being more low walkable areas assessed than high walkable areas as these suburban sprawl areas were all identified as low walkable by focus group participants.

The CGL study WI was determined using an adapted version of Frank, Saelens and Sallis' WI index (Frank et al. 2005, Section 2.6.5). The purpose of this was to provide a scale that allowed all sites to be compared on a composite measure of density, land use and connectivity. It also facilitated comparison with other WIs in published studies.

5.5.3 Data Analysis

Results are presented as standardised z-scores and raw data. Standardised scores allow for the comparison of a variety of scales with differing units by creating a new distribution where the mean is 0 and the standard deviation is 1. The score is constructed by subtracting an observation from the mean of all observations and dividing the result by the standard deviation (Field 2009, p. 796). The purpose of this

[47] GIS analysis was carried out using Arc GIS software version 10.1.

was to provide a scale that allowed all sites to be compared on density, connectivity, land use and a composite index. Calculating the standardised z scores also facilitated the construction of an index for all areas shortlisted similar to the WI index outlined in section 2.6.5. A limitation in this process is that at this stage of the study there are more low walkable than high walkable areas which may distort the z scores of the area characteristics as the mean may be weighted towards the low walkable area characteristics. In order to control for this, the final selected areas will be subjected to a repeated GIS analysis using an even number of high and low walkable areas. The results from this study were exploratory, yet necessary to inform the site selection process. The issue of potential weighting towards low walkable areas was considered later in the short listing process.

5.5.3.1 Population density

The population densities of the areas were calculated using a measurement from the POWCAR dataset. This measurement provides an incomplete picture of the residential population as it only considers working adults. However, it was considered a sufficient proxy measurement for this stage of the study. Table 5-5 displays the number of working adults residing within the 1 km buffer area.

5.5.3.2 Land use mix

Employment destination points from the POWCAR dataset were used as a proxy measurement for land uses other than residential housing. Table 5-5 shows the number of employment points within the same 1 km buffer area. This measurement differs greatly from the methods used by the NQLS and IPEN studies as it does not consider the type of land use and the variety of land use. This measure is an indicator of land uses other than residential. Consideration of the mix of land use will be considered under the application of criteria in the next short listing method.

5.5.3.3 Connectivity

The Pedshed (connectivity) measure is a percentage of the catchment area within a crow flies distance which can be reached within the same distance using the street network (Chin *et al.*, 2008). A high ratio score indicates high area connectivity, the maximum score is 1. A diagram showing a Pedshed output is shown in Figure 5-5. The ratio for 1km in Figure 5-5 is calculated by dividing the street network (walking) catchment area within 1km from the origin point (here the combined red and orange area) by the total area inside the blue dotted line, the area within a 1km radial buffer of the assigned origin point, the blue dot.

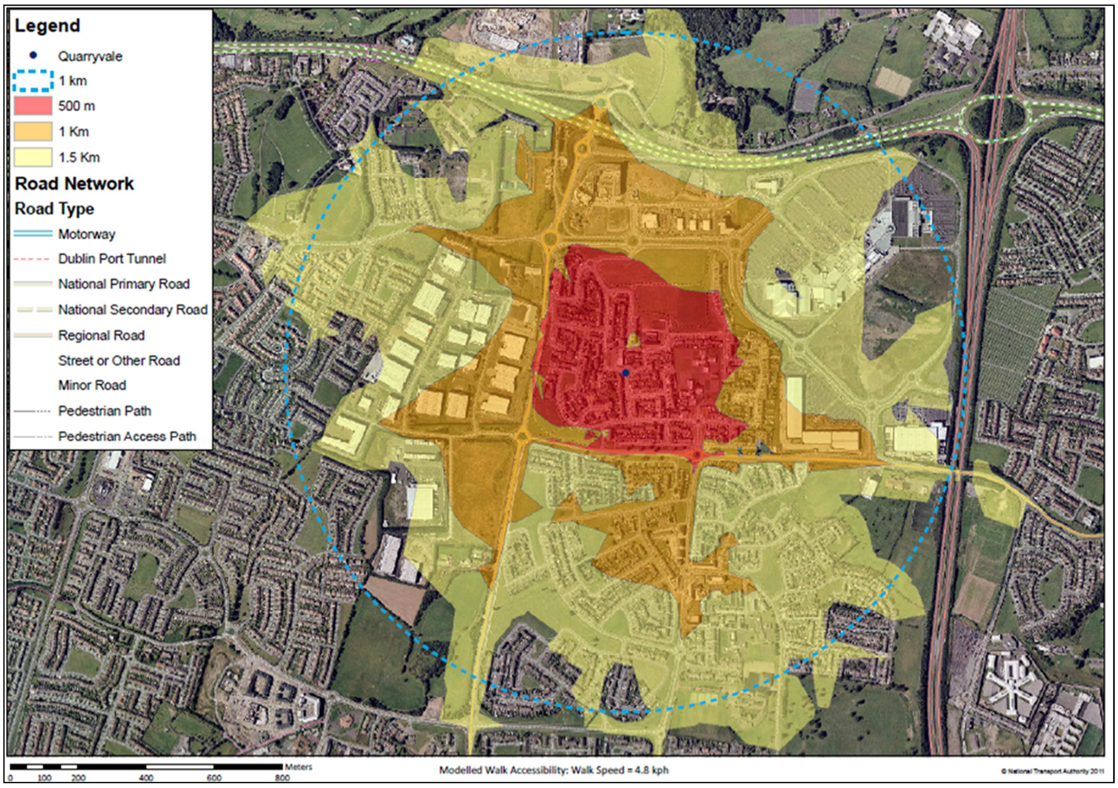


Figure 5-5: Pedshed output diagram

The Pedshed analysis was carried out using the street network, excluding motorways, as walking is not permitted along them. The road network data used for the analysis was from the DTM. Due to outdated mapping for some areas on the DTM it was necessary for the researcher to add primary information to the datasets. This included the addition of pedestrian- paths and access points. This information was gathered using a combination of aerial photography, open street map wiki mapping (www.openstreetmap.org), site visit information and photographs. Network updates included new roads/paths, closed laneways and informal paths/tracks which were predominately identified using aerial photography. New roads were mainly within new suburban housing developments.

5.5.3.4 Walkability Index (WI)

The WI (walkability index) is calculated from the equation WI = *(z-score of land use mix) + (z-score of net residential density) + (z-score retail floor area ratio) + (2 * z-score of intersection density)* (Frank et al. 2005; Sallis et al. 2009; Frank et al. 2010, Section 2.6.5). The rationale given for the item weightings were evidence of i) a strong influence of street connectivity on non-motorised travel choices and ii) reported utilitarian walking distances (Frank *et al.*, 2010). The equation originated from Cervero and Kockleman (1997) and Saelens and colleagues' work (2003) and was further developed by Frank and colleagues work on the SMARTRAQ and NQLS projects (Frank et al. 2005; Frank et al. 2010; Sallis et al. 2009, section 2.6.5). Other researchers have used variation of this equation, for example the BEPAS study omitted the retail floor area element as this information was not available to them (Van Dyck *et al.*, 2010).

For this study an adaptation of the WI walkability index was constructed substituting the Pedshed connectivity ratio for the intersection density. The retail floor area element of the equation was omitted similar to the BEPAS study. The land use mix measure used for NQLS and the IPEN studies was substituted with a standardised measure of employment points per hectare, 'land use'. This resulted in the following equation:

*WI = (z-population points per hectare) + (2*z-Pedshed ratio) + (z-employment points per hectare)*.

A second WI measure WI_U was also calculated for this study. The WI_U is an unweighted index which all elements have equal weighting. Previous edits of the WI have assigned various weightings to elements of the equations (Section 2.6.5). The unweighted index is included to inform the comparison of areas without any potential bias introduced by weighting. Previous edits of the WI equation have been weighted using regression models using minutes walking reported by different populations and have resulted in a variety of equations. In these studies no consideration is given to street level characteristics and variance in the resulting equations may be because of neighbourhood characteristics not captured by the model. By considering an unweighted model, the original format of the WI index (Leslie *et al.*, 2007), potential bias is removed as the identified macro environment items are considered on an equal footing within the index. Similar to other studies using the developing WI index variability in walkability was measured using the index. However in this study it is being used to inform site selection rather than a definitive measure of walkability.

5.5.4 Results

Table 5-5 outlines the results of the GIS study on shortlisted areas. Connectivity scores of identified neighbourhoods are 91% positive for high walkable neighbourhoods and 31% positive for low walkable neighbourhoods. Inner city neighbourhoods are 100% positive, outer city 83% positive and 27% of suburban neighbourhoods scored positive connectivity. The low walkable areas of Walkinstown, Crumlin and Beaumount scored positively for connectivity, in comparison to other low walkable areas. These areas are all in the outer city rather than the suburbs. Tallaght 1, the area in Tallaght selected closest to Tallaght Village, is the exception to the low walkable suburb scores. All of these areas were developed before the other low walkable areas, the connectivity scores of the high and low walkable areas appear to be connected with the era which the areas were developed. Inner city areas, the oldest areas of the city, scored 100% positive scores. Suburban areas which are in close proximity to traditional villages, Tallaght 1 and Dalkey, scored higher in connectivity than other suburban areas 73% of which scored negative connectivity scores.

The balance of positive and negative standardised mean density scores were roughly consistent between the inner city (50% positive), outer city (60% positive) and suburban areas (47% positive). More high walkable areas scored positive density scores (64%) than low walkable areas (44%). Inner city areas had the highest proportion of positive land use proxy scores (83%). In the outer city 50% of the areas scored positive land use scores and the suburbs had 20% positive scores. While high walkable areas had more positive scores (55%) than low walkable areas (31%) a greater proportion of positive scores were found in high walkable deprived areas (80%) compared to high walkable not deprived areas (33%). The range of scores vary from -0.92 to 3.91 (or from 0.4 to 104.5 employment points per hectare).

As would be expected the WI and WI_U results show variation throughout walkability, deprivation and zone categories similar to the items which construct the indices. The indices also compound the trend towards older inner city areas as being high walkable and newer isolated suburban estates as low walkable. The WI and WI_U both score the inner city as 83% positive, the outer city as 67% positive and the suburbs as 20% positive. The greatest proportion of positive area scores are in the high walkable deprived category (80% for both indices). All the areas in this category are in the inner city. Low walkable not deprived areas, recently built suburban developments, scored 14% positive and 29% positive for the WI and WI_U scales respectively.

Table 5-5: Objective GIS results for method 4

Area.	*Category*[1]	*Zone*[2]	*Connectivity*[3] z (Pedshed Ratio)	*Density*[4] z (Pop/ha)	*Land Use*[5] z (Emp/ha)	*WI*[6] z	*WI_u*[7]
South Circular Road	HW - ND	I	1.37 (0.50)	-0.47 (29.0)	0.57 (32.4)	2.85	1.48
Ranelagh/ Rathmines	HW - ND	O	1.63 (0.54)	-0.41 (30.5)	-0.69 (5.2)	2.17	0.54
Sandymount	HW - ND	O	0.26 (0.33)	-1.34 (7.8)	-0.82 (2.2)	-1.65	-1.91
Blackrock	HW - ND	O	-1.50 (0.06)	0.05 (41.4)	0.60 (32.9)	-2.36	-0.86
Dalkey	HW - ND	S	0.65 (0.39)	-0.25 (34.3)	-0.77 (3.5)	0.29	-0.36
Malahide Village	HW - ND	S	0.00 (0.29)	0.01 (40.6)	-0.49 (9.4)	-0.48	-0.48
Stoneybatter	*HW - D*	*I*	1.05 (0.45)	1.41 (74.4)	1.04 (42.6)	4.55	3.50
Mountjoy Square	*HW - D*	*I*	2.02 (0.60)	2.22 (93.8)	3.91 (104.5)	10.18	8.16
Rialto	*HW - D*	*I*	0.59 (0.38)	-0.20 (35.4)	0.11 (22.5)	1.09	0.50
Eastwall	*HW - D*	*I*	0.85 (0.42)	2.16 (92.5)	1.17 (45.4)	5.04	4.19
Ringsend/Irishtown	*HW - D*	*I*	0.20 (0.32)	-1.28 (9.4)	-0.87 (1.3)	-1.74	-1.96
Blanchardstown Environs	LW – ND	S	-0.91 (0.15)	-0.75 (22.2)	-0.62 (6.6)	-3.20	-2.29
Tallaght Environs 5	LW – ND	S	-0.98 (0.14)	1.27 (70.9)	0.23 (24.9)	-0.46	0.52
Swords Suburbs	LW – ND	S	-1.37 (0.08)	0.38 (49.6)	-0.52 (8.8)	-2.88	-1.51
Walkinstown	LW – ND	O	0.26 (0.33)	0.07 (42.0)	0.34 (27.4)	0.93	0.67
Lucan	LW – ND	S	-0.46 (0.22)	0.39 (49.6)	-0.52 (8.8)	-1.05	-0.59
Balgriffin	LW – ND	S	-1.50 (0.06)	-1.19 (11.5)	-0.75 (3.8)	-4.95	-3.45
Stepaside	LW – ND	S	-1.44 (0.07)	-0.50 (28.1)	-0.14 (17.1)	-3.51	-2.08
Crumlin	*LW - D*	*O*	1.05 (0.45)	-0.73 (22.6)	0.04 (20.9)	1.40	0.35
Beaumount	*LW - D*	*O*	0.00 (0.29)	0.32 (48.0)	-0.08 (18.3)	0.24	0.24
Tallaght Environs 1	*LW - D*	*S*	0.91 (0.43)	-1.04 (15.2)	-0.74 (4.0)	0.04	-0.87
Tallaght Environs 2	*LW - D*	*S*	-0.52 (0.21)	-1.30 (8.9)	-0.91 (0.4)	-3.26	-2.73
Tallaght Environs 3	*LW - D*	*S*	-0.33 (0.24)	0.75 (58.5)	-0.24 (14.9)	-0.14	0.19
Tallaght Environs 4	*LW - D*	*S*	-0.07 (0.28)	0.49 (52.2)	-0.44 (10.6)	-0.07	-0.01
Clondalkin Area 1	*LW - D*	*S*	-1.24 (0.10)	-0.90 (18.5)	-0.61 (7.0)	-3.99	-2.75
Clondalkin Area 2	*LW - D*	*S*	-0.52 (0.21)	-0.25 (34.2)	0.16 (23.5)	-1.14	-0.62
Quarryvale	LW – D	S	0.00 (0.29)	1.09 (66.6)	1.03 (42.3)	2.12	2.12

[1]HW: High Walkable, LW: Low Walkable, D: Deprived & ND: Not Deprived
[2] I: Inner City, O: Outer City & S: Suburbs
[3]Ped-Sheds ratio 1km walking catchment area to 1km crow-flies area
[4]Density calculated as working population per hectare 1km radius
[5]Land Use calculated using a proxy measure of employment destinations per hectare within a 1km radius
[6]WI walkability index score from Sallis (2009) = *(z-score of land use mix) + (z-score of net residential density) + (2 * z-score of intersection density)*
[7]WI_U walkability index score with no preferential weighting of items = = *(z-score of land use mix) + (z-score of net residential density) + (z-score of intersection density)*

5.5.5 Review

Preliminary GIS results suggest that of the three macro scale factors measured (density, land use and connectivity) high and low connectivity has the greatest relationship with the walkable areas identified by focus group participants. This finding may explain why a greater weighting is attributed to connectivity than land use mix and density in the WI index. The age of the area also appears to be an important consideration in relation to both connectivity and walkability.

Perceived unsafety from traffic and the dominance of large transport infrastructure (roads and roundabouts) were the primary reasons Walkinstown and Beaumount were selected as low walkable in the focus groups. The positive connectivity scores for these low walkable areas would suggest that while there is a road network in these areas, as suggested by the positive connectivity results, priority may be given to vehicular traffic over pedestrians and hence reducing the walkability of the area. Blackrock, Beaumount, Walkinstown and Crumlin are all in close proximity to arterial routes (distributer roads) traversing and leaving the city.

While in general density scores are greater for high walkable areas, density scores did not clearly group into city zones or walkability categories. This which supports the finding of a disconnect between walkability and density observed in studies one and two. It is unclear if this phenomenon is unique to the GDA and requires further investigation.

Low walkable areas which had positive scores for the proxy ‘land use’ measure were all in the vicinity of industrial parks or large retail centres. Inner city areas also scored higher on the land use proxy. A limitation of the land use mix measurement used in this study was lack of an indicator of the diversity of the employment destinations within the neighbourhoods selected unlike the land use mix measured by Leslie and colleagues (2007) and Frank and colleagues (2005) in the WI index. Our measure indicates employment points or uses other than residential. For example the area identified in Beaumont is adjacent to a hospital which employs over 3000 staff and Quarryvale is adjacent to a large out of town shopping centre with 99 tenants. Both of these destinations are large employers but with a single land use. Therefore, while our measure identifies the presence of other land uses it does not necessarily reflect the diversity identified as positive for walkability by Leyden (2003), Hoehner and colleagues (2005)and Lee and Moudon (2006) (section 2.7.1).

Connectivity is an integral part of three of the fourteen walkability criteria developed in study two (section 4.5). Criteria five states that ‘a walkable area has a connected street network within the area with various routes available’; criteria nine, ‘a walkable areas has seamless connections to adjacent areas’ and criteria 10, ‘a walkable area has no major barriers to access the greater city area’. Land use mix is related to one of the fourteen criteria, criteria 3: a walkable area has accessible facilities in a village centre or frequent nodes. Density is not directly reflected in any of the criteria but is related to scale (section 4. 3.3) criteria one ‘a walkable area is built to human scale’.

The strength of the relationship between connectivity and the walkability assigned to shortlisted areas are reflected in the GIS scores. Similarly the lower association with land use mix and density is also reflected in the scores. The higher weighting attributed to connectivity in the WI index is also evident in the WI scores for the areas and attributes to a greater association between the WI index and the shortlisted areas than the unweighted WI_U index. These associations are tested statistically on the final areas selected in method six.

By constructing an index which combines all three measures a prejudice is observed towards older inner city areas for high walkable area selections and isolated suburban housing estates for low walkable selections. This is consistent with New Urbanist theory, the foundation of the WI walkability index (section 2.6). While consideration for this finding is important when short listing areas, it is also important to keep the context in which the areas were selected in mind. To investigate the influence of walkability on behaviours an area’s character needs to be considered alongside its structure. The next method in the short listing process involved a desktop study and site visits to apply criteria scores to areas.

5.6 Site Selection Method 4: Expert Review and Ground Truthing

5.6.1 Introduction

Study two of this thesis highlighted how a pedestrian's experience is influenced by a cumulative impact of multiple interactions similar to Kelly and colleagues' (2011) mixed methods transportation study. A 14-item walkability criteria was derived from the informative qualitative research findings (section 4.4.5). However, not all of the developed walkability criteria could be objectively measured with available spatial data. While street level audits (section 2.6.2) would have potentially enabled a walkability assessment based on the criteria, undertaking neighbourhood street audits of all of the shortlisted areas was unfeasible. The desktop study involved applying walkability criteria to the shortlisted areas using a variety of data sources and qualitative information thus introducing street and neighbourhood level characteristics into the site selection process. By considering objective measurements of the environment from method three of this study (section 5.5) and miscellaneous street and neighbourhood information from a variety of sources alongside qualitative data from study two, this process addresses the limitations of either method by adopting a mixed methods approach.

The purpose of this study is to shortlist 20 areas for the population study, five in each area category, by applying the walkability criteria developed in study two of this thesis to the areas shortlisted in methods one to four of this study. The purpose of the desktop study was to encapsulate elements of the neighbourhood, the streetscape, land use characteristics and their mix and other items which were not available as objective GIS data in the site selection process. The purpose of the site visits was to validate shortlisted site selections by undertaking 'ground truthing' or verification of the applied walkability criteria. A secondary purpose of the site visits was to identify residential blocks or estates to survey within the shortlisted areas.

The fourteen criteria constructed in study two of this thesis are outlined in table 5-6.

Table 5-6: Walkability Criteria

A walkable area…

Core Theme	1.	is built to human scale
Village	2.	is an identifiable place
	3.	has accessible facilities in a village centre or frequent nodes
	4.	has a recreational walk facility nearby
Permeability	5.	has a connected street network within the area with various routes available
	6.	is not severed by a large, fast through road
	7.	has sufficiently wide, good quality footpaths
	8.	has good public transport access
	9.	has seamless connections to adjacent areas
	10.	has no major barriers to access the greater city area
Streetscape	11.	has visual interest along routes
	12.	has a pleasant atmosphere contextual to area characteristics
	13.	has no visual disorder
	14.	has routes overlooked with doors onto the street

5.6.2 Procedure

The CGL study research team (N=6) met and discussed the area selections and their suitability for the study. Each member of the team was given a pack which included:

1) OS street mapping (Scale 1:15 000 and 1:7 500 for inner city areas)
2) Slides with images of each area referenced on the OS maps[48]. Photographs taken by the researcher were shown alongside aerial photography from online mapping services Google Maps™ and OpenStreetMap[49].

[48] A sample slide is included in Appendix D.2

[49] OpenStreetmap is a wiki-mapping service which is updated and constantly validated by users. This mapping source was particularly useful in newer suburban regions as Google™ base mapping and some OS mapping was out of date.

3) Where available, additional street level imagery was consulted using with Google Street View™[50]. In areas where this information was not available the researcher presented photographs taken on preliminary site visits.

4) A summary of the qualitative data associated with the shortlisted areas (study two, Appendix D.1).

5) The walkability criteria list developed in study two

6) GIS results from Method 3 (Section 5.5)

7) Pobal interactive mapping showing the small area boundaries and the deprivation scores for shortlisted areas (Section 5.4)

These resources were used to inform discussion on the selected areas by being able to review the area structure, land uses and streetscape remotely. OS mapping at this scale identifies hierarchal street network, public transport information and local amenities (post office, library, churches, parks, schools etc).

Following the desktop study, three of the CGL research team visited the 27 areas shortlisted at the end of method three, GIS. Researchers walked around each of the areas individually to undertake a physical observation audit and experience the area's atmosphere and activity. Consideration was also given to the number of people walking in and using the area. Photographs and notes were taken and information was sought from local shop owners relating to the practical area boundaries and the safety of the area. Soft spatial and temporal information relating to where gangs and drug dealers congregate, and at what times, were invaluable to ensure the safety of the data collection team. Areas which were deemed too dangerous to survey were removed from the shortlist.

Following the site visits each member of the site visit team (N=3) used information from the research team discussion, desktop study resources and observations from site visits to generate a 'walkable area criteria score'. A positive score (of +1) was applied for each criterion met and a negative score given (of -1) for each criterion

[50] Google Street View™ is an interactive web based 360-degree street-level imagery GIS tool accessed through the Google Maps™ webpage (http://maps.google.ie/)

negatively associated with the area. It was noted that not all criteria were relevant to all areas. In scenarios where a criterion was not clearly met no score (0) was given. For example where an area does not have a village core or node it is difficult to assess if the area is severed by a large fast through route, also an area may have an adjacent village but the village may be difficult to access on foot (e.g. Stepaside). An average score was determined for each area. If there was a disagreement on an area, the area was discussed with respect to the criteria. It was agreed that following discussion if two or more researchers disagreed with an area's inclusion then the area was removed from the shortlist, this happed for two areas.

During the study adjacent small areas of similar deprivation were selected informed by the small area deprivation mapping. In the population survey if more responses are required from an area, the area can be increased to include another adjacent small area of similar deprivation until a sufficient sample size is reached. At the end of the site visits the areas within each category were listed preferentially based on criteria score and suitability for surveying. Five areas were listed in each category with four to be surveyed and a reserve area. Care was taken to ensure a spatial distribution of areas which represent the whole city area for comparison.

5.6.3 Results

The final (N=20) areas shortlisted for study are listed in Table 5.7 and shown in Figure 5.6.

Table 5-7: Shortlisted sites for further study

	High Walkable	Low Walkable
Deprived	1. Stoneybatter 2. Rialto 3. Eastwall 4. Mountjoy Square 5. Ringsend/ Irishtown	11. Crumlin 12. Fettercarin, Tallaght 13. Deansrath, Clondalkin 14. Beaumount/ Oscar Traynor Road 15. Quarryvale, Clondalkin
Not Deprived	6. Sandymount 7. Dalkey 8. SCR/ Portobello 9. Ranelagh/ Rathmines 10. Malahide	16. Stepaside suburbs 17. Firhouse estates 18. Swords suburbs 19. Balgriffin 20. Lucan estates

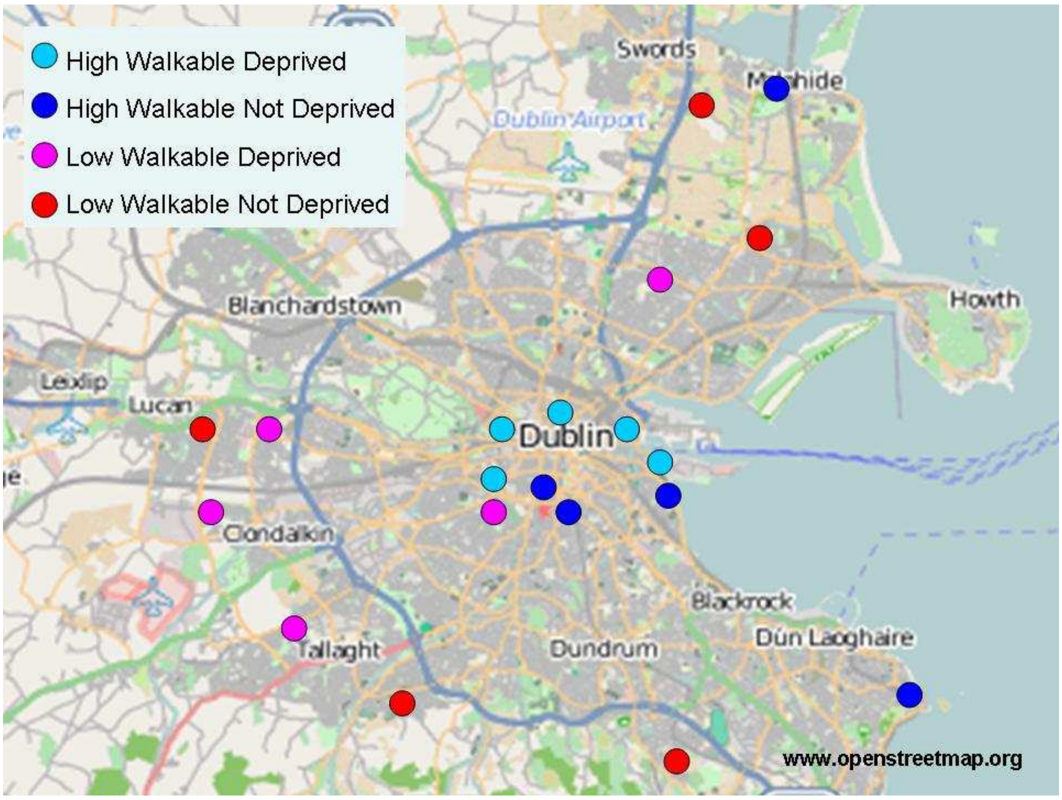


Figure 5-6: Short listed sites

The walkability criteria scores for the shortlisted areas in Table 5-7 are presented graphically on Figure 5-7 below. The boxes indicate the overall criteria score and the lines indicate the range of relevant criteria. Therefore an area where the box is close to the top of the line indicates a greater number of positive walkability scores.

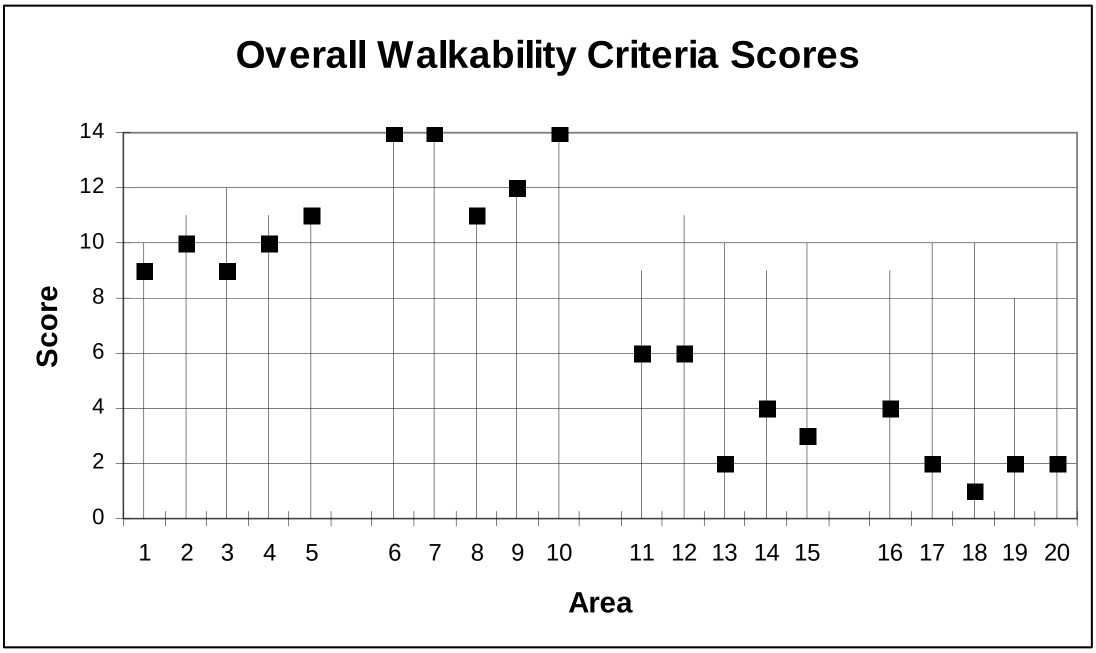


Figure 5-7: Walkability criteria scores

5.6.4 Review

The first large scale walkability study in Europe, BEPAS in Belgium (Van Dyck *et al.*, 2010) noted that using the WI GIS method to select sites for data collection prioritises attributes that have links to active transportation rather than aesthetics or public open spaces. They noted that in Belgium the high number of parks and attractive buildings in the proximity of high walkable areas may have had a plausible impact on the associations they found between high walkability and recreational walking and suggest that this may be a distinct 'European' finding. A key strength of the site selection methodology applied in this study is that these facilities and aesthetical features area integrated into the high walkable selected sites and omitted from low walkable sites. This is a strength of this study as a clearer association can be made between the availability of recreational walking facilities and reported recreational physical activity behaviour rather than guessing it may the case. By not considering the availability of recreational destinations in the assignment of the areas walkability status the BEPAS study compromised their investigation of this possible association.

As discussed in sections 2.6.5.2 and 4.4, Ewing and colleagues' (2006) developed a regression model which examines the relationship between urban design features and walkability which found that human scale, enclosure, imageability, transparency and tidiness were associated with the walkability of an area. While this model could not be replicated for this study, method four of this study facilitated reflection of these urban design features within the selection of sites. In the absence of suitable GIS datasets to measure these attributes this method was a useful alternative. A limitation of this process was that specialised knowledge on the perceptual nature of these features was not a key skill of any of the research team. However, the focus group transcripts of the areas included descriptions of these relevant features within their spatial contexts by urban designers and architects. This qualitative data greatly informed the consideration of these features by the group.

All of the above methods are not without limitations and it was deemed that ground truthing was required for final validation of the selected areas and specifically to identify the residential areas to be surveyed.

The overall criteria scores assigned to the areas showed an expected difference between high and low walkable areas. The members of the research team who undertook the final site selection site visits agreed on the list of shortlisted areas. Statistical differences in the criteria scores between walkability and deprivation categories were desired along with differences in objective measure of the final selected areas to allow for comparison to the IPEN projects and other international studies. This was undertaken in the next method, Method 5: final GIS measurements.

5.7 Site Selection Method 5: GIS Review

5.7.1 Introduction

The purpose of Method 5 was to provide an objective evaluation of 'walkability' and SES status of the 20 shortlisted areas.

5.7.2 Procedure

The GIS analysis procedures outlined in section 5.5.2 were repeated on the final 20 selected areas. An additional measure of public transport availability was included in the GIS analysis using previously unavailable data. The population density analysis was carried out using a GIS layer with total population in the area from census data rather than the POWCAR dataset which only contained information on working population. Data on rail station locations was accessed from the DTM and an additional GIS layer with bus stop locations was provided to the DTM by Dublin Bus. As the data layers were from different sources mapping from each area was examined for inconsistencies and fit. Bus stops at opposite sides of a two-way road were paired and counted as a single stop to prevent a bias score over one-way street networks.

An index was constructed to reflect the availability of public transport to residents in each of the 20 areas. In Ireland urban development guidelines recommend radial catchments (Euclidean Model) of 500 metres and 1000 metres for bus and rail catchments respectively (DECLG 2009). However literature on bus and rail catchments note contradictions to these guidelines. Effective catchments can vary based on trip purpose (Guerra *et al.*, 2011), degree of urbanisation (Harrison and Connor, 2012) and the availability of other transport options (Harrison and Connor, 2012). McDonnell and colleagues (2006) used a network bus catchment of 800 metres consistent with the 10-minute walk used by the DTO. This is in contrast to radial catchments of 400 metres favoured in the literature they reviewed.

Similarly for rail, Guerra, Cervero and Tischler (2011) found that when predicting rail usage a half mile radius (approximately 800 metres) was suggested for residential catchments in the USA. In Dublin, Harrison and O'Connor (2012) found that the majority of users using light and heavy rail in Dublin walk less than 700 metres to a station but in outer suburban areas with poorer public transportation people were willing to walk further. As radial catchments have been recommended in Irish planning policy (DECGL 2009) they were used for this study. In method three of this study (section 5.5.4) the average network to buffer ratio for shortlisted areas was found to be 0.46, with a range from 0.06 to 0.6, effectively halving radial catchments. Considering this information standardised scores of the number of bus stops within a 1km catchment and standardised score of the number of rail stops in a 1.5km catchment of the centre point of each selected area were determined. The standardised bus and rail scores were added together to create a public transport area index for the area surrounding the identified survey areas.

In section 5.5.4 of this study an observed relationship between the objective measures used in the construction of the WI index and region of the city was found. The age of an area has been associated with walkability in both study two and in section 5.5 of this study. Further consideration is given to this relationship in this section by graphically representing house age in the shortlisted areas using available census data.

5.7.3 Data Analysis

The standardised z score analysis carried out in method three, section 5.5, was repeated with less items and an equal number or areas in each category to give a more accurate indication of the distribution of scores. This process also increased the reliability of the indicies constructed using the standardised z scores as there is no weighted bias towards a specific area category.

Data was tested for normality of distribution. When divided into high and low walkable categories the data is normally distributed. Independent t-tests were carried out to assess differences between high and low walkable areas. However, when divided into the four area categories (HWD, HWND, LWD &LWND) or divided into city zones (Inner city, Outer city and Suburbs) the data was no longer normally distributed and non parametric tests are used to investigate differences between these categories. Kruskal-Wallis tests were carried out to investigate if differences exist between all categories and were followed by Mann Whitney U tests to test for differences between two independent categories. A Bonferroni adjustment of six was applied in the investigation of walkability/ deprivation categories and an adjustment of three was applied to the investigation of city zones. Effect sizes were also calculated for all investigated relationships.

Using self-report census data on the year houses were built in ED areas a graphical representation of the age of the selected areas was produced. Data were grouped using available divisions into i) before the popularity of the car pre 1940 (Wickham, 2006), ii) post car after 1940 and iii) the Celtic tiger construction boom of post 1990. The dates used were restricted by the ranges of dates reported in Census data. The ED areas do not reflect the small area geographies of the study areas similar to the data shortcomings due to the size of the EDs reported in sections 2.6.7 and 5.3.4.

5.7.4 Results

Tables 5-8 to 5-11 outline the results of the objective GIS and comparison between the groups. Table 5-8 shows the scores for all 20 areas. Results area presented as standardised z- scores and the raw data is reported in brackets (parenthesis) in each column except for the criteria score.

Table 5-9 shows the difference in the standardised mean scores for high and low walkable areas under the assessed categories. Significant differences were observed between high and low walkable areas for all measures except bus stops. Dublin city is well serviced by bus services throughout the city. The significant difference in access to rail stations contributes to the significant difference in the public transport index which combines bus and rail access scores.

Differences between high and low walkable areas were significant to greater than a 99% confidence interval for the 5km connectivity measures and the criteria scores. Population density was the only significant difference to be within the 95% confidence interval but outside 99% indicating a weaker difference than the other significant differences between high and low walkable areas.

Table 5-10 shows a significant difference in population density between the four area categories however this difference was not substantiated in post hoc tests. A significant difference in population density is observed between inner city areas and suburban areas (table 5-11).

Low walkable deprived areas have a significantly lower 1km connectivity score to all of the other area groups with a large effect size (r=0.8). High walkable areas, deprived and not deprived, were also significantly more connected than low walkable deprived areas over 5km (Table 510). Suburban connectivity scores for 1km and 5km measures was significantly less than inner city areas and suburban areas were significantly less connected than inner city areas over 5km (Table 5-10).

Table 5-8: Objective GIS results for final areas

Area No.	Category[1]	Zone[2]	1km Pedshed Connectivity[3]	5km Pedshed Connectivity[4]	Density [5]	Land Use[6]	Public Trans[7]	WI[8]	WI unweighted[9]	Criteria Score
			Z (ratio)	Z (ratio)	Z (Pop/ha)	Z (Emp/ha)				
1	HW - D	I	0.28 (0.40)	0.49 (0.59)	0.40 (53.9)	0.25 (30.9)	1.3	1.22	0.94	9
2	HW - D	I	1.25 (0.55)	1.15 (0.69)	1.26 (74.7)	0.81 (46.0)	2.7	4.57	3.32	10
3	HW - D	I	-0.04 (0.35)	0.56 (0.60)	-0.21 (39.1)	0.98 (50.7)	0.8	0.69	0.73	9
4	HW - D	I	1.47 (0.59)	0.95 (0.66)	2.13 (95.7)	1.99 (77.8)	4.3	7.06	5.59	10
5	HW - D	I	-0.22 (0.32)	0.36 (0.56)	-0.09 (42.0)	0.12 (27.4)	-	-0.41	-0.19	11
Average			*0.55 (0.44)*	*0.70 (0.62)*	*0.70 (61.1)*	*0.83 (46.6)*	*2.3*	*2.63*	*2.08*	*9.8*
6	HW – ND	O	0.69 (0.46)	0.09 (0.53)	-0.31 (36.6)	-0.03 (23.3)	0.1	1.04	0.35	14
7	HW – ND	S	1.39 (0.58)	0.69 (0.62)	-0.77 (25.6)	-0.69 (5.4)	-1.4	1.33	-0.06	14
8	HW – ND	I	0.90 (0.50)	1.22 (0.70)	1.87 (89.4)	2.94 (103.6)	1.0	6.61	5.71	11
9	HW – ND	O	1.04 (0.52)	1.02 (0.67)	1.06 (69.9)	0.06 (25.8)	1.3	3.20	2.16	12
10	HW – ND	S	-0.60 (0.26)	0.56 (0.60)	-0.15 (40.6)	-0.54 (9.4)	-	-1.89	-1.29	14
Average			*0.68 (0.46)*	*0.72 (0.62)*	*0.34 (52.4)*	*0.35 (33.5)*	*0.3*	*2.06*	*1.37*	*13*
11	LW – D	O	0.47 (0.43)	0.36 (0.57)	0.59 (58.5)	-0.34 (14.9)	-0.1	1.20	0.73	6
12	LW – D	S	-0.10 (0.34)	-0.83 (0.39)	-0.07 (42.4)	-0.74 (3.9)	0.7	-1.02	-0.92	6
13	LW – D	S	0.05 (0.36)	-1.03 (0.36)	-0.66 (28.2)	-0.61 (7.5)	-0.5	-1.18	-1.22	2
14	LW – D	O	0.27 (0.40)	0.09 (0.53)	0.16 (48.0)	-0.22 (18.3)	0.6	0.49	0.21	4
15-P[10]	LW – D	S	0.02 (0.36)	-0.90 (0.38)	-0.66 (28.1)	-0.26 (17.1)	-1.7	-0.89	-0.90	3
Average			*0.14 (0.38)*	*-0.46 (0.45)*	*-0.13 (41.0)*	*-0.43 (12.3)*	*-1*	*-0.28*	*-0.42*	*4.2*
16	LW – ND	S	-1.78 (0.07)	-1.96 (0.22)	-1.43 (9.4)	-0.84 (1.3)	-1.2	-5.85	-4.06	4
17	LW – ND	S	-1.41 (0.13)	-1.43 (0.30)	-0.72 (26.7)	-0.81 (2.2)	-1.8	-4.34	-2.94	2
18	LW – ND	S	-1.06 (0.19)	-1.10 (0.35)	-1.29 (12.9)	-0.74 (3.9)	-1.7	-4.15	-3.09	1
19	LW – ND	S	-1.78 (0.07)	1.08 (0.68)	-1.35 (11.5)	-0.75 (3.8)	-2.1	-5.65	-3.88	2
20 – P[10]	LW – ND	S	-0.84 (0.22)	-1.36 (0.31)	0.22 (49.6)	-0.57 (8.8)	-2.2	-2.02	-1.18	2
Average			*-1.37 (0.14)*	*-0.95 (0.37)*	*-0.91 (22.0)*	*-0.74 (4.0)*	*-1.8*	*-4.40*	*-3.03*	*2.2*

[1]HW: High Walkable, LW: Low Walkable, D: Deprived & ND: Not Deprived, [2] I: Inner City, O: Outer City & S: Suburbs, [3]Ped-Sheds ratio 1km walking catchment area to 1 km crow-flies area, [4]Ped-Sheds ratio 5km walking catchment area to 5 km crow-flies area, [5]Density calculated as population per hectare 1km radius, [6]Land Use calculated using a proxy measure of employment destinations per hectare within a 1km radius, [7]transport accessibility = (z score bus stops in 1km catchment) + (z score rail stations within 1.5km catchment), [8]WI = (z score population density) + (2*z score connectivity ratio) + (z score land use mix), [9]WI with no weighting = (z score population density) + (z score connectivity ratio) + (z score land use mix),[10]P denotes area surveyed in pilot study

Table 5-9: Objective GIS differences between high and low walkable areas

Measure	*HW*		*LW*				
	Mean (sd)	Range	Mean (sd)	Range	t(18)	r	ρ
z Population Density	.52 (1.0)	2.9	-.52 (.7)	2.0	-2.7	0.5	.015*
z 1km Connectivity	.62 (.7)	2.1	-.62 (.9)	2.3	-3.5	0.6	.003**
z Land Use Mix	.59 (1.1)	3.6	-.59 (.2)	0.6	-3.2	0.6	.005**
z 5km Connectivity	.71 (.3)	1.1	-.71 (.9)	3.0	-4.5	0.7	.000***
WI	2.34 (3.0)	9.0	-2.3 (2.5)	7.1	-3.8	0.7	.001**
WI_u	1.7 (2.4)	10.5	-1.7 (1.7)	4.8	-3.7	0.7	.002**
z Bus stops	.46 (1.0)	3.3	-.37 (.9)	2.8	-1.9[1]	0.4	.081
z Rail stops	.80 (.8)	2.3	-.64 (.6)	1.9	-4.3[1]	0.7	.001**
Public Transport	1.26 (1.7)	7.0	-1.0 (1.1)	2.9	-3.4[1]	0.6	.003**
Criteria Score	11.4 (2.0)	5	3.2 (1.8)	5	-9.7	0.9	.000***

[1]t (16), effect size r = $\sqrt{\frac{t^2}{t^2+df}}$,

Table 5-10: Objective GIS differences between high/ low walkable deprived/ not deprived areas

Measure	*HWD*	*HWND*	*LWD*	*LWND*				
	Mean (sd)	Mean (sd)	Mean (sd)	Mean (sd)	F(3)	ω	ρ	
z Population Density	.70 (1.0)	.34 (1.1)	-.13 (.5)	-.91 (.7)	3.3	0.5	.047*	Not in post hoc
z 1km Connectivity	.55 (.8)	.68 (.8)	.14 (.2)	-1.38 (.4)	12.7	0.8	.000***	LWND < HWD*, LWND< LWD & HWND**
z Land Use Mix	.83 (.7)	.35 (1.5)	-.43 (.2)	-.74 (.1)	3.7	0.5	.035*	HWD > LWND *
z 5km Connectivity	.70 (.3)	.71 (.4)	-.46 (.6)	-.95 (1.2)	6.7	0.7	.004**	HWD & HWND > LWND*
WI	2.60 (3.1)	2.10 (3.1)	-.30 (1.1)	-4.40 (1.5)	8.9	0.7	.001**	HWD & HWND > LWND*, LWD > LWND**
WI_u	2.08 (2.4)	1.4 (2.7)	-.40 (.8)	-3.03 (1.1)	6.9	0.6	.003**	LWND < LWD & HWD*
z Bus stops	.89 (1.1)	.02 (0.7)	.24 (.9)	-.97 (.4)	4.3	0.6	.024*	Not in post hoc
z Rail stops	1.38 (.7)	.22 (.4)	-.45 (.8)	-.82 (.0)	11.9	0.8	.000***	HWD > LWD***, HWD > LWND**
Public Transport	2.27 (1.6)	.25 (1.2)	-.22 (1.0)	-1.79 (.4)	11.0	0.8	.001**	HWD > LWND*
Criteria Score	9.8 (0.8)	13.0 (1.4)	4.2 (1.8)	2.2 (1.1)	69.8	0.9	.000***	HWND > LWD &LWND***, HWND > HWD*, HWD> LWD**, HWD > LWND***

effect size ω= $\sqrt{\dfrac{SS_M-(df_M)MS_R}{SS_T+MS_R}}$,

Table 5-11: Objective GIS differences between inner city, outer city and suburban areas

Measure	***Inner City*** Mean (sd)	***Outer City*** Mean (sd)	***Suburbs*** Mean (sd)	**F(2)**	**ω**	**ρ**	
z Population Density	.9 (1.0)	.4 (.6)	-.7 (.6)	9.6	0.7	.002**	IC > S*
z 1km Connectivity	.6 (.7)	.6 (.3)	-.6 (1.0)	5.5	0.5	.014*	S < IC & OC*
z Land Use Mix	1.2 (1.1)	-.13 (.2)	-.7 (.2)	17.3	0.8	.000***	S < IC*& S < OC**
z 5km Connectivity	.8 (.4)	.4 (.4)	-.6 (1.0)	6.5	0.6	.008**	IC > S**
WI	3.3 (3.2)	1.5 (1.2)	-2.6 (2.3)	11.3	0.7	.001**	S < IC*& S < OC**
WI_u	2.7 (2.6)	.9 (.9)	-2.0 (1.4)	13.5	0.8	.000***	S < IC*& S < OC**
z Bus stops	.8 (1.0)	.7 (0.6)	-.8 (.5)	11.2	0.7	.001**	S < IC & OC*
z Rail stops	1.2 (.7)	-.2 (.7)	-.6 (.6)	12.1	0.8	.001**	IC > OC*, IC > S**
Public Transport	2.0 (1.5)	.5 (.6)	-1.3 (0.9)	16.8	0.8	.000***	S < IC*& S < OC**
Criteria Score	10 (0.9)	9 (4.7)	5 (4.6)	3.15	0.4	.069	

effect size ω= $\sqrt{\dfrac{SS_M - (df_M)MS_R}{SS_T + MS_R}}$,

The WI measure showed a significant difference where high walkable areas scored higher than the low walkable not deprived areas. No significant difference was observed between high walkable areas and the low walkable deprived areas. A significant difference was observed between low walkable deprived and low walkable not deprived areas (Table 5-10). Post hoc analysis of the unweighted WI index showed the low walkable not deprived areas score significantly lower than deprived areas both high and low walkable (Table 5-10). WI and WI_U indices were significantly different between the suburbs and inner city (ρ = .001) and suburbs and outer city (ρ = .000) with large effect sizes of 0.7 and 0.8 respectively (Table 5-11).

Rail transportation was more accessible in the high walkable deprived inner city areas than the low walkable deprived and low walkable not deprived areas (Table 5-10) and the outer city and suburbs (Table 5-11). A weak significant difference between area categories for bus stop accessibility was not substantiated in post hoc tests (Table 5-10). A significant difference was observed between the suburbs and inner and outer city areas for bus stop accessibility (Table 5-11). The suburban areas had significantly fewer bus stops than either the outer or inner city. Similarly, public transport provision is significantly less in the suburbs than either the inner or outer city zones (Table 5-11). The public transport index showed a significantly higher score for high walkable deprived areas than low walkable not deprived areas (Table 5-10).

High walkable not deprived areas score significantly higher *criteria scores* than all other area categories (Table 5-10). High walkable deprived area's *criteria scores* were also significantly higher than low walkable areas, both deprived and not deprived. Walkability criteria scores were the only measure not to show a significant difference between city zones (Table 5-11). The differences between *criteria scores* had a very large effect size (r= 0.9). All of the significant differences observed have an effect size above .5, the threshold for a large effect as reported by Field (2009,p.332).

Differences in the age of housing stock within the shortlisted areas is shown in figure 5.8.

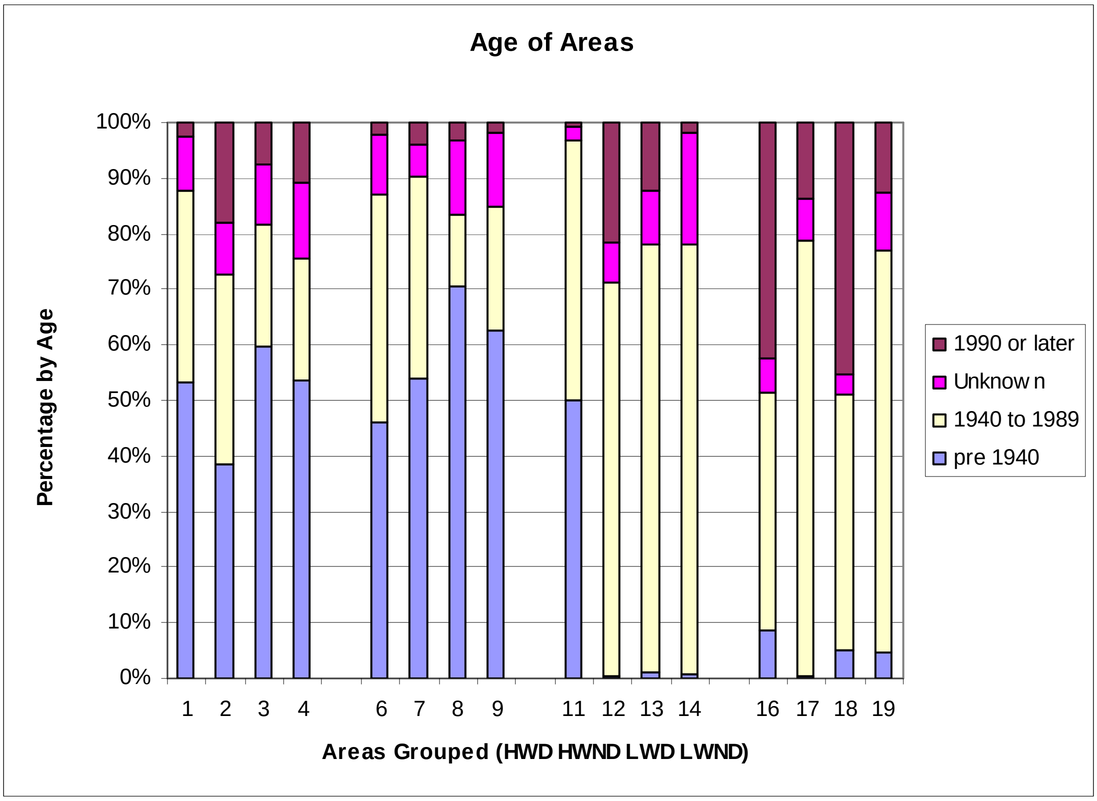


Figure 5-8: Percentage homes in area by years built, proxy for age of the area

5.7.5 Review

Differences in the standardised bus stop measure were not observed between high and low walkable areas or between area walkability and deprivation categories. A significant difference was observed between city regions with less access to bus stops in suburban areas. The measure for bus stops indicated stops only with no measure of the number of services or the destination catchment areas of the services. A measure of public transport accessibility which reflects this catchment would further inform walkability research and should be considered in future work. Rail services and hence the overall public transport index could be improved in this manner.

The public transport scores show greater rail accessibility in the deprived, high walkable, inner city areas. This is due to the proximity of these areas to the large inter city stations in the inner city and their proximity to radial heavy and light rail routes which increase in concentration as they approach the city centre.

Objective GIS measurements and composite GIS indices (WI, WI_U and public transport index) were significantly different between city zones (inner, outer and suburbs) but *criteria scores* did not differ between zones in the same way. Connectivity is an integral element of the criteria as is scale rather than density and accessible facilities. Mixed land used will be unfavourably biased in high density inner city areas but may not reflect the presence of services required for a functioning community. A large mixed use development may provide a mix of land uses but may not provide any of the services required by the community. The relationship between density and scale was explored in study two of this thesis and requires further investigation. The stratification of areas using the criteria which considers scale rather than density and a population density score for the areas being investigated will facilitate this assessment. The possibility that the *criteria scores* could be a better indicator of walkability than the WI index is indicated by the lack of significant difference between city zones unlike the WI index which appears to be weighted towards urban/ higher density areas consistent with the New Urbanist ideals which were embraced by early walkability research (section 2.2).

The opinion that high walkable areas 'developed' in times when people walked whereas low walkable areas were built when people had cars was given many times in the focus groups, study two. Figure 5-8 showed a trend where approximately 50% of housing in high walkable areas was built pre 1940 with only approximately 5% or less built since 1990 in high walkable not deprived areas and slightly more in inner city high walkable deprived areas. Some of the inner city deprived areas have undergone regeneration in recent years, particularly Rialto where the Fatima Mansions social housing towers have been replaced with new social housing units. In contrast, low walkable areas had less than 10% of houses built before 1940 and approximately 10 to 40% built since 1990. It can therefore be concluded that the morphological era of a neighbourhood is important for its walkability.

An exception to this visual trend is Crumlin, low walkable deprived area 6. Crumlin was constructed on the outskirts of Dublin City between 1931 and 1945. This large social housing scheme area contained more than half of the 6019 houses built by Dublin Corporation to re-house people from the post World War I slums in the city, an exercise which doubled the corporation's housing stock. The rapid expansion of the area left many areas without facilities and the ill preparation of the development resulted in many social issues which took time to address (McManus, 2002). This rapid expansion of the city is similar to the rapid expansion of the suburban areas of the GDA observed during the Celtic tiger construction boom of the late 1990's and 2000's where many housing developments were built without consideration for the social and practical operational aspects of communities. Low walkable not deprived areas selected for this study are examples of this type of construction. This evidence suggests that the age of the area and its development history should be a consideration when assigning a walkability rating to the area. A limitation of the area age analysis is that the data used is from self-report census data and is for ED level areas. Both factors can potentially reduce the accuracy of the data. The areas may reflect geographic areas greater than the small areas selected for study.

5.7.6 Discussion

As the field of study investigating the relationship between the built environment and physical activity, health and well-being develops, the role of neighbourhood characteristics and their contextual design need to be considered alongside objective (quantitative) measures of the neighbourhood to gain a better insight into the resident's perceptions. The benefits of the mixed methods site selection methodology used for this study, with its foundations in a focus group setting, is the utilisation of professional knowledge to encapsulate environmental perceptions of familiar geographies. The professional diversity of the groups was a great advantage as it afforded a unique forum to discuss areas for selection.

Public health research methods have measured built environment variables they expected to be related to neighbourhood physical activity (Sallis, 2009). As the research area has grown researchers in the field have merged their knowledge with researchers from transportation and land planning disciplines (Saelens *et al.*, 2003a; Handy *et al.*, 2002; Pikora *et al.*, 2003; Frank and Engelke, 2001) and developed site selection methods and walkability indices which unsurprisingly produced results which frequently reported links to transportation walking. The ease of use of these methods has meant that the comparison of objective measures using GIS and environmental street audits has been a preferable methodology in recent years (Brownson *et al.*, 2009; Sallis, 2009).

However concerns have been raised in both this project and by Purciel and colleagues (2009) that when considering the aesthetic elements of the streetscape studies usually emphasise natural elements rather than the contextual design of the built environment. Studies one and two of this project have also highlighted how the priorities of different built environment professions vary and hence an audit or objective study carried out by any one of these professions will potentially carry a bias towards the features they wish to advocate. A considerable strength of this study methodology and the criteria used for site selection and investigation is that they were based on a holistic study encompassing a variety of views to reduce this professional or disciplinary bias.

In this project a number of limitations presented themselves including available datasets, quality and reliability of data. While other studies have continued with site selection using limited GIS datasets with incomplete data, reduced datasets or reduced scope (Moudon *et al.*, 2007; Badland *et al.*, 2009; Van Dyck *et al.*, 2010) this study did not. It was my opinion that a universal image of walkability which enables an investigation of the multiple potential influences on an individual's perception of their environment was more valuable to the research field than replicating a measure already reproduced in a number of cities. For example the concept of human scale was identified as a key element of walkability in study two. Scale's relationship with density was acknowledged along with the fact that while the concepts are related they are not mutually exclusive. It was felt that carrying out another city survey investigating density as a determinate with no consideration for scale would hamper the progression of the research area unnecessarily. The project planning was brought back to first principles to establish how best to select areas for study. The timely publication of census small areas deprivation mapping was a huge benefit to this project.

The ease of use of the WI index with its transportation and land use foundations is its primary advantage over other GIS based walkability models which require a larger selection of GIS data sources (Purciel *et al.*, 2009). These are more difficult to replicate because of limitations with available data. Future approaches may explore how to utilise existing GIS datasets to encompass useful features and also suggest measurements and data to there responsible for the collection and maintenance of local authority or national level databases which may be useful to public health research and other research fields.

While an incomplete and dated dataset was used to create the objective measures for this study, the application of the survey on defined small geographies can potentially facilitate more accurate measures of density, land use, public transport and deprivation measures when the 2011 Census data is published. A comparison of the Pedshed connectivity measure used to alternative connectivity measures may also be beneficial (Purciel *et al.*, 2009). Barriers to movement into adjacent neighbourhoods was also considered in the objective analysis of the connectivity of the areas using a Pedshed calculation for a larger catchment, 5km.

The density of an inner city area will influence the relationship between the WI index and transport walking because of the high number of assessable destinations. Also an indicator of land use mix will be greater in an inner city area compared to residential areas and hence will bias towards an inner city area and not necessarily reflect the services and destinations required for a liveable community. Stratification of areas using the WI index would have split the areas into inner city as high walkable and the suburbs as low walkable whereas the criteria scores allow for a holistic exploration of what makes an area walkable regardless of density, a potential misconception of walkability research highlighted in study two of this thesis. The *criteria score* consider scale, both village scale and negative carchitecture scale. The criteria applied in the area selection also reflects all five of the items in Ewing and colleagues' urban design walkability model where scale constitutes over 40% of their walkability model's weighting (Ewing *et al.*, 2006b).

A primary advantage of the site selection methodology used is the identification of real communities. A frequently cited limitation of the WI site selection method is that census tracts do not reflect operational communities (Badland *et al.*, 2009; Lovasi, 2009; Van Dyck *et al.*, 2010). A limitation of this study was our shortlist of areas from the focus group study did not have a sufficient number of high walkability deprived areas. This finding may be an indicator of the low desirability of these areas but also their non-perfect walkability criteria scores which were reduced by the presence of visual disorder, an important contributor to an individual's perception of personal safety, section 4.3.7. This visual disorder or unpleasant atmosphere is not considered in the WI site selection method whereas it contributed to the assignment of a walkability status in this study.

The high walkable areas selected are traditional village areas with the exception of the Portobello and Mountjoy Square areas which are both close to the city centre and services locally by frequent service nodes. All of the high walkable areas contain a large proportion of housing stock built before the popularity of the motorcar.

The shortlisted low walkable outer city areas can be described as being carchitecture scale (Section 4.3.3). The low walkable outer city areas of Crumlin and Beaumount are areas which were built post World War I to re-house the large numbers of tenement families needing homes. Vast estates were built in a relatively short space of time resulting in sprawling residential areas (McManus 2002). All of the remaining low walkable areas are in the suburbs. When built Crumlin and Beaumont were suburbs to the then city, they were then integrated into the city structure as it grew. Two high walkable not deprived areas are situated in the suburbs. These areas, Dalkey and Malahide, are historic coastal towns which have become part of the city structure as it expanded but have retained their village characteristics.

Suburban low walkable residential areas can be categorised into two groupings. Large scale social housing developments from the 1960's and 70's situated between the large inter-city roads which are now motorways form one group. These areas include the listed regions around Clondalkin and Tallaght. Each of these areas has a town/village centre but the residential areas which were referred to in the focus group study are outside the walking catchments of these towns, more than 1.5 kilometres. The second category is more recent housing developments which were developer built during the construction boom of the 1990's and 2000's. These areas are not deprived and these developments are usually walled with one entrance into the development which results in long distances to local amenities. Figure 4.20 in the previous chapter illustrates how these newer developments differ from traditional neighbourhoods.

All low walkable suburban areas were segregated from the greater city by large motorways consistent with criteria 10: a walkable area has no major barriers to access the greater city area. Lower socioeconomic low walkable areas were better serviced by local public transport. The Clondalkin and Tallaght areas have a mix of a traditional village core, a large shopping centre, and expanses of social housing estates and new and old developer built estates. Following site visits to the areas, study areas were selected outside the walking catchment of the traditional village cores.

The final areas selected have profiles which have foundations in their history, age, morphology and who influenced their development (e.g. developers or political decisions/policies). All of these factors alongside the walkability criteria scores, deprivation scores and objective measure of the environment allow for a holistic exploration of what makes these areas walkable or not. The variety of professional knowledge and input informing the site selection is a very positive foundation to expand a research area which has been somewhat blinkered by the ease of use of transportation principals.

5.8 Conclusions

This study examined the application of the walkability criteria produced in study two to select sites for a walkability population study in a city with limited GIS resources. The methodology was successfully validated alongside existing measures of walkability used in international studies. The strength of this study is that it validates a holistic list of walkability criteria using a process which utilises the expertise of city residents who have specialist knowledge of the built environment and the populations living in the city. The mixed methods approach combines the quantitative methods favoured by many public health and transportation professionals and the qualitative approaches favoured by urban designers and environmental psychologists.

While the popular WI index stratifies areas into categories based on characteristics which have been significantly associated with transport walking, using this site selection method to short list areas may be limiting scope for further investigation. The elimination of areas by controlling for a limited number of characteristics which are associated with one type of neighbourhood physical activity can potential inhibit the discovery of other associations with neighbourhood physical activity.

The calculation of a WI index score for the areas shortlisted using the walkability criteria developed in the previous study allows for confidence that the areas can be compared to international studies in future work.

Limitations of this study were; (i) there was a lack of deprived areas on high walkable lists from study two and (ii) the study may be difficult to replicate.

Only two of the high walkability areas identified in the focus group study were deprived. Because of this, additional areas had to be identified by the research team based on the developed walkability criteria. Criteria scores for high walkable deprived areas were significantly lower than high walkable not deprived areas. The role of visual disorder on the streetscape and its association with deprivation was a key factor in this limitation. In general, the international studies that adopt a high/low walkable, high/low socio-economic status approach to site selection using objective GIS do not account for streetscape features. The mixed methods approach to site selection used in this study controls for the subjective measures of the streetscape.

Dublin is a low to medium density city with a population of 1.3 million (www.cso.ie). The size of the city makes an exercise that relies on socio-spatial recall feasible. A regional approach may be beneficial to replicate this study in larger cities. This method also used a list of areas derived from a focus group study that involved 26 individuals each contributing two hours of their time. Outdated GIS data on street and path networks meant audits and mapping exercises were also undertaken by the researcher. While smaller multidisciplinary groups could be enlisted to generate a list of areas and partnerships with local authority GIS teams could reduce time demands associated with auditing and mapping, the study would not technically be replicated.

This study forms a strong basis for further study. The next step for this research is to validate the walkability criteria using self-reported area perceptions and behaviours of the residents of the shortlisted communities.

6 Study 4 – Population Study

6.1 Introduction

When considered in a multi-disciplinary context, the concept of walkability was found to be ambiguous (Studies one and two). A clear definition of walkability was required to select neighbourhoods of high and low walkability to ensure the integrity of the CGL Study. Using information developed as part of the CGL mixed methods study four area categories separated by level of walkability (high/low) and level of deprivation (high/low) were identified (study 3). This final study (study 4) is a cross sectional population survey carried out to investigate if where you live makes a difference to your mobility and physical activity behaviours.

Development of a survey instrument was guided by the Social Cognitive Theory, where behaviour (i.e. walking) is understood in terms of the interaction of personal, behavioural and environmental determinants (section 2.4). The specific environmental correlates that can influence an individual's behaviour come from a variety of experiences, associations and individual characteristics (Biddle and Mutrie, 2008). Considering this, identifying individual environmental determinants of neighbourhood walking would require a complex model which is beyond the scope of the current study. However, by treating the four area categories as individual units we can observe and compare the characteristics, perceptions and behaviours of the residents of these environments.

Similar population studies have been carried out internationally, predominately in America and Australia (Van Dyck *et al.*, 2010; Brownson *et al.*, 2009), with recent European studies carried out in Belgium, Holland, Czech Republic and Sweden (van Lenthe and Kamphuis, 2011; Kamphuis *et al.*, 2010; Van Dyck *et al.*, 2010; Bergman *et al.*, 2009; Frömel *et al.*, 2009). Calls have been made for more European studies particularly in older, historic cities (Van Dyck *et al.*, 2010). No Irish walkability studies were identified. This study differs from the identified international studies as it encompasses a more comprehensive environment measurement tool and site selection process than the WI index (Frank et al. 2010, Section 2.6.5.1) and NEWS questionnaire (Cerin et al. 2009, Section 2.6.1) which dominate international walkability studies (Brownson *et al.*, 2009).

The purpose of this study was to answer research questions to inform a conceptual model of behaviour based on the social ecological model. These specific research questions are:

Do the area categories differ in their:

a) resident's perceptions of their neighbourhood environment and

b) resident's travel and recreational walking behaviours

Ethical approval for the survey was granted by Dublin City University research ethics committee (DCUREC/2011/005).

6.2 Hypotheses

The following hypotheses were formulated with respect to living in high walkable not deprived neighbourhoods:

1) Perceptions of the physical environment will vary between the four area categories of HWND (high walkable not deprived), HWD (high walkable deprived), LWND (low walkable not deprived) and LWD (low walkable deprived)

2) That those living in LWND and LWD areas will report less minutes walking for transport, for recreation and less total physical activity per week than those living in HWND and HWD areas.

3) That those living in LWND and LWD areas will own more cars, and spend more on motor fuel, than those living in HWND and HWD areas.

4) That the correlates associated with walkability will differ based on area category of residence, reflecting poorer neighbourhood satisfaction, less access to local services and higher barriers to walking in LWND and LWD areas in comparison to HWND and HWD.

6.3 Methodology

A cross-sectional study, using a mixed-method active recruitment approach, was undertaken to investigate the outlined hypothesis.

6.3.1 Procedure

a) A multi-section questionnaire was developed from a combination of valid and reliable self-report measures and researcher developed questions. This process included a pilot study undertaken to test the developed questionnaire.

b) A mixed-method active recruitment strategy was developed and piloted, and the data was collected accordingly.

c) Results from completed questionnaires were transferred into statistical software and analysed.

The timeline for this study was:

Questionnaire Design	October 2010 to March 2011
Questionnaire Testing	March 2011
Survey Pilot Study	April 2011
Questionnaire Amendments	May 2011
Population Survey	July to September 2011
Revisits to areas	October/November 2011
Data imputing and cleaning	September to December 2011

6.4 Instrument: The Cleaner, Greener, Leaner (CGL) Questionnaire

For the CGL cross-sectional population study a questionnaire was required which would collect information on (i) neighbourhood perceptions, (ii) travel behaviours, (iii) perceived access to basic services, (iv) neighbourhood satisfaction, (v) physical activity behaviours, (vi) barriers to neighbourhood walking, (vii) motorised vehicle ownership and usage and (viii) demographic information in as concise a manner as possible. No questionnaires were found which collected all the information desired for the CLG survey but the NQLS survey (Sallis *et al.*, n.d.) provided a good template. It has been used recently in the PLACE study in Australia, SMARTRAQ studies in the USA and the

IPEN/ IPS international studies (Cerin and Leslie, 2008; Sallis *et al.*, 2009; Brownson *et al.*, 2009).

The NQLS is a long survey instrument administered in two surveys, with 220 items and 165 items in surveys 1 and 2 respectively. This was considered too long for a single survey cross sectional study by the researcher. It consists of questions on quality of life, social cohesion, satisfaction with life, neighbourhood satisfaction, mood, neighbourhood preference, places to exercise, work place environments and reason for moving to the area. It also uses measures from other valid questionnaires, including the NEWS environment perception measures (Saelens and Sallis, 2002b; Cerin *et al.*, 2009a), the IPAQ-long form physical activity measure (Craig *et al.*, 2003; IPAQ Core Group, 2002), the benefits of and barriers to regular physical activity and social support (Sallis *et al.*, 1997, 2001). The survey also asks which of 10 destinations you walked to from your home in the past month and the same question is asked again about the destinations you walked to from your workplace. The NEWS questionnaire (Saelens and Sallis, 2002b) and its abbreviated version NEWS-A (Saelens and Sallis, 2002a) are the most frequently used self-report measures of environment perceptions (Brownson *et al.*, 2009). The NEWS instrument has been shown to have good reliability and content and criterion validity (Brownson *et al.*, 2004a; Cerin *et al.*, 2007; Saelens *et al.*, 2003a; De Bourdeaudhuij *et al.*, 2003; Leslie *et al.*, 2005). The NQLS is a relatively new survey tool and little has been reported to date on its findings, reliability and validity. However, a reference list for all the questions used in the survey is available (Sallis *et al.*, 1997, 2001).

The CGL questionnaire is a multi-section instrument combined from i) valid and reliable self-report measures and ii) researcher developed measures. An outline of the complete CGL questionnaire used for this study is included in Appendix E.1 & E.2. Appendix E.3 includes the reliability scores, sources of the questions used and individual question response rates from the CGL study reported in this chapter.

The development of the CGL instrument went through three stages:

Step 1 – A draft instrument was developed based on the literature review, existing measures and the findings of studies one and two. The instrument was reviewed and revised by the research team until agreement was reached on the instrument content.

Step 2 – The instrument was tested for reliability and a face validity exercise was undertaken before the instrument was piloted in two areas, a representative group of the intended sample.

Step 3 – Amendments were made to the instrument based on the pilot results and feedback from data collectors.

6.4.1 Reliability and Validity

A 7-day test-retest reliability analysis was undertaken for the behavioural and environmental components of the CGL questionnaire with a convenience sample of exercise science students (N=22, 55% male, average age 25.7yrs $\pm$ 5.97). This testing was done before the neighbourhood pilot study and is referred to as the 'pre-pilot' in this thesis. Alpha coefficients and intra-class correlation coefficients (one way random effect model single) (Cicchetti 1994; Field 2009, p.677), are presented in Appendix E.3 tables E.2 to E.10. Reliability (α) scores ranged from .29 to 1.0. Test-retest reliability results for the IPAQ physical activity 7-day recall question were not included in this score range as the method used does not account for variation in behaviours in consecutive weeks. The reported reliability and validity of the IPAQ question is discussed in section 6.4.5. Environment items scored between .29 and .91 and the remainder of the questions scored between .45 and 1.0 (Appendix E.3). The lowest reliability score for a researcher developed environment question was 0.41. Low scores were observed for NEWS items on neighbourhood crime rate which due to the variable nature of this concept was expected, as a recent crime event or news story may influence individual perceptions over time. This concept would require further investigation which is outside the scope of this project. These reported reliability scores compare favourably to those reported for the NEWS questionnaire (Brownson *et al.*, 2004a; Saelens *et al.*, 2003a; Sallis, n.d.).

The CGL questionnaire's content validity was assessed via a number of methods. As the questionnaire was derived from a number of already validated instruments (NEWS, NQLS etc), the content validity of these questions were deemed acceptable. Additionally, its face validity (Litwin, 1995) was assessed by the research team (N=4), and by the data collection team (N=5). At each stage, the questionnaire was completed individually and feedback on question appropriateness, lack of clarity or suggestions on how to improve the questionnaire's design and quality were recorded and analysed.

The neighbourhood deprivation rating, important for accurate area selection (see section 5.4), was validated using self-report socio-economic indicator survey responses. Results of both the reliability and validity testing at the pre-pilot stage led to changes in word order, questionnaire design and length of the final instrument.

6.4.2 CGL Questionnaire Pilot Study

The CGL questionnaire, post pre-pilot testing, was further piloted on two low walkable areas short listed in study three, one deprived and one not deprived (areas 15 and 20). The pilot study yielded response rates of 21% and 23% respectively. As a result changes were made to procedure for data collection which are outlined in section 6.5.3. Changes to content of the questionnaire post pilot testing involved reformatting to enhance the respondent's experience, improved clarity in question wording and hence understanding of the questions. Illustrations and colour were added by a graphic designer and questionnaire was printed as an A4 booklet (Appendix E.1). The sequence of the questions was altered, with quicker to answer questions preceding those that required more concentration, such as the IPAQ-SF. This was found to be particularly important when surveying deprived areas where reading or comprehension difficulties were found to be common. To protect the anonymity of respondents each questionnaire had a unique identifier code, the first two digits of which identified the area.

6.4.3 Question Development - Personal Correlates

Demographic information was collected on age, gender, marital status and nationality. Socio-economic indicators (job status, education level and home ownership) were determined using Irish census questions (CSO 2006). A researcher developed question asked for individual and household income with an introductory sentence assuring the confidentiality of replies. This sentence was included because of low response rates for income questions in Irish questionnaires (CSO 2004). Questions from the NQLS were used to collect information on years of residence at the current address, the number of people in the household, number of children, their ages and whether or not the household has a dog.

6.4.4 Question Development - Environmental Correlates

Environmental items measured in the CGL study relate to (i) neighbourhood perceptions, (ii) destinations within walking distance of respondent's homes and (iii) neighbourhood satisfaction.

6.4.4.1 Neighbourhood perceptions

The CGL instrument evaluated respondents level of agreement with 41 statements (items) relating to their perceptions of their neighbourhood. These were rated on a 5-point Likert scale, ranging from 1 = 'strongly disagree' to 5 = 'strongly agree'. A neutral response, neither agree nor disagree (=3) was added to the Likert scale, this deviates from previously validated measures, Questionnaire items were grouped based on the format of the beginning of the sentence rather than sub-scale specific. This facilitated a reader-friendly layout. The full questionnaire is available in Appendix E.1, examples of items are given below.

The NEWS instrument (Saelens & Sallis 2002b, Appendix E.4) forms the basis of the neighbourhood perceptions section of the CGL questionnaire with 62% (23 of the 37 NEWS items) incorporated into the measure. NEWS is a 37-item instrument which has confirmed factorial validity relating to walking and cycling for transport using six subscales (land-use mix access, street connectivity, walking/cycling facilities, aesthesis, pedestrian/traffic safety and crime safety) (Cerin *et al.*, 2009a). Responses for NEWS are reported on a 4-point Likert scale from strongly disagree to strongly agree with no neutral option. A review of the NEWS scale for use in an Irish context, and based on the findings of study two and the literature review, several NEWS items were either excluded or amended for the CGL questionnaire. For example, the NEWS scale was validated for transportation but not for recreational walking, so an amended recreational destination item, which offers more than a specialised walking route or trail, as recreational walking destination was included. Researcher-developed items were also added to the CGL questionnaire. For example, informed by the findings of study 2, individual perceptions of scale, imageability, vibrancy, attractiveness and comfort of one's neighbourhood, which were found to be important in studies one and two, were added to the CGL questionnaire.

Identified limitations of the NEWS items and resulting amendments, for the purpose of shortening the CGL instrument and making it more contextually relevant for this project were:

In the '*access to services*' NEWS sub-scale (N= 7 items), items C1 (can shop in local stores) and C6 (streets are hilly) were retained. Item C3 'parking is difficult in local shopping areas' was omitted and an alternative item 'there are large car parks in front of shops and businesses' was introduced. This reflects the scale of the area and the issue of dominance of car parking spaces in areas built for the car (section 4.3.3.2). Item C7 (canyons and hills as barriers) was omitted as it was considered irrelevant for Dublin. Items C2 (stores are within walking distance) and C4 (many places to go within walking distance) were combined in item 'my neighbourhood has a variety of shops/ homes/ businesses and amenities'. Item C5 (it is easy to walk to a transit stop) was amended to 'I can easily travel to the majority of places I want to go to in Dublin using public transport'. This amended item gives contextual function to a transit stop addressing its ease of use and relevance.

In the '*streets in my neighbourhood*' sub-scale (N=5 items) two items have a strong focus on cul-de-sacs with the assumption that cul-de-sacs are a negative feature for walkability. Study two (Section 4.3.6) of this thesis disputes this association and as a result these items were omitted along with items D3 and D4 which refer to perceptions of functional connectivity measures, block lengths and four way intersections, in favour of a single permeability measure. This is item D6 from NEWS: 'There are many alternative routes for getting from place to place in my neighbourhood'. The four omitted items all measure the structure of the street network, connectivity, instead of the perception of being able to move through the area, permeability (Section 4.3.6). Connectivity can be determined objectively using GIS or neighbourhood street mapping.

In the '*places for walking and cycling*' sub-scale (N= 5 items) items E1 (presence of sidewalks) and E2 (maintenance of sidewalks) were combined to create a new item which also incorporates pedestrian level of service (Section 4.3.6.3). The new item 'In my neighbourhood there are sufficiently wide, good quality footpaths' encompasses the functionality of footpaths. Items E4 (cars as a buffer) and E5 (grass verge as a buffer) were combined to create a new item 'In my neighbourhood footpaths are separated from the road by a buffer (examples given)'. The final item in this sub-scale, access to bicycle and pedestrian trails, was replaced with an item which refers only to walking. Rather than reference to a specialised trail, the new item asks if there are nice places to go for a walk for recreation within walking distance of the respondents home and offers the neighbourhood itself as a destination for recreational walking (Section 4.3.5).

In the '*neighbourhood surroundings*' sub-scale (N=6 items) items F1 (presence of trees), F3 (interesting things to look at) and F5 (many attractive sights – landscaping and views) were combined into a single measure of positive visual interest: 'In my neighbourhood there are many attractive sights such as gardens, trees, green spaces, attractive buildings and views'. This item also incorporates NEWS item F6 (attractive buildings/ homes) which was reversed for one of the CGL measures of visual disorder: 'In my neighbourhood there are badly maintained, unoccupied or unattractive buildings or houses'. Item F4 (litter) was maintained. The final item in this sub-scale referred to shade from trees. This item's limitation is its irrelevance to Irish weather and was replaced with 'While walking in my neighbourhood in bad weather I can find shelter from the wind and rain'. Shelter in the built environment from sun or bad weather is not solely provided by tress and this revised item reflects this (Section 4.3.7).

The NEWS '*safety from traffic*' sub-scale (N= 8 items) was also reduced. Only three of the original eight items were retained. G3 'the speed of traffic on the street I live on is usually slow (30mph or less)' was unaltered, G6 was slightly amended to read 'there are pedestrian crossings/ pedestrian lights to help walkers cross busy roads' and G8 was slightly amended to include air pollution from all sources and not just traffic fumes to read 'there is a lot of air pollution (from all sources including traffic fumes)'. These items were considered the most relevant from the original 8 NEWS safety from traffic items for the CGL study. Additional items were added to the CGL survey on noise pollution and waiting times at pedestrian crossings. Both items relate to pedestrian comfort influenced by traffic related neighbourhood characteristics (Sections 4.3.3 & 4.3.7).

All six items in the NEWS '*safety from crime*' scale (N= 6 items) were retained for the CGL study questionnaire. Item H2 was slightly amended to read 'people walking on the street can be easily seen by people in their homes, shops and other occupied buildings'. Item H3 (I see and speak to other people while I am walking) was replaced by two items. 'There are many friendly or familiar faces' and 'there are many other people walking' which incorporate comfort and walking as a behavioural norm in the neighbourhood (Section 4.3.7). NEWS item H3 does not differentiate between a positive or negative interaction with other people. An additional safety question which is in NQLS but not in NEWS was also retained 'Is safe enough that I would let a 10 year old child walk around my neighbourhood alone in daytime'. This item was amended slightly replacing the word 'block' with 'neighbourhood' and 'boy' with 'child'.

Additional researcher-developed items include assessment of perceptions of permeability, transparency/overlooking, vibrancy, attractiveness, imageability, social cohesion, comfort, visual/social disorder and village characteristics. An explanation of these correlates and their level of importance in our understanding of factors that influence perceptions of walkability was explained in the literature review. An example of items relating to each of these sub-scales is shown on Table 6-1. Upon completion of the 41 CGL neighbourhood environment items respondents were asked how they would rate their neighbourhood as a place to walk on a 5-point Likert scale. The scale went from 1 – very walkable to 5 - not at all walkable. A prompt 'walkability means pedestrian friendly' was included for clarity.

6.4.4.2 Destinations within walking distance

The Leyden Instrument is a reliable (α=0.7) and valid measure of the number of listed destinations that respondents perceive are within walking distance of their home (Leyden, 2003). The questionnaire was amended, with the assistance of the original instrument author, to include seventeen destinations relevant to Dublin communities. A summation score of accessible destinations is reported. A perfect alpha reliability score of 1 was reported for the amended measure (Appendix E.3).

Access to a good public transport service, which fulfils the needs of its neighbourhood residents, was highlighted as an important element in walkability in study two (Section 4.3.6.4). The CGL questionnaire assessed respondent's perceived access to such a service by asking them 'how easy or difficult is it to use public transport near your home with consideration for access to, frequency of service and service destinations'. Responses were measured on a 5 point Likert-scale from 1 – very easy to 5 – very difficult. The measure was found to have very good reliability (α=.8).

Table 6-1: Researcher Developed Questionnaire Item Details

Theme	*Item wording*	α(ICC)
Permeability (Section 4.3.6.2)	While walking in my neighbourhood there area places I avoid	.9 (.9)
Transparency/ overlooking (Section 4.3.7)	Many high walls alongside footpaths	.8 (.9)
	Shops and businesses close shutters over their shop fronts when closed	.4 (.6)
Vibrancy (Section 4.3.7.2)	People about all day and in the evening shopping and visiting restaurants and pubs nearby	.5 (.7)
	Children playing in the neighbourhood	.7 (.8)
Attractiveness (Section 4.3.7)	Many inviting, locally owned shops	.4 (.6)
Imageability (Section 4.3.5.2)	Is a unique area with personality and character'	.8 (.9)
Social cohesion (Section 2.6.3)	Many of my friends and family live within walking distance	.8 (.9)
	I fell connected to people that live in my neighbourhood	.7 (.8)
Comfort (Section 4.3.7)	Places to stop and rest while walking	.5 (.7)
Visual/social disorder (Section 4.3.7)	There are homeless people and/or beggars	.9 (1.0)
	Has little or no graffiti	.6 (.7)
Village characteristics (Section 4.3.5)	A mix of age groups, young and old people, as well as a mix of family types	.8 (.9)
	My neighbourhood has a village feel to it	.7 (.8)

6.4.4.3 Neighbourhood satisfaction

The CGL questionnaire includes a 12-item neighbourhood satisfaction scale, this was based on the NQLS satisfaction question and the Adamstown Population Study's (Amárach Research & SDCC 2009) neighbourhood satisfaction questionnaire. Five out of 12 CGL items were similar to those used in the second NQLS survey. No information was available on the reliability or validity of either the Adamstown Study questionnaire or the NQLS, so the revised question was tested alongside researcher developed items from the CGL questionnaire. Alpha scores ranged from .6 to 1.0 for question items (Appendix E.3). Items were measured on a 5-point Likert scale from 1 – very dissatisfied to 5 – very satisfied.

6.4.5 Question Development - Behaviours

Behavioural items measured in the CGL study relate to (i) travel behaviour, (ii) vehicle ownership, (iii) fuel spend, (iv) physical activity behaviour and (v) reported barriers to walking.

Travel behaviour measures comprised of usual trip mode, frequency and trip time (as a proxy for distance), to eleven identified destinations. A 'journey not applicable' option was provided so only relevant trips could be filtered from the data. The travel behaviour questions are researcher developed. These measures were constructed by combing the Leyden Walkability Instrument (Leyden, 2003) with the CSO Census POWCAR mode question (2006) with added trip frequency and duration measures. This question identifies the habitual transport behaviours of respondents. The Census motorised vehicle ownership question (CSO 2006) was used, followed by the Twin Cities Walking Study motorised vehicle description question (Forsyth *et al.*, 2003). Weekly individual fuel spend and weekly household fuel spend were measured using a researcher developed question as a proxy for mileage (distance) driven. The research team was in agreement that weekly fuel spend would be easier to recall than vehicle miles travelled.

Physical activity behaviour was measured using the IPAQ. The IPAQ has two formats, long and short. The long format (IPAQ-LF) has 27 items relating to: job related physical activity (7 items), transportation physical activity (6 items), housework/ house maintenance/ caring for family (6 items), recreation/ sport/ leisure-time physical activity (6 items) and time spent sitting (2 items). The short form IPAQ-SF is a more concise measure with seven items incorporating the categories from the IPAQ-LF. The IPAQ SF is the most popular physical activity measure in the world (Lee *et al.*, 2011). The measure's reliability has been reported to be 'generally good' (0.25 to 0.88) by Craig and colleagues (2003, p.1385) with a score over .65 for 75% of the 12 tests they carried out on the 'total physical activity' measure. However, the IPAQ has low validity when compared to objective measures of physical activity typically overestimating by 83% (Lee *et al.*, 2011). Van der Ploeg and colleague's (2010) study supported the ability of the IPAQ short form to provide reliable and valid estimates of time spent on walking behaviour. Despite this validity limitation the IPAQ-SF's popularity for physical activity and use in built environment studies warranted its inclusion in the CGL questionnaire for comparability to other studies. An amendment was made to the IPAQ-SF scale to expand items relating to our physical activity behaviours of interest, active transport and recreational walking. In the IPAQ-LF these items are separate and were condensed for the IPAQ-SF instrument. The resulting self-report physical activity measure for the CGL questionnaire was a 9-item measure. Total physical activity can still be measured using the revised instrument. The amended measure is outlined in Appendix E.2.

The barriers to neighbourhood walking measure in the CGL questionnaire is an amended format of the NQLS barrier to regular physical activity question (question Y, Sallis et al. n.d.). The CGL amended version simplifies the question by asking how often do a list of items 'prevent you from walking in your neighbourhood?', our physical activity of interest, rather than the original term 'prevent you from getting regular physical activity'. Responses are on a 5-point Likert scale from never to very often. Listed items include eight of the 15 original items from the NQLS question with an additional 6 researcher developed items. The additional items include items to address the behavioural response to perceptions of the built environment (e.g. feeling unsafe from crime and not feeling part of the community) (Section 2.5). Walkability research has drawn associations between perceptions of the built environment and behaviour but no self-report questions were identified which asked respondent if their perceptions influence their behaviour. Some of the original items were removed to facilitate the inclusion of the additional items to prevent the question from getting lengthy and onerous.

6.5 Data Collection Procedure

6.5.1 Data Collector Training

A team of data collectors (N=12) received a one-day training workshop and on-site mentorship training. The workshop covered doorstep interview techniques, questionnaire completion, role play and data inputting. The training mentorship took place in study neighbourhoods where data collectors were accompanied by an experienced researcher who gave feedback and assessed their performance until they were deemed competent to continue as an individual collector in the doorstep team.

6.5.2 Pilot Study

Changes were made to the data collection procedure (outlined below) following the pilot study outlined in section 6.4.2. These changes were made because in the deprived area, informed by local knowledge from shopkeepers and other local services, data collectors had to leave the area before 5pm for safety reasons. This was due to the congregation of inhospitable groups in the area. This had the potential to impact on recruitment of individuals from the area who were working nine to five jobs. Additionally, in the not-deprived area many people were observed to arrive home from work/sports late in the evening. To counteract these potential sample limitations a variety of recruitment and response options were used. Due to the importance of questionnaires collected reflecting the immediate environs of respondent's homes and the low percentage of doors answered and the pilot response rate (22%) a decision was made to visit every house in the targeted areas.

6.5.3 Sample and Recruitment

Guided by the results of study three (Section 5.6) a group of census small areas were selected within the designated study sites as a starting point. Adjacent small areas of similar deprivation and walkability status were visited until 50 surveys were returned from that area. A similar method to the one used by Badland and colleagues (2009). Active recruitment strategies with a variety of response options were used in order to increase the likelihood the number of returned complete surveys. While this protocol takes away from the uniformity of the data collection procedure, it was considered to be a positive action to ensure a friendly, engaging, respondent-centred approach to data collection. This involved data collectors calling to each residential door, introducing themselves and explaining the purpose of the study. Residents who were over 18 years were asked if they would be willing to complete the questionnaire and if they agreed they were offered four response options. The questionnaire could be i) completed on the doorstep with the researcher, ii) collected by the data collectors later that day, iii) completed by the respondent in their own time and returned by using the freepost (postage paid) envelope provided or iv) completed online using a web address provided. A cover letter and a copy of the questionnaire are in Appendix E.1.

The participant was assured that the questionnaire was anonymous and voluntary. A lottery based incentive (€50 voucher for a local shop) was provided to participants on return of their completed questionnaire; an incentive used by Cerin and Leslie (2008). Before leaving the door the data collector thanked them for their time and answered any questions they had. A contact telephone number was provided on the questionnaire. Reminder posters were put up in local shops, post offices and takeaways (fast food outlets) with the permission of the proprietor to encourage timely return of the self-completed questionnaires.

The population study was carried out between July and September 2011. Two areas were revisited in October/November as the number of returned surveys was less than the required quota. One area was found to be a 'ghost estate' a term given to unfinished estates with unoccupied houses following the Irish property crash. This area (area 17, a low walkable not deprived suburban area), did not reach the quota of 50 responses and had no remaining occupied homes to survey. As the overall number of responses for the LWND area category was greater than the target of 200, no more questionnaires were collected and the 41 responses from this area were included in the total LWND sample.

6.6 Data Analysis

Survey results were imputed into the Statistical Package for the Social Sciences (SPSS) version 17 by a team of researchers. As the data input was carried out by a number of researchers a procedure was put in place to minimise errors. Data checking and data preparation procedures are outlined in Appendix E.5. Means, standard deviations and proportions were used to describe the data where appropriate. All data were tested for normality calculating skewness, kurtosis and observing distribution curves. It was found that the majority of cases were not normally distributed.

6.6.1 Factor (Component) Analysis

The neighbourhood perceptions correlates (N= 41 items), the barriers to neighbourhood walking scale (N=15 items) and the neighbourhood satisfaction scale (N= 12 items) were reduced using factor analysis for comparison analysis. Principal component analysis (PCA) was used for factor extraction due to its relevance for social data, particularly in the construction of environment scales in behaviour research (Ogilvie *et al.*, 2008; Pallant, 2010; Field, 2009). Orthogonial (Varimax) rotation with Kaiser Normalisation (eignevalue rule) was used to maximise the dispersion of loading within factors by constructing uncorrelated sub-components of the data and therefore producing more interpretable components (Field, 2009; Pallant, 2010). Horn's Parallel analysis was carried out to compare eigenvalues from a randomly generated dataset of the same size using Watkins' (2000) computer software to the sub components generated from the PCA and Varimax rotation to verify the number of sub-components as the Kaiser test can overestimate the number of sub-components to be retained (Pallant, 2010). Before carrying out component analysis, the suitability of the data was checked for (i) adequate sample size and (ii) the relationship between variables. The ratio of question variables to cases was acceptable for PCA for each of the measures with a minimum ratio of 26 cases per variable (environment). This is greater than the minimum recommended ratio of between 10 to 20 people per measured variable (Field, 2009; Thompson, 2004). The relationship between variables in each of the measures/scales was determined using Kaiser –Meyer-Olkin (KMO) measure of sampling adequacy[51] and Bartlett's test of sphericity[52] (Pallant, 2010; Ogilvie *et al.*, 2008). The KMO statistic was also calculated for individual items. All items where individual KMO values were less than 0.5 were removed to avoid issues relating to multi-collinearity or singularity within the data. Components were constructed using items with loadings of greater than 0.5.

6.6.1.1 Component Analysis 1: Neighbourhood perceptions instrument

PCA was carried out on the 41 questionnaire items on neighbourhood perceptions. Rotation converged in eight iterations into eight components. The KMO measure (0.9) verified the sampling adequacy for the analysis. This result is considered 'superb' by Field (2009,p. 659). Bartlett's test of Sphericity $\chi^2(820) = 13035.8$, $\rho<.001$ indicated that correlations between items were sufficiently large for PCA. Initial analysis showed eight components had eigenvalues over Kaiser's criterion of 1 and in combination explained 51% of the variance.

Five items with individual KMO values less than 0.5 or strong correlations, 0.6 or greater, with other items were removed and the PCA was repeated on 36 items. The items removed were Ed4, Eb7, Eb8, Ef4 and Ea4 (described in Appendix E). Because of the high correlation between Ed3 and Ed4, Ed4 'In my neighbourhood there is a lot of noise' was removed from the analysis. Similarly Ee2, Eb7 and Eb8 were highly correlated and were all related to crime rate. Ee2, which is a general statement relating to crime rate was retained while Eb7 and Eb8, which were both NEWS sub-categories of crime, which have temporal references to crime rate were removed. Ef4, 'My local neighbourhood has a neighbourhood feel to it', had a high correlation to many items relating to the village concept (Section 4.3.5) so it was omitted from the analysis to avoid influencing the PCA calculation. Ea4, 'In my neighbourhood there are many attractive sights' was removed because it had an individual KMO of 0.4 and a correlation of 0.6 with item Ea5.

Because the survey responses are from 16 neighbourhoods with varying characteristics, components produced from this exercise are not suitable for the production of a scale to measure walkability at this stage of the analysis. This is

[51] a measure of degree of common variance between variables

[52] a test of the null hypothesis that the variables are completely uncorrelated

because the street level contextual features will differ between areas within the four area categories. This factor analysis exercise was undertaken to identify grouping of items to facilitate comparison of area categories under headings derived from the grouped items. Constructs were reviewed for content and examined to investigate if they vary in relation to walkability. Table 6-2 outlines the output from the PCA of the remaining 36 items. Convergence occurred after eight iterations with a KMO = 0.9 and the Bartlett's test of Sphericity was $\chi^2(630) = 9362.64$, $\rho<.001$ indicating that correlations between items were sufficiently large for PCA. The eight components explained 51% of the variance.

Table 6-2: Rotated Component Matrix Environment Correlates

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Ee2 Has a high crime rate	**-.73**							
Ee4 Is generally free from rubbish/ litter	**.69**							
Ef6 While walking in my neighbourhood there are places I avoid	**-.69**							
Ec1 Badly maintained, unoccupied or unattractive buildings or houses	**-.64**							
Ee1 Has little or no graffiti	**.61**							
Ed3 A lot of air pollution (from all sources including traffic fumes)	**-.61**							
Ee5 Is safe enough that I would let a 10 year child walk around my neighbourhood alone in daytime	**.60**							
Ec5 Homeless people and/or beggers	**-.54**	.34						
Eb6 Shops and businesses close shutters over their shop fronts when closed	**-.50**					.31		
Ee6 Is well lit at night	.44							
Ed1 A variety of shops/ homes/ businesses and amenities		**.78**						
Ec2 Many inviting, locally owned shops		**.61**						
Ec7 People about all day and in the evening shopping or visiting restaurants and pubs nearby		**.63**						
Ed2 A mix of age groups ,young and old people, as well as a mix of family type		**.59**				.32		
Ef2 I can do most of my shopping at local shops		**.57**						
Ee3 Is an unique area with personality and character		**.57**						
Ea5 Nice places, within walking distance of my home, to go for a walk for recreation (such as a park or even just around the neighbourhood itself)		**.51**						
Ea3 Many different routes for walking from place to place so I don't have to go the same way every time		.44					.41	
Eb5 There are a many other people walking		.39			.41			
Eb3 There are many friendly or familiar faces			**.73**					
Ef3 I feel connected to people that live in my Neighbourhood		.36	**.65**					
Eb2 Many of my family and friends live within walking distance			**.65**					
Ea2 Pedestrian crossings/ pedestrian lights to help walkers cross busy roads		.37			.30		.40	
Ef5 I can easily travel to the majority of places I want to go in Dublin using public transport		.31	.34				.49	
Ea7 Wide roads with multiple lanes of traffic				**.74**				
Ea6 Large car parks in front of shops and businesses				**.74**				
Eb9 footpaths are separated from the road by a buffer (for example: grass verge, parked cars or other barrier)				**.52**				
Ea1 Sufficiently wide, good quality footpaths				.39				
Eb4 While walking in bad weather I can find shelter from the wind and rain					**.76**			
Ec3 Places to stop for a rest while walking		.37			**.52**			
Eb11 People walking on the street can be easily seen by people in their homes, shops and other occupied buildings						**.67**		
Ec4 Children playing in the neighbourhood						**.59**	-.36	
Eb10 The speed of traffic on the street I live on is usually slow (Prompt: 30kph or less)					.32	**.50**		
Ef1 While walking in my neighbourhood I often have to wait a long time for a pedestrian light							**-.61**	
Ec6 Many high walls alongside footpaths								**.69**
Eb1 Streets are hilly, making it difficult to walk								**.75**

Following parallel analysis six of the eight sub components generated were retained as their eigenvalues exceeded the corresponding data from the random sample using parallel analysis (Table 6-3). The six components used explained 45% of the variance.

Table 6-3: Parallel Analysis for Environment Components

Component No	*Actual Eigenvalue from PCA*	*Criterion Value from Parallel Analysis[1]*	*Decision*
1	6.35	1.35	Accept
2	3.46	1.31	Accept
3	2.14	1.28	Accept
4	1.65	1.25	Accept
5	1.48	1.23	Accept
6	1.21	1.21	Accept
7	1.14	1.18	Reject
8	1.02	1.16	Reject

[1]Determined using Watkins (2000) Monte Carlo software recommended by Pallant (2010)

The percentage variance explained by each constructed component and their internal consistency scores for the generated scales are outlined in table 6-4. The *Crime and Disorder, Village* and *Social* components all have alpha scores of over 0.7 which is ideal however the *Scale, Comfort* and *Overlooking* components have alpha scores less than 0.7. Since the number of items in each of the factors is less than 10 the alpha scores for factors can be small so the ICC should also be measured. The ICC scores for the sub components are within the optimal range of 0.2 to 0.4 (Pallant, 2010). Considering this information the six generated sub components were deemed suitable by the researcher.

Table 6-4: Environment Component properties

Component	*# items*	*α*	*ICC*	*Variance Explained*
1 Crime and Disorder	8	0.8	0.3	17.6%
2. Village	7	0.8	0.4	9.6%
3. Social	3	0.7	0.4	5.9%
4. Scale	3	0.6	0.3	4.6%
5. Comfort	2	0.5	0.4	4.1%
6. Overlooking	3	0.4	0.2	3.4%

Components produced comprise of items loaded with a factor greater than 0.5 from the PCA are outlined in Table 6-2. Component one (n=8, α=.8) was constructed with the following items: (i) A lot of air pollution (negative loading), (ii) Homeless people and/or beggers (negative loading), (iii) badly maintained, unoccupied or unattractive buildings or houses (negative loading), (iv) has a high crime rate (negative loading), (v) has little or no graffiti, (vi) is safe enough that I would let a 10 year old child walk around my neighbourhood alone in the daytime, (vii) while walking in my neighbourhood there are places I avoid (negative loading) and (viii) shops and businesses close shutters over their shop fronts when closed (negative loading). Although item Ee4 loaded onto this component in the PCA it was not included as it reduced the internal consistency (α- score) of the component. This component was named '*Crime and Disorder*' as items relate to a perception visual disorder, spatial avoidance, discomfort and personal safety from crime. This component is scored positively despite being negatively titled; items which negatively loaded onto the component were reversed for the component construction.

The second component (n=7, α=.8) was constructed from the following items: (i) a variety of shops/ home/ businesses and amenities, (ii) many inviting locally owned shops, (iii) people about all day and in the evening shopping or visiting restaurants and pubs nearby, (iv) a mix of age groups, young and old people, as well as a mix of family types, (v) I can do most of my shopping at local shops, (vi) is a unique area with personality and character, (vii) nice places to go for a walk for recreation. This component was named '*Village*' as it relates to the village concept discussed under in section 4.3.5. The component represents an area with high imageability, with day-long uses with a diversity of residents and a diversity of land uses facilitating the daily needs of residents, including recreational walking.

The third component (n=3, α=.7) was constructed from the following items: (i) There are many friendly or familiar faces, (ii) I feel connected to people that live in my neighbourhood and (iii) many of my family and friends live within walking distance. This component was named '*Social*' as it reflects a grouping of social cohesion items included in the neighbourhood perceptions section of the questionnaire. The forth component (n=3, α=.6) was constructed using the following items: (i) wide roads with multiple lanes of traffic, (ii) large car parks in front of shops and businesses and (iii) footpaths are separated from the road by a buffer. This component was named '*Scale*' as it comprises of items which are indicative of the 'carchitecture' scale, in contrast to a human scale, described in section 4.3.3. The fifth component (n=2, α=.5) was constructed using the following items: (i) while walking in bad weather I can find shelter from the wind and rain and (ii) places to stop for a rest while walking. This component was called '*Comfort*' as the items are indicative of opportunities to take refuge from the elements or to rest (Section 2.7.2). The sixth component (n=3, α=.4) was constructed using the following items: (i) people walking on the street can be easily seen by people in their homes, shops and other occupied buildings, (ii) children playing in the neighbourhood and (iii) the speed of traffic on the street I live is usually slow. This component was called '*Overlooking*' as the items are indicative of activity on the street and a human pace of movement which affords observation (Section 4.3.7). Items relating to pedestrian crossings, lighting and footpaths, functional items and the ease of use of public transport did not load strongly onto a single component.

6.6.1.2 Component Analysis 2: Barriers to neighbourhood walking

The CGL barriers to walking ('Prevent') question asks: 'How often do the following prevent you from walking in your neighbourhood?' Replies were given on a 5-point likert scale from 1- Never to 5 – Very often. A total score was calculated using a summation of total scores for all 15 items. Since there was a mix of psychosocial and physical environment barriers a component analysis was carried out to reduce the number of items for comparison. PCA was carried out on the 15 question variables. Rotation converged in five iterations into five components (Table 6-5). The KMO measure (0.8) verified the sampling adequacy for the analysis. Bartlett's test of Sphericity $\chi 2(105) = 3698.4$, $\rho<.001$ indicates that correlations between items were sufficiently large for PCA. Initial analysis showed four components had eigenvalues over Kaiser's criterion of 1 and in combination explained 58% of the variance. Individual KMO's and correlations were also checked and all correlates were retained for analysis. Following parallel analysis all four components were retained as their eigenvalues exceeded the corresponding data from the random sample (Table 6-6).

Table 6-5: Rotated Component Matrix for 'Prevent' Question

	1	2	3	4
Not being in the right mood	**.78**			
Lack of time	**.71**			
Lack of energy	**.67**		.46	
Bad weather	**.63**			
Easier to drive even short journeys	**.59**			
Lack of company or others to walk with	**.58**			
Not enjoying exercise	**.59**		.34	
Being self-conscious about your appearance	.38			
Feeling unsafe from traffic		**.80**		
Feeling unsafe from crime		**.79**		
Not feeling part of the community		**.75**		
Disability or poor health			**.85**	
Fear of falling/ getting injured		.43	**.65**	
Ruining my hair or make-up				**.87**
Wanting to wear fashionable shoes unsuitable for walking distances				**.87**

Table 6-6: Parallel Analysis for 'Barriers to neighbourhood walking' Correlates

Component No	*Actual Eigenvalue from PCA*	*Criterion Value from Parallel Analysis[1]*	*Decision*
1	4.31	1.20	Accept
2	1.89	1.16	Accept
3	1.40	1.13	Accept
4	1.14	1.10	Accept

[1]Determined using Watkins (2000) Monte Carlo software recommended by Pallant (2010)

The percentage variance explained by each constructed component and the reliability scores for the generated scales are outlined in table 6-7. All alpha scores are over 0.7 which is ideal. The ICC scores for the sub components are greater than the optimal range of 0.2 to 0.4 (Pallant, 2010). Considering this information the four generated components were deemed suitable by the researcher.

Table 6-7: Barrier component's properties

Component	*# items*	*α*	*ICC*	*Variance Explained*
1 Psychosocial Correlates	7	0.8	0.4	28.7%
2. Comfort and Inclusion	3	0.7	0.5	12.6%
3. Vulnerability	2	0.7	0.5	9.3%
4. Fashion	2	0.7	0.6	7.6%

Components produced are comprised of items loaded with a factor greater than .5 from the PCA outlined in Table 6-5. Component one (n=7, α=.8) relates to *psychosocial barriers* (i) not being in the right mood, (ii) lack of time, (iii) lack of energy, (iv) bad weather, (v) easier to drive even short distances, (vi) lack of company or others to walk with and (vii) not enjoying exercise. Component two (n=3, α=.7) relates to an individual's *comfort and feeling of inclusion* (i) feeling unsafe from traffic, (ii) feeling unsafe from crime, (iii) not feeling part of the community. Component three (n=2, α=.7) relates to *vulnerability* due to age or disability (i) disability or poor health and (ii) fear of falling/ getting injured. Component four relates to *fashion* (n=2, α=.7) with items (i) ruining my hair or make-up and (ii) wanting to wear fashionable shoes unsuitable for walking distances. The item 'being self-conscious about your appearance' did not load onto any component.

In the results section (6.4.6) the difference between the individual items 'time' and 'easier to drive' were considered individually as long journey/ commute times related to the proximity to the work place, and other relevant destinations, in addition to a long working day can impact on the time available for other activities. The scenario where it is easier to drive to destinations rather than walk is conceivable in low walkable neighbourhoods although the motivation to walk over drive may be related to the psychological profile of the respondent. The three items from the second component (feeling unsafe from crime, feeling unsafe from traffic and not feeling part of the community) were also considered individually.

6.6.1.3 Component Analysis 3: Neighbourhood satisfaction components

The CGL neighbourhood satisfaction question asks: 'Thinking about your neighbourhood, how satisfied are you with the following?' Replies were given on a 5-point Likert scale from 1 – very dissatisfied to 5 - very satisfied. PCA was carried out on the 12 questionnaire items on neighbourhood satisfaction to reduce the number of items for comparison. Rotation converged in three iterations into two components. The KMO (0.9) measure verified the sampling adequacy as very good for the analysis (Field, 2009). Bartlett's test of Sphericity $\chi^2(66)$ = 5246.5, ρ<.001 indicates that correlations between items were sufficiently large for PCA. Both components had eigenvalues over Kaiser's criterion of 1 and in combination explained 63% of the variance. The KMO statistic was also calculated for individual items and all item values were greater than 0.5 so all were retained. All items loaded onto one of the two components (Table 6-8). Following parallel analysis both components were retained as their eigenvalues exceeded the corresponding data from the random sample (Table 6-9).

Table 6-8: Rotated Component Matrix for Neighbourhood Satisfaction Items

	1	*2*
Living in your neighbourhood	.42	**.68**
Appearance of your neighbourhood		**.76**
Feeling of safety from crime		**.79**
Noise level		**.82**
The amount of motorised traffic		**.75**
Air quality		**.75**
Ease of getting to and from work or the place I study	**.76**	
Ease of getting to and from convenience stores and other shops	**.80**	
Places to socialise nearby	**.68**	
Ease of getting home late at night	**.79**	
Access to basic services nearby (shops, medical services, banking, schools etc)	**.77**	
Access to public transport	**.82**	

Table 6-9: Parallel Analysis for 'Neighbourhood satisfaction' Correlates

Component No	*Actual Eigenvalue from PCA*	*Criterion Value from Parallel Analysis[1]*	*Decision*
1	5.20	1.18	Accept
2	2.33	1.13	Accept

[1]Determined using Watkins (2000) Monte Carlo software recommended by Pallant (2010)

The percentage variance explained by each constructed component and the reliability scores for the generated scales are outlined in table 6-10. All alpha scores are over 0.7 which is ideal. The ICC scores for the sub components are greater than the optimal range of 0.2 to 0.4 (Pallant, 2010). Considering this information the two generated components were deemed suitable by the researcher.

Table 6-10: Barrier component's properties

Component	*# items*	*α*	*ICC*	*Variance Explained*
1 Access	6	0.9	0.5	43.3%
2. Comfort	6	0.7	0.5	19.4%

Two components were produced comprising of items loaded with a factor greater than 0.5 from the PCA outlined in Table 6-8. Component one (n=6, α=.9) relates to '*Access*' to facilities with items (i) ease of getting to and from work or the place I study, (ii) ease of getting to and from convenience stores and other shops, (iii) places to socialise nearby, (iv) ease of getting home late at night, (v) access to basic services nearby (shops, medical services, banking, schools etc), and (vi) access to public transport. The second component (n=6, α=.7) relates to individual's comfort. Items in component two are: (i) living in your neighbourhood, (ii) appearance of your neighbourhood, (iii) feeling of safety from crime, (iv) noise level, (v) the amount of motorised traffic and (vi) air quality.

6.6.2 Identifying Differences between area categories

To test our hypotheses and evaluate any differences between area categories, non-parametric tests were carried out on (1) demographic and socio-economic profile, (2) neighbourhood environment perceptions, (3) transport and physical activity behaviours, (4) the correlates which prevent neighbourhood walking and (5) neighbourhood satisfaction. The Kruskal – Wallis (KW) test analysed differences between all four area categories, this was followed by Mann-Whitney U tests to identify differences between two independent area categories. As there were six individual U tests carried out for each correlate or component a Bonferroni adjustment of six was applied to the statistical score to control for Type 1 errors. This adjustment reduced the 95% confidence interval statistic from 0.05 to 0.008. The effect sizes for the KW tests determining differences between groups were also determined. To accommodate a visual comparison of the different measures, standardised (z) scores of the correlates and components are presented graphically. Means, standard deviations and median scores are presented for correlates and components for each of the area categories. The mean of the standardised (z) correlate scores for area categories were calculated and presented graphically to facilitate visual comparison of the results.

6.7 Results

In the following section the following denotations are used for the area categories as identified in study three; HWD for high walkable deprived, HWND for high walkable not deprived, LWD for low walkable deprived and LWND for low walkable not deprived. In this section each set of results is presented on a table, followed by a graph comparing area categories and standardised scores of the relevant correlates. For each correlate a smaller graph illustrates the standardised scores and significant differences between area categories.

6.7.1 Response Rate

The response rate was calculated based on the percentage of people who received and returned a survey; it was 43%, higher than the expected 25% based on the pilot study results. Response rates varied in high and low walkable deprived and not deprived areas (Table 6-11). A total of 7344 doors were visited in 16 areas of the Greater Dublin Area. Twenty percent of the 3086 doors which were answered declined to participate.

Table 6-11: Response rates (%(n)) by walkability and area deprivation rating

	Deprived	*Not Deprived*
High Walkable	31% (278)	56% (279)
Low Walkable	39% (262)	47% (242)
Totals	35% (540)	52% (521)

Of the returned questionnaires 52% were returned by post, 38% opted to have the questionnaire collected, 6% filled it in on the doorstep and 4% filled out the survey online. The number of responses from areas varies from 41 (32% of doors visited, Area 19, LWD, suburbs) to 95 (24% of doors visited, Area 1, HWD, inner city). The area response rates vary from 24% (Area 4, HWD, inner city) to 65% (Area 7, HWND, suburbs).

6.7.2 Sample and Demographics

The mean age of the total sample (N=1061) was 46.9 years (± 16.1, Range 18 to 92yrs). Respondents were predominately female (63% of total sample). There were a higher number of female respondents in low walkable (LW) areas (69%) than high walkable (HW) areas (57.5%). Differences between area categories were identified using a Kruskal-Wallis Test (H(3)=16.3, ρ<0.001). LWD areas and LWND areas both reported a significantly greater number of females than the HWND areas. Significant differences were not found between the HWD group and any other group. A significant difference was observed in the age profile between all groups (H(3) =119.5, ρ<0.001) except between the HWD and LWD area (Figure 6-2). 'Age' and 'years at this address' were significantly correlated for the whole sample, Spearman's correlation coefficient 0.7. This result was replicated at area category level; however LWND areas had a weaker correlation with age only explaining 30% of the duration of residency's despite being statistically significant, Table 6-12.

Table 6-12: Age and Years at address correlation

	Mean Age (yrs)	Median Age (yrs)	Years at this address, M	Age-years at address correlation[1]
HWD	46.2	42.5	9.3	0.8**
HWND	54.1	55	17.0	0.7**
LWD	47.8	46	20.0	0.7**
LWND	38.2	37	5.0	0.4**
Total	46.9	44	10.0	0.7**

[1]Spearmans coefficient, **ρ<0.001

All of the socio-economic indicators tested showed significant differences between not deprived (ND) and deprived areas (D) for both high and low walkability with the exception of 'Job Status' (Table 6-13). For job status, no significant difference was found between the HWND areas and the HWD areas (Table 6-13). HWD areas scored significantly greater than LWD for all socio-economic indicators investigated indicating a higher level of deprivation in LWD areas than in HWD areas (Table 6-13). Standardised scores for these items are presented graphically for comparison in Figure 6-1 and individually in Figures 6-2 to 6-6.

HWND areas had a significantly greater home ownership score than all other area categories. A higher home ownership score indicates more residents own their homes without a mortgage, a low score indicates more residents renting from local authorities. Similar to socio-economic measures HWD areas showed a significantly higher home ownership score than LWD areas. Not deprived areas had significantly higher marital status scores than deprived areas. Further investigation is required to determine if this is related to the age profile of the areas or deprivation.

Table 6-13: Personal Correlates differences between area categories

Measure	N	***HWD*** Mean (sd) Median	***HWND*** Mean (sd) Median	***LWD*** Mean (sd) Median	***LWND*** Mean (sd) Median	H(3)	ρ	η^2	
Age group	980	2.35(1.1) 2.0	2.92 (1.0) 3.0	2.47 (1.1) 3.0	1.78 (.8) 2.0	124.8	.00	0.13	HWND > HWD & LWD &LWND **, LWD > LWND**, HWD> LWND**
Gender (% male)	1045	40% (.5)	45% (.5)	30% (.5)	30% (.5)	16.3	.00	0.01	HWND > LWD**, HWND > LWND*
Job Status	1012	2.38 (.8) 3.0	2.47 (.7) 3.0	1.93 (.9) 2.0	2.58 (.8) 3.0	83.4	.00	0.08	HWND > LWD **, LWND > HWND*, LWND > HWD & LWD **, HWD > LWD**
Years at address	1035	17.7 (19.5) 9.3	19.8 (16.9) 17.0	22.4 (16.1) 20.0	5.13 (3.1) 5.0	180.6	.00	0.17	LWD > HWD &LWND **, HWD > LWND**, HWND > LWND**
Individual income (€)	675	30,481.4 (31,278.4) 22,724	48752.5 (39,540.9) 38,000	20,714.5 (14,963) 15,500	41,992 (31,544) 38,000	93.1	.00	0.14	HWND > HWD & LWD **, LWND > LWD & HWD**, HWD > LWD**
Household income (€)	557	45,137.35 (36,473.3) 34,250	86,751.60 (71,1822) 66,500	31,834 (26,751.1) 22,232	72,000 (51,378) 65,000	101.9	.00	0.18	HWND > HWD & LWD **, LWND > LWD & HWD**, HWD > LWD*
Marital status	1026	1.03 (.94) 1.0	1.44 (.83) 2.0	1.20 (.88) 2.0	1.40 (.88) 2.0	36.6	.00	0.03	HWND > HWD**, HWND > LWD *, LWND > HWD**, LWND > LWD*
Education level	1021	4.57 (1.8) 5.0	5.58 (1.3) 6.0	3.57 (1.5) 3.0	5.53 (1.2) 6.0	232.6	.00	0.23	HWND > HWD & LWD **, LWND > LWD & HWD**, HWD> LWD**
Home ownership	982	2.82 (1.0) 3.0	3.39 (.8) 4.0	2.36 (1.3) 3.0	2.65 (.79) 3.0	123.2	.00	0.12	HWND > HWD & LWD & LWND **, HWD > LWD**

HWD= High Walkable Deprived, HWND = High Walkable Not Deprived, LWD= Low Walkable Not Deprived and LWND= Low Walkable Not Deprived, *ρ<0.0083 (95th Percentile) & **ρ<0.0016 (99th Percentile) following Bonferroni test, H = Kruskal Wallis Chi Square Statistic, η^2= effect size

Age group: 1 = 18-35yrs, 2 = 36-45yrs, 3=46-60yrs & 4=60+yrs. **Gender:** Male = 1 & Female = 0. **Home ownership**: 4 = Own home with no mortgage, 3 = Own home with mortgage, 2 = Rent privately & 1 = Rent from local authority. **Job Status**: 3 = Employed or Student, 2= Retired & 1 = Looking after home or family, unemployed or unable to work because of illness or disability. **Education level**: 1 = some or no primary education to 7 postgraduate qualification. **Marital Status**: 0 = Single, 1 = widowed or separated/divorced, 2 = married or living with partner

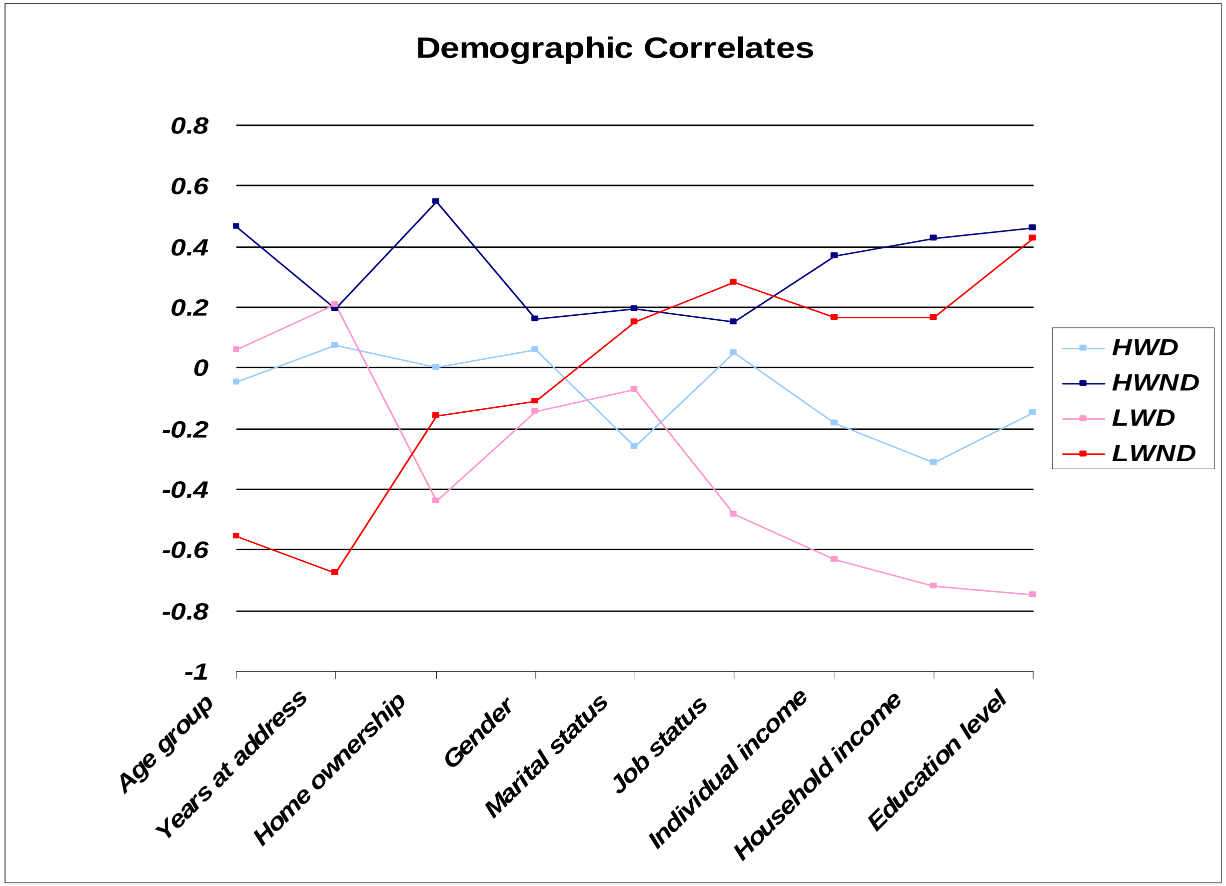


Figure 6-1: Standardised scores of demographic correlates

Age group: 1 = 18-35yrs, 2 = 36-45yrs, 3=46-60yrs & 4=60+yrs. **Gender:** Male = 1 & Female = 0. **Home ownership**: 4 = Own home with no mortgage, 3 = Own home with mortgage, 2 = Rent privately & 1 = Rent from local authority. **Job Status**: 3 = Employed or Student, 2= Retired & 1 = Looking after home or family, unemployed or unable to work because of illness or disability. **Education level**: 1 = some or no primary education to 7 postgraduate qualification. **Marital Status**: 0 = Single, 1 = widowed or separated/divorced, 2 = married or living with partner

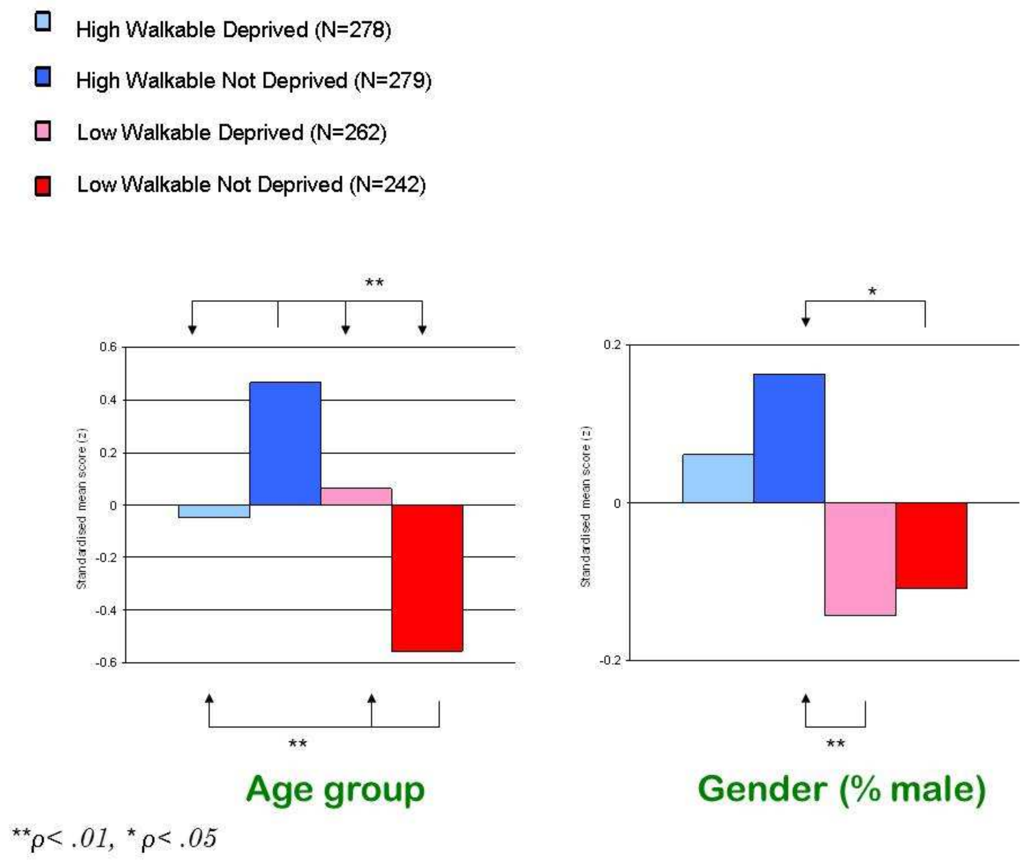


Figure 6-2: Age group and Gender significant differences between groups

Age group**: 1 = 18-35yrs, 2 = 36-45yrs, 3=46-60yrs & 4=60+yrs.** Gender: **Male = 1 & Female = 0**

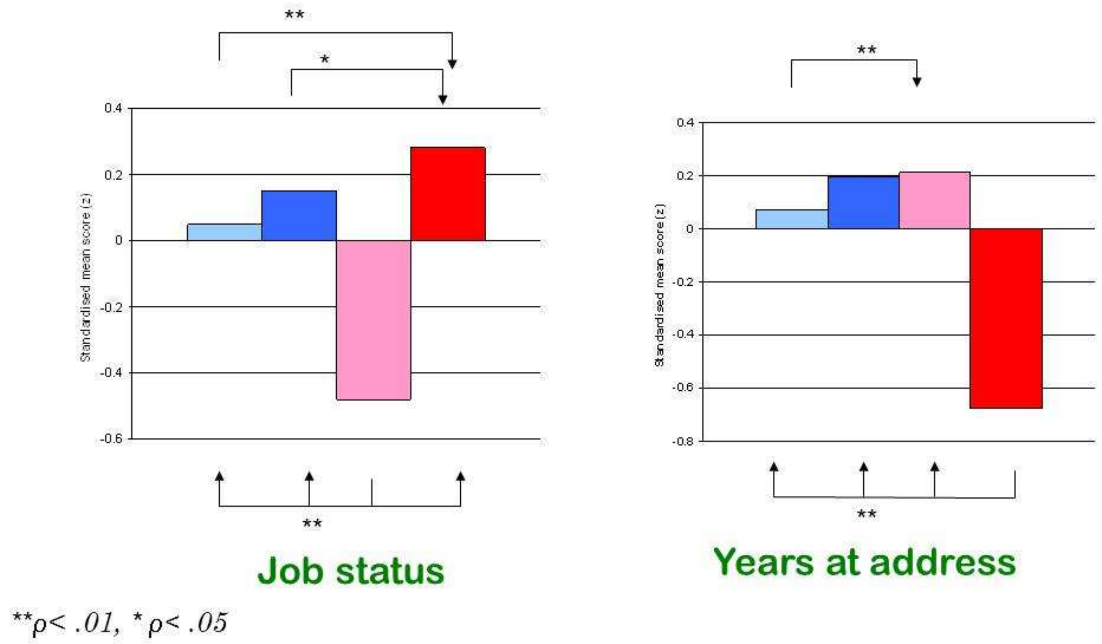
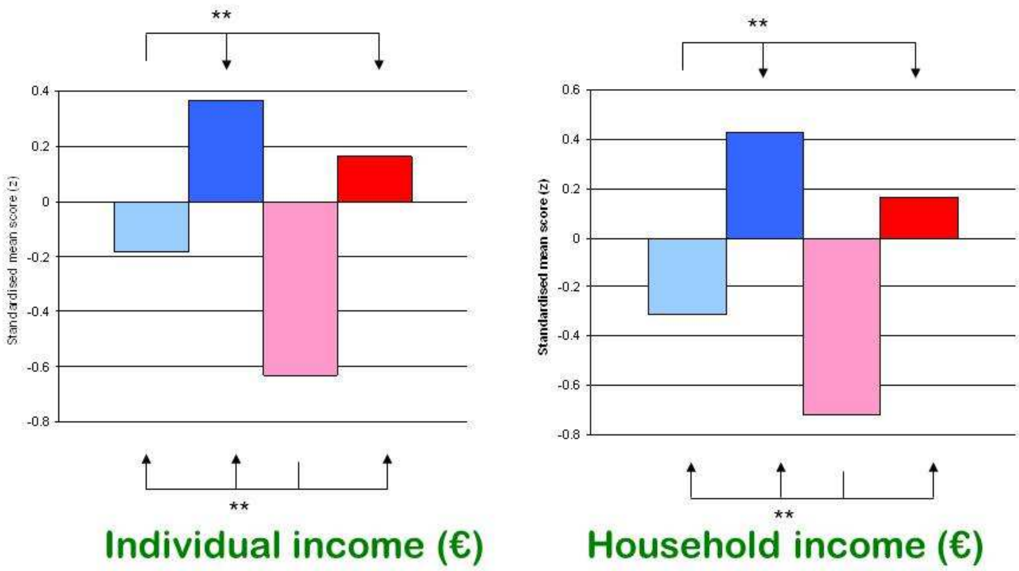


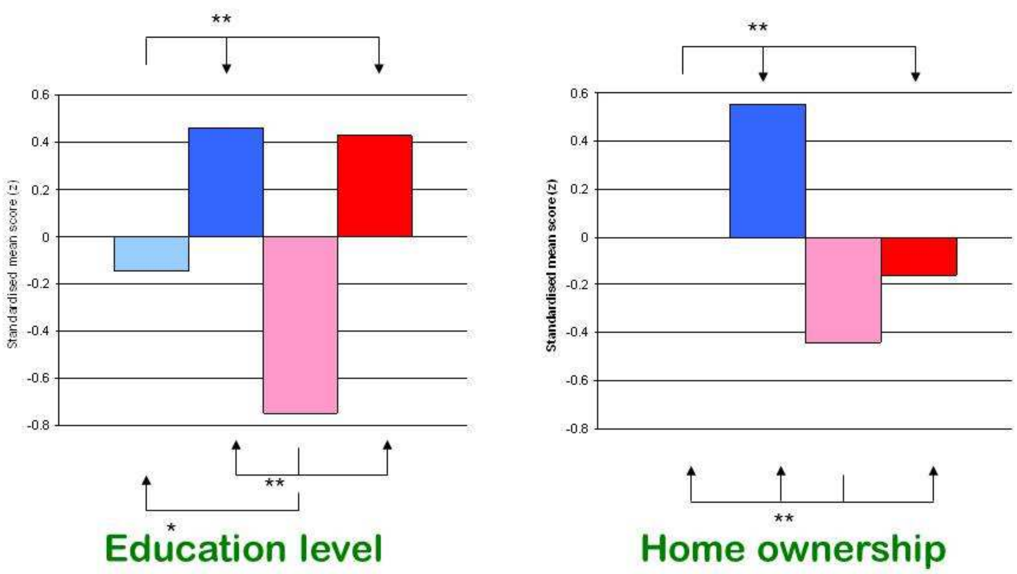
Figure 6-6-3: job status and Years at address significant differences between groups

Job Status: 3 = Employed or Student, 2= Retired & 1 = Looking after home or family, unemployed or unable to work because of illness or disability



**ρ< .01, *ρ< .05

Figure 6-4: Significant differences in Income between groups



**ρ< .01, *ρ< .05

Figure 6-5: Significant differences between groups on Education level and Home ownership

Education level: 1 = some or no primary education to 7 postgraduate qualification. **Home ownership**: 4 = Own home with no mortgage, 3 = Own home with mortgage, 2 = Rent privately & 1 = Rent from local authority.

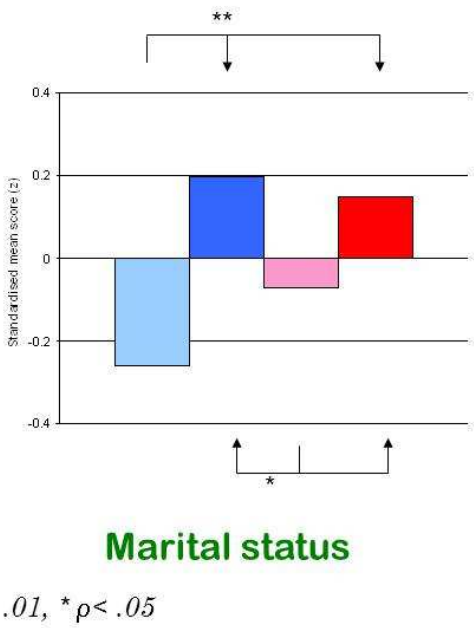


Figure 6-6: Significant differences between areas on Marital status

Marital Status: 0 = Single, 1 = widowed or separated/divorced, 2 = married or living with partner

6.7.3 Validation of SES

Deprivation ratings were assigned to areas during the site selection process and are outlined in section 5.4 of this thesis. Verification of area SES was carried out using demographic data collected during the population survey. The factors identified were job status, education level, home ownership, individual income and household income. Non-parametric tests were used on the data as it was neither homogenous nor normally distributed. A significant difference in SES was identified between assigned deprived and non-deprived areas. Results are outlined in Table 6-14.

Table 6-14: SES verification scores

	Median Score	N	Mann-Whitney U, r (effect size)
Education Level	5	1020	67088.5**, -0.42
Home Ownership	2	1028	108766.5**, -0.17
Job Status	3	1027	103288.5**, -0.19
Individual Income	€28,000	674[1]	34010.5** , -0.35
Household Income	€62,700	556[2]	19838.5**, -0.41

** p<0.001, [1]63% of total sample, [1]53% of total sample

Deprived areas (Mdn = 4, completed secondary education) had a significantly lower education level than non deprived areas (Mdn = 6, completed third level). Although deprived areas had the same median value for home ownership/ renting (Mdn = 2, rent privately) there was a significant difference between the groups (Table 6-14). The deprived areas had a greater mean rank (559) than the not deprived areas (468) which indicates a greater proportion of the population residing in privately rented or social housing. Deprived areas had a significantly higher score on the job status scale (Mdn = 2) than non deprived areas (Mdn = 3) indicating a greater number of retired or unemployed/dependant people than employed people or students living in those areas. Deprived areas had significantly lower individual incomes (Mdn = €20,000) than non deprived areas (Mdn = €38,000). Similarly, deprived areas had a significantly lower household income (Mdn = €29,500) than non deprived areas (Mdn = €65,500).

6.7.4 Environment Correlates

Table 6-15 outlines the comparison scores for perceived environment correlates measured on the population survey questionnaire. Figure 6-7 illustrates Table 6-15 as standardised (z) scores for visual comparison. In a multi-item analysis significant differences between area categories are illustrated in Figures 6.8 to 6.12. Six components were constructed from PCA analysis (section 6.3.4.1.1). The Leyden instrument is a proxy measure for land use mix and proximity to services, the liveability of an area described as 'destinations' in the results (section 2.6.1.3). Three single-item correlates which reflect walkability criteria not reflected in the generated components were also investigated. These correlates were (i) 'Public Transport' relating to being able to easily travel to the majority of places in Dublin using public transport (Ef5), (ii) 'Many different routes' which relates to the permeability of the area (Ea3) and (iii) 'Nice places to walk' relating to recreational walking (Ea5). This final item is an item in the 'Village' component but was investigated individually because of its specific hypothesised relationship with recreational walking (Section 2.3). Significant differences were found between all area categories for items and component constructs except the 'Overlooking' component.

HWND areas scored significantly higher than all other area categories on the village component (Mdn=31) and the 'nice places to go for a walk' item (Mdn=5). HWD areas scored higher (Mdn=25, 4) than the two low walkable area categories for both correlates (LWD Mdn=24, 4, LWND Mdn=23, 4). HWND areas scored significantly higher (Mdn=6) than all other area categories (Mdn=4) on the 'comfort' component. Low walkable areas scored significantly higher (LWD Mdn=10, LWND Mdn =9) than high walkable areas (HWD Mdn=7, HWND Mdn=6) on the scale component which reflects carchitecture scale which is considered negative for walkability (section 4.3.3). Crime and disorder scores were significantly higher (indicating less crime and disorder as the component is reverse coded) in not deprived areas (HWND Mdn=30, LWND Mdn=31) than deprived areas (HWD Mdn=21, LWD Mdn=24). The social construct, destinations, perceived availability of alternative routes item (permeability) and public transport item (easily travel to where I want to go) scores were all significantly lower for LWND areas (Mdn=9, 10, 3, 3) than all other area categories (HWD Mdn=10, 16, 4, 5, HWND Mdn=11, 16, 4, 5, LWD Mdn=11, 15, 4, 4). These areas were typically recently constructed suburban estates. LWD areas also scored significantly lower (Mdn=15) than high walkable areas (HWD Mdn=16, HWND=16) for the destinations score. Public transport scores were higher for the HWD area category (Mdn=5) than the low walkable area categories (LWD Mdn=4, LWND Mdn=3) but no significant difference was found between LWD (Mdn=4) and HWND (Mdn=5) area categories (Table 6-15).

Table 6-15: Environment Correlate differences between area categories

Measure (N)	N	***HWD*** Mean (sd) Median	***HWND*** Mean (sd) Median	***LWD*** Mean (sd) Median	***LWND*** Mean (sd) Median	H(3)	ρ	η^2	
Village[1] Component	1054	24.8 (5.3) 25.0	30.5 (4.1) 31.0	23.0 (5.1) 24.0	22.5 (5.6) 23.0	325.8	.00	0.3	HWND>HWD & LWD & LWND**, HWD>LWD & LWND**
Crime & Disorder[2] Component	1054	21.0 (6.1) 21.0	29.7 (5.6) 30.0	23.7 (5.8) 24.0	30.9 (4.8) 31.0	372.6	.00	0.4	LWND>LWD & HWD**, HWND>LWD & HWD**
Social[3] Component	1056	10.0 (3.2) 10.0	10.6 (2.8) 11.0	10.7 (3.0) 11.0	8.6 (2.7) 9.0	81.65	.00	0.1	LWD>LWND**, HWND>LWND**, HWD>LWND**
Scale[4] Component	1053	7.0 (2.5) 7.0	6.2 (2.3) 6.0	9.5 (2.6) 10.0	9.5 (2.7) 9.0	273.5	.00	0.3	LWD>HWD & HWND**, LWND>HWD & HWND**
Comfort[5] Component	1052	4.4 (2.0) 4.0	6.2 (2.0) 6.0	4.1 (1.8) 4.0	4.3 (1.8) 4.0	179.9	.00	0.2	HWND>HWD & LWD & LWND**
Overlooking[6] Component	1053	10.6 (2.5) 11.0	10.8 (2.3) 11.0	10.9 (2.6) 11.0	11.2 (2.2) 11.0	7.7	.05		
Destinations	1040	14.0 (1.9) 16.0	15.2 (1.3) 16.0	13.2 (2.8) 15.0	10.3 (3.3) 10.0	351.7	.00	0.3	HWND>HWD & LWD & LWND**, HWD>LWD & LWND**, LWD>LWND**
Many different routes	1055	3.9 (1.1) 4.0	4.2 (.9) 4.0	3.7 (1.1) 4.0	2.9 (1.2) 3.0	157.7	.00	0.2	HWND > LWD & LWND**, HWD > LWND**, LWD > LWND**
Nice places to walk	1055	3.8 (1.4) 4.0	4.6 (.7) 5.0	3.2 (1.3) 4.0	3.4 (1.3) 4.0	227.5	.00	0.2	HWND>HWD & LWND & LWD**, HWD>LWND & LWD**
Public transport	1057	4.3 (1.0) 5.0	4.2 (1.1) 5.0	4.1 (1.1) 4.0	3.0 (1.4) 3.0	176.8	.00	0.2	HWD>LWND**, HWD>LWD*, HWND>LWND**, LWD>LWND**

[1]Village construct comprising of: Ed1 + Ec2 + Ec7 + Ef2 + Ed2 + Ee3 +Ea5, [2]Crime and Disorder Construct: Ee1 + $Ee2_R$ + $Ef6_R$ + $Ec1_R$ + $Ed3_R$ + Ee5 + $Ec5_R$ +$Eb6_R$, [3]Social Construct: Eb2+ Eb3 +Ef3, [4]Scale Construct: Ea7 + Ea6 + Eb9, [5]Comfort Construct: Eb4 + Ec3, [6]Overlooking Construct: Eb10 + Ec4 + Eb11, Area Categories: HWD= High Walkable Deprived, HWND = High Walkable Not Deprived, LWD= Low Walkable Not Deprived and LWND= Low Walkable Not Deprived, *$\rho<0.0083$ (95th Percentile) & **$\rho<0.0016$ (99th Percentile) following Bonferroni test, H = Kruskal Wallis Chi Square Statistic, η^2= effect size

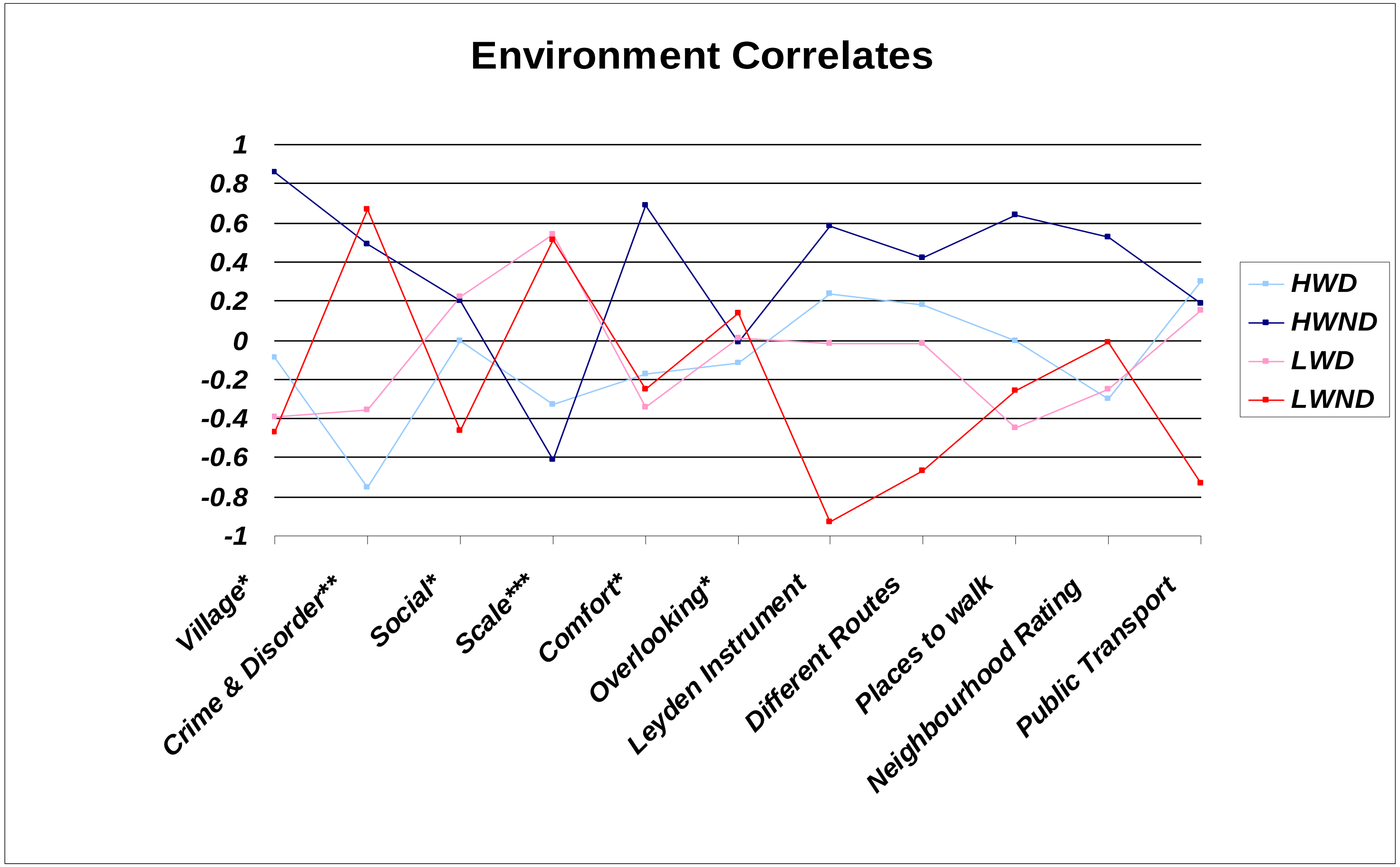


Figure 6-7: Table 6.15 Illustrated as Standardised Scores of Environmental Correlates

*Components from PCA on environment items, **Component positively scored with majority of items reversed: higher score = less crime and disorder, ***Component negatively worded: higher score = greater scale which is more car-scale, lower score = lower scale which is more human scale, Area Categories: HWD= High Walkable Deprived, HWND = High Walkable Not Deprived, LWD= Low Walkable Not Deprived and LWND= Low Walkable Not Deprived

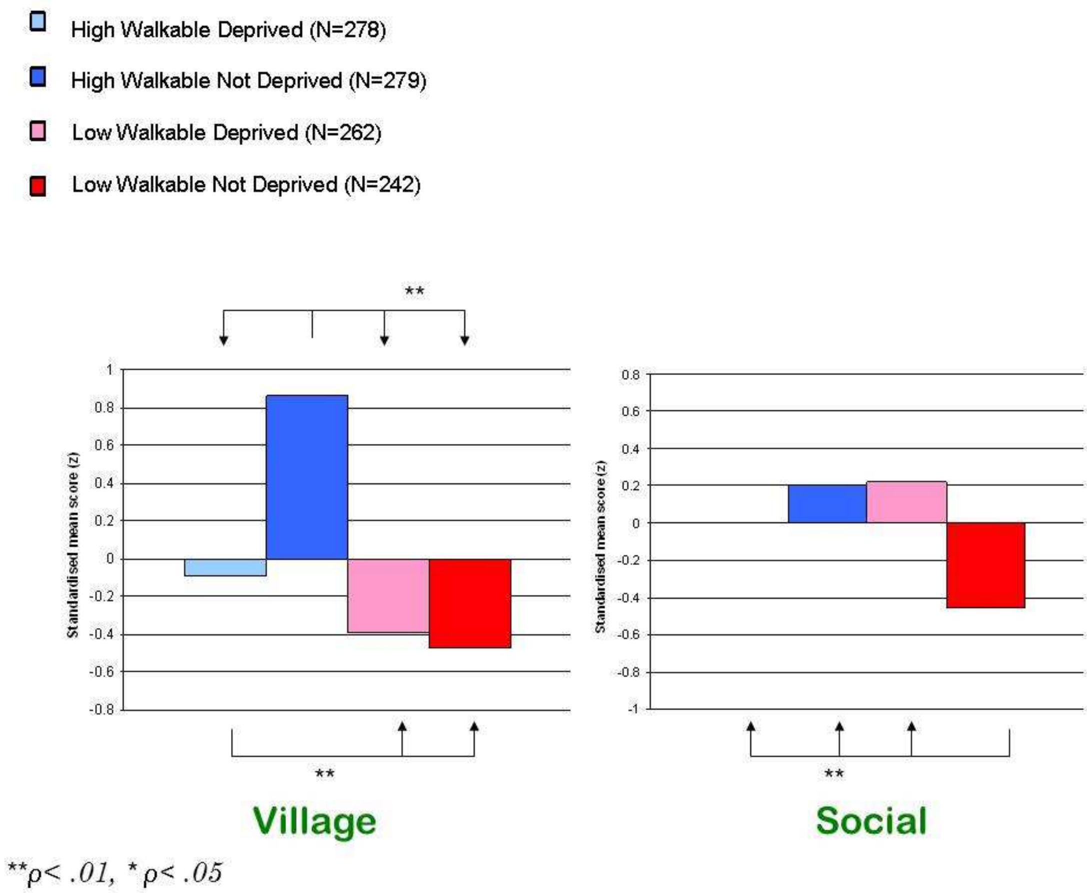


Figure 6-8: Significant differences between areas on 'Village' and 'Social'

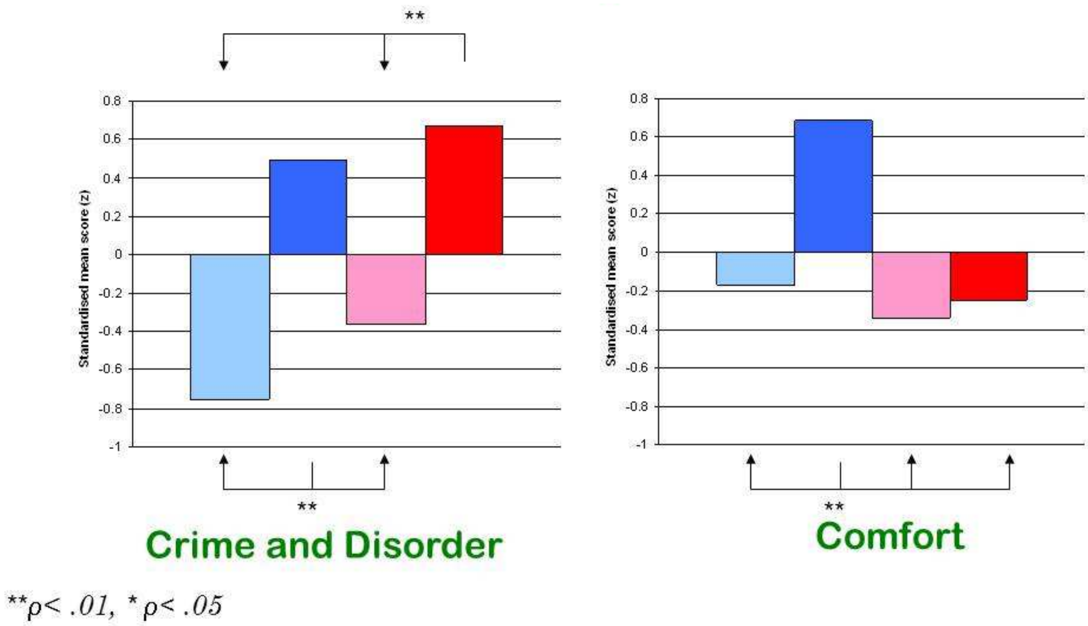
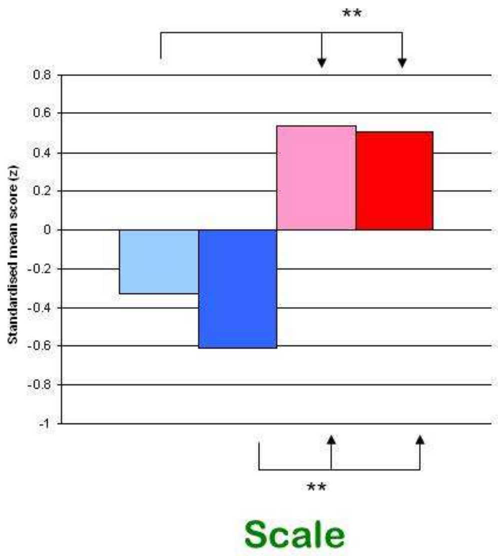
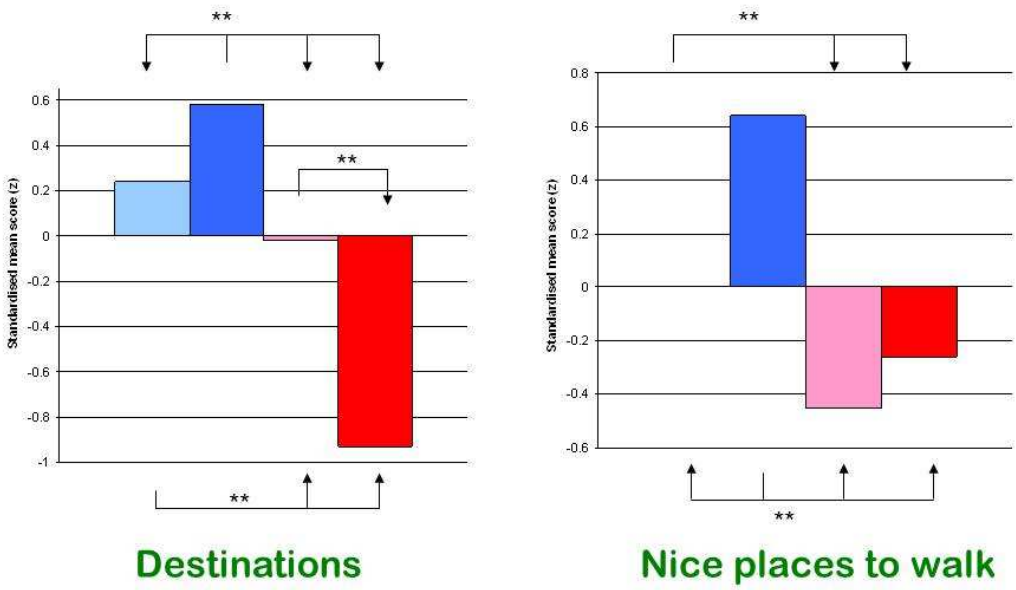


Figure 6-9: Significant differences between areas on 'Crime and disorder' and 'Comfort'



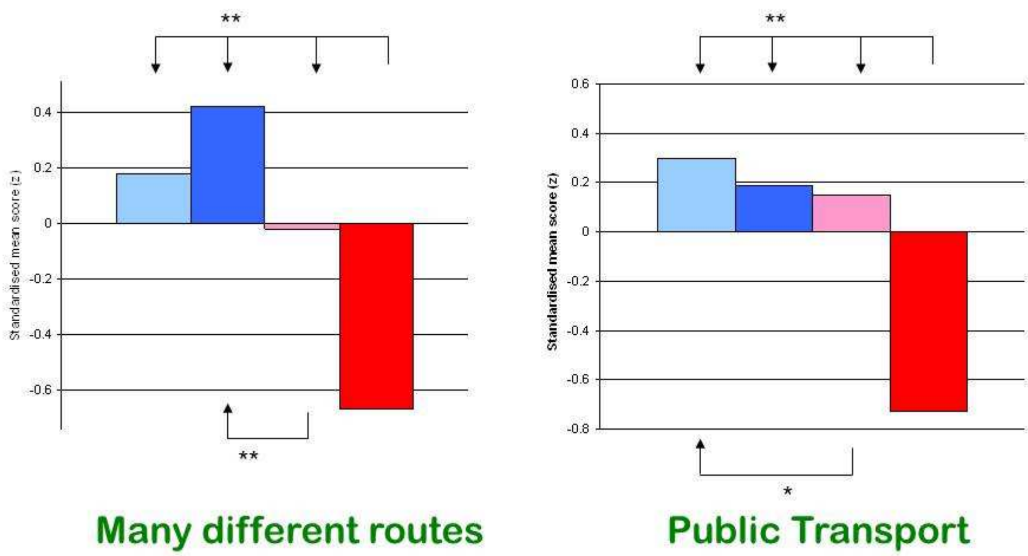
**ρ< .01, *ρ< .05

Figure 6-10: Significant differences between areas on 'Scale'



**ρ< .01, *ρ< .05

Figure 6-11: Significant differences between areas on 'Destinations' and 'Nice places to walk'



**p< .01, *p< .05

Figure 6-12: Significant differences between areas on 'Many different routes' and 'Public transport'

6.7.5 Behaviour Correlates

The behaviours identified for comparison between high and low walkable areas were minutes active transport, minutes walking for recreation and an average mode score[53]. Measures of the percentage of these trips which were taken by active modes and using public transport were also reported. The number of cars per adult was compared between area categories as was individual and household weekly fuel spend. Only individual fuel spend is presented on Figure 6-13 and 6-14 as the trends for individual and household fuel spend were almost identical. Walking minutes were measured using the IPAQ short version and reported as minutes rather than MET minutes per week because of the higher reported validity for walking minutes (section 6.4.5). Total physical activity is reported as MET minutes/week.

Table 6-16 shows the between area comparisons for behavioural correlates. LWND areas reported significantly higher scores for cars per adult (Mdn=1.0), individual and household fuel spend (Mdn= €30, €50) and significantly lower trip mode score (Mdn=1.4), active travel minutes per week (Mdn=72.5 mins) and percentage active

[53] Constructed using mode of transport responses for the relevant trips to identified destinations. Average mode score for relevant trips: Active = 3, Public Transport = 2, Motorised = 1

trips (Mdn=20%) than all other area categories. HWD areas reported significantly higher average mode score (Mdn=2.6) and active travel minutes (Mdn=210mins) than LWND and LWD areas (average mode score Mdn=2.3, active travel mins Mdn=120mins). The percentage active travel minutes score[54] was significantly higher for HWD areas (Mdn=66%) than HWND (Mdn=63%), LWD areas (Mdn=55%) and LWND areas. Cars per adult and fuel spends were also significantly higher for HWND areas (Cars per adult Mdn=.8, individual fuel spend Mdn=€20, household fuel spend Mdn=€30) than deprived areas (Cars per adult: HWD Mdn=.5, LWD Mdn=.5, individual fuel spend: HWD Mdn=€5, LWD Mdn=€15, household fuel spend: HWD Mdn=€10, LWD Mdn=€20). Household fuel spend was significantly higher in LWD areas than HWD areas. Percentage public transport trips were significantly higher for HWD areas (Mdn=0%) than not deprived areas (both Mdn=0%). There was no significant difference between area categories on total physical activity (MET minutes per week) but HWND areas scored significantly higher (Mdn=120mins) than all other area categories on recreational walking (HWD Mdn=65mins, LWD Mdn=60mins, LWND Mdn=60mins) (Table 6.15).

[54] Ibid.

Table 6-16: Behaviour Correlates comparison between area categories

Measure	N	***HWD*** Mean (sd) Median	***HWND*** Mean (sd) Median	***LWD*** Mean (sd) Median	***LWND*** Mean (sd) Median	H(3)	ρ	η^2	
Cars per adult	922	0.4 (0.4) 0.5	0.7 (0.4) 0.8	0.6 (0.6) 0.5	0.9 (0.4) 1.0	164.3	.00	.18	LWND > LWD & HWD & HWND**, HWND > LWD & HWD**
Individual fuel spend (€)	962	13.8 (17.9) 5.0	23.0 (19.0) 20.0	17.1 (17.8) 15.0	34.7 (19.4) 30.0	168.3	.00	.17	LWND>HWND & LWD & HWD**, HWND > LWD & HWD**
Household fuel spend (€)	916	19.6 (27.8) 10.0	38.7 (34.1) 30.0	30.6 (36.8) 20.0	55.5 (32.5) 50.0	183.3	.00	.20	LWND>HWND & LWD & HWD**, HWND> LWD & HWD**, LWD>HWD**
Active travel (Mins_per_wk)	874	331.1 (360.9) 210.0	256.4 (329.3) 140.0	211.0 (277.9) 120.0	131.0 (192.3) 72.5	75.5	.00	.08	HWD>LWD & LWND**, HWND>LWND**, LWD>LWND**
Recreational walking (Mins_per_wk)	902	147.0 (218.0) 65.0	201.0 (274.3) 120.0	188.8 (547.2) 60.0	122.7 (160.5) 60.0	14.1	.00	.11	HWND>HWD & LWD*, HWND> LWND**
Total physical activity per week (Met_mins_per_wk)	690	4623.0 (5760.1) 3032.8	4185.3 (4053.5) 3372.0	4509.2 (6183.2) 2994.8	3821.9 (4089.1) 2352.0	5.23	.16		
Average trip mode score	861	2.43 (.5) 2.6	2.30 (.4) 2.4	2.21 (.6) 2.3	1.57 (.5) 1.4	256.8	.00	.30	HWD > LWD & LWND **, HWND>LWND**, LWD>LWND**
Percentage active trips (%)	871	66 (71) 70	63 (67) 70	55 (56) 60	25 (22) 25	251.3	.00	.30	HWD >HWND & LWD & LWND **, HWND>LWND**, LWD>LWND**
Percentage public transport trips (%)	888	10 (15) 0	6 (6) 0	9 (16) 0	6 (6) 0	20.7	.00	.02	HWD >HWND & LWND **

Area Categories: HWD= High Walkable Deprived, HWND = High Walkable Not Deprived, LWD= Low Walkable Not Deprived and LWND= Low Walkable Not Deprived, *ρ<0.0083 (95th Percentile) & **ρ<0.0016 (99th Percentile) following Bonferroni test, H = Kruskal Wallis Chi Square Statistic, η^2= effect size, Average mode score for relevant trips: Active = 3, Public Transport = 2, Motorised = 1

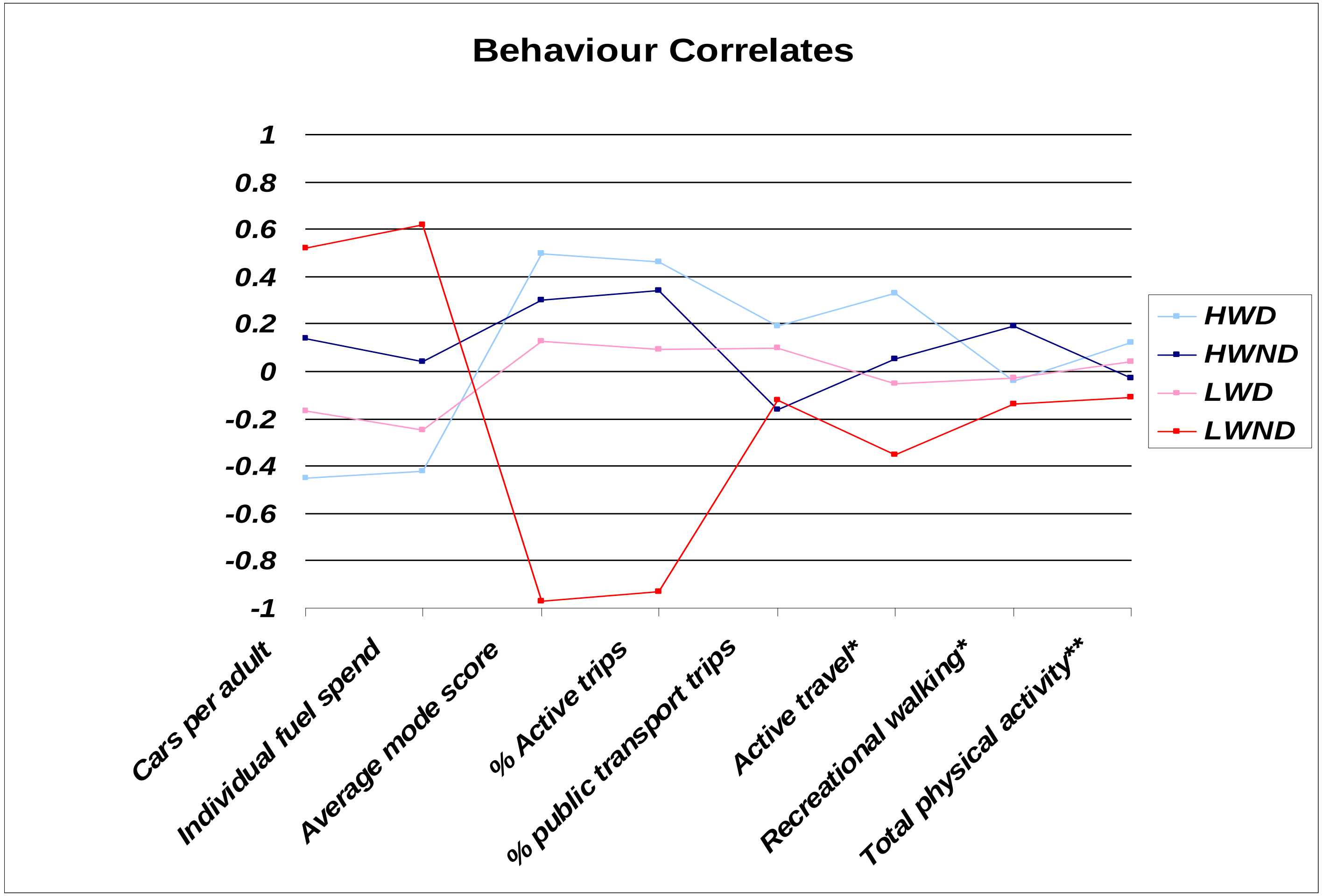


Figure 6-13: Table 6.16 Illustrated as Standardised scores of Behaviour Correlates

*Minutes per week, ** Met-minutes per week, Area Categories: HWD= High Walkable Deprived, HWND = High Walkable Not Deprived, LWD= Low Walkable Not Deprived and LWND= Low Walkable Not Deprived, Average mode score for relevant trips: Active = 3, Public Transport = 2, Motorised = 1

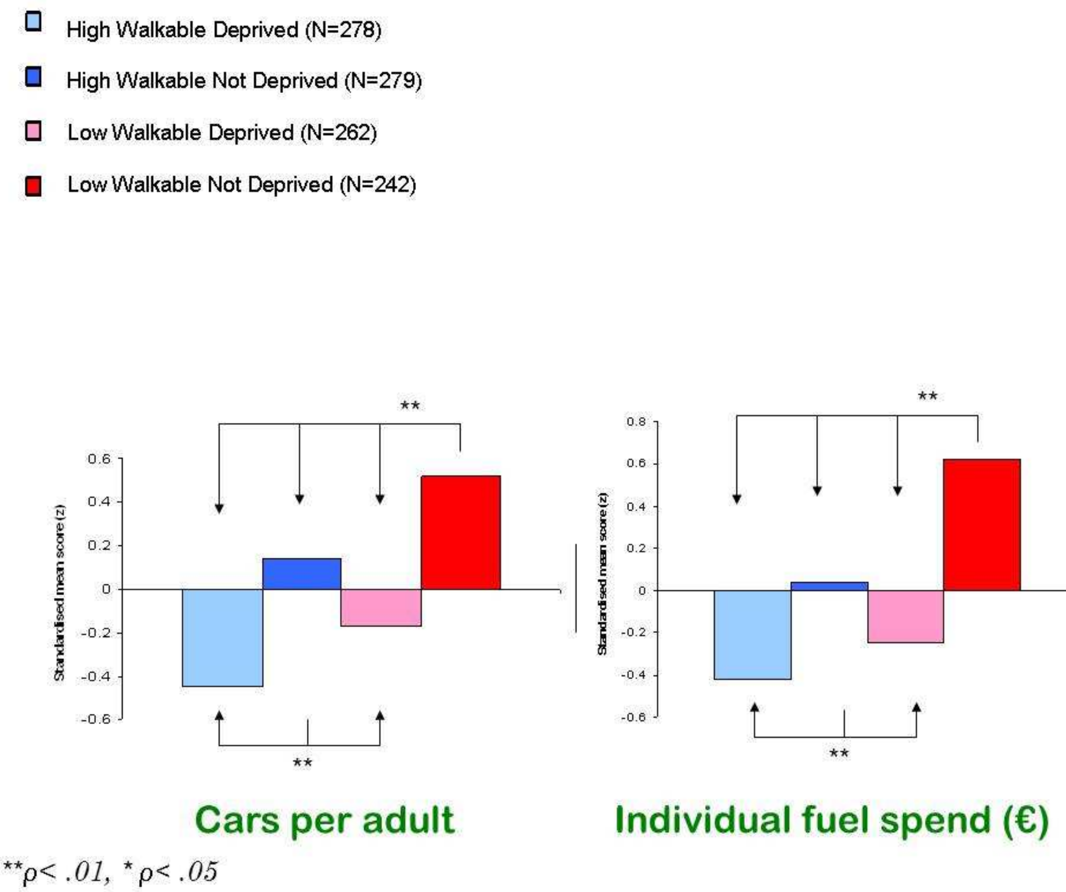


Figure 6-14: Significant differences between areas on 'Cars per adult' and 'Individual fuel spend'

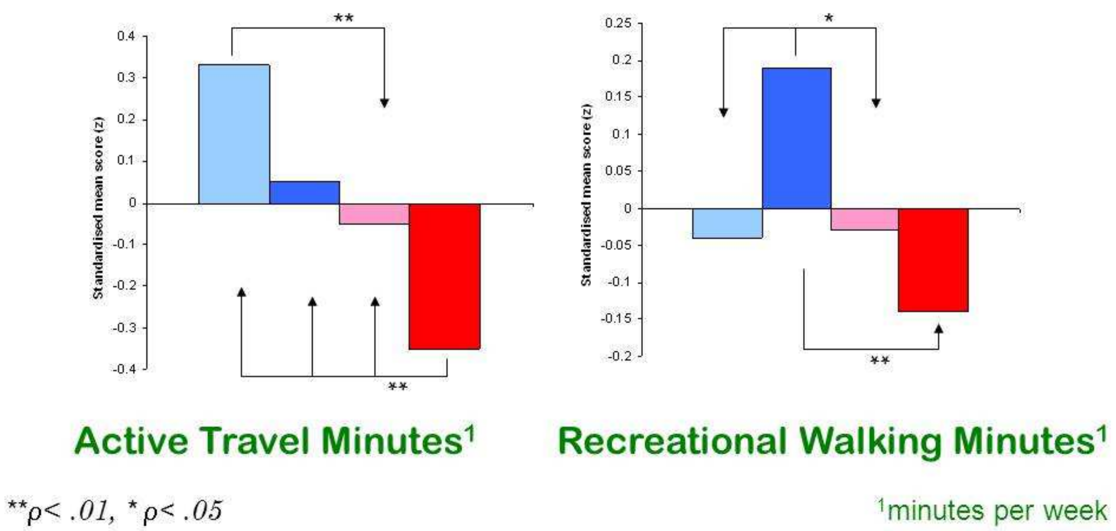


Figure 6-15: Significant differences between areas on 'Active travel minutes' and 'Recreational walking minutes'

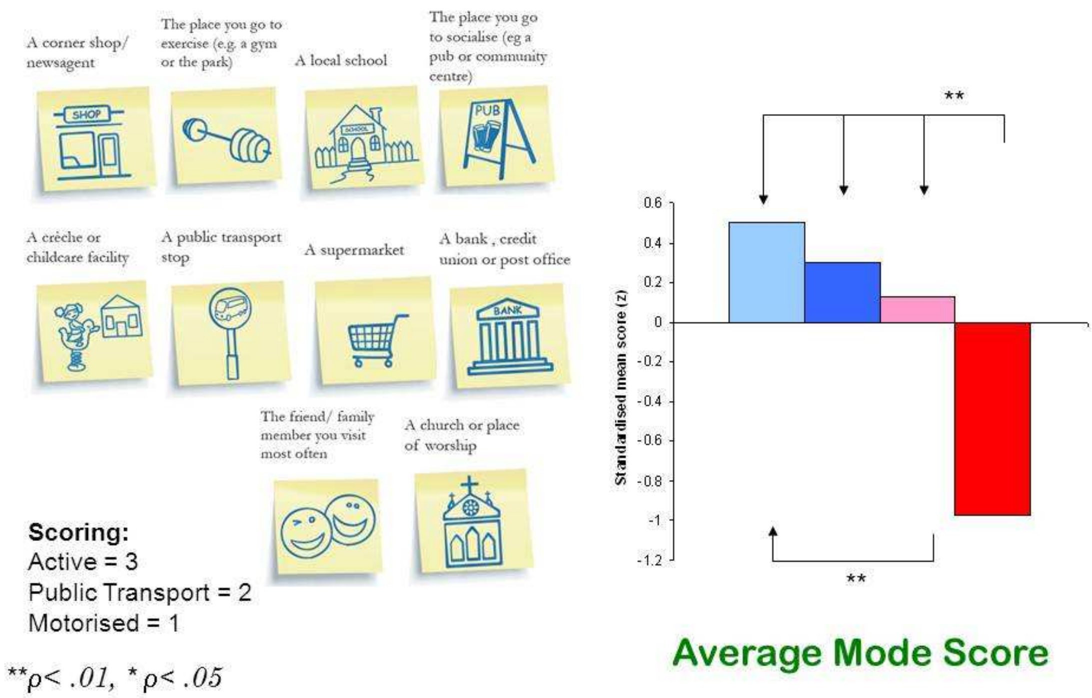


Figure 6-16: Significant differences between areas on 'Average mode score'

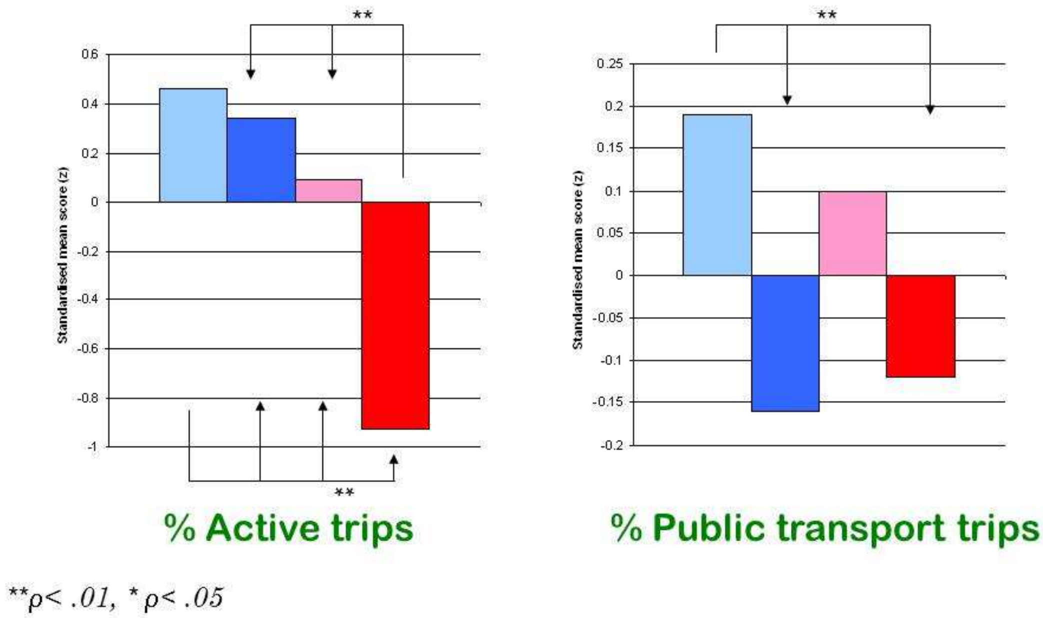


Figure 6-17: Significant differences between areas on '% Active trips' and '% Public transport trips'

6.7.6 Barriers to Neighbourhood Walking Correlates

Differences between area categories are shown in Table 6-17 and graphically represented in Figures 6-18 to 6-23. The between-area results for four components constructed from PCA analysis (section 6.3.4.1.2), namely psychosocial, comfort and inclusion, vulnerability and fashion are presented first. This is followed by a single-item analysis for two items from the ‘environment’ component. Respondents in LWND areas reported a higher likelihood of psychosocial correlates preventing the walking in their neighbourhood (Mdn=12) than all other area categories. This result was replicated for both individual correlates investigated from this component. LWD area residents (Mdn=10) were also more likely to report psychosocial correlates prevent them walking than residents of HWND areas (Mdn=6.5). This result was replicated for the ‘lack of time’ correlate also. Residents of deprived areas were significantly less likely to walk in their neighbourhood because of items from the comfort and inclusion component (LWD Mdn=1, HWD=1) than individuals in not deprived neighbourhoods (LWND Mdn=0, HWND Mdn=0). This result was replicated for the feeling unsafe from crime correlate. LWND residents were also less likely to walk in their neighbourhood because of comfort and inclusion (Mdn=0) than HWND (Mdn=0). HWND residents were significantly less likely not to walk in their neighbourhood because of feeling unsafe from traffic and not feeling part of the community than all other area categories (Mdn=0 for all area categories). LWD residents were more likely not to walk in their neighbourhood because of not feeling part of the community than LWND residents. Residents in deprived areas were more likely not to walk in their neighbourhood because of feeling vulnerable than residents of not deprived areas. No significant difference was found between area categories for the fashion component. The total barriers score for HWND areas (Mdn=8) was significantly less than all other areas indicating less perceived barriers to walking. HWD areas (Mdn=10.5) also scored significantly less than low walkable areas (LWD Mdn=14, LWND Mdn=13.5).

Table 6-17: Difference between area categories on barriers to walking correlates

Measure	N	*HWD* Mean (sd) Median	*HWND* Mean (sd) Median	*LWD* Mean (sd) Median	*LWND* Mean (sd) Median	H(3)	ρ	η^2	
Psychosocial component	919	8.2 (4.39) 8.0	7.0 (4.7) 6.5	9.5 (5.0) 10.0	11.4 (4.9) 12.0	103.3	.00	0.11	LWND>HWND & LWD & HWD**, LWD> HWND*
Comfort and inclusion component	990	1.7 (2.1) 1.0	.55 (1.2) .0	1.9 (3.4) 1.0	1.0 (1.6) .0	89.9	.00	0.09	LWD > HWND & LWND **, HWD > HWND & LWND **, LWND> HWND*
Vulnerability component	979	1.1 (1.7) .0	.5 (1.1) .0	1.4 (2.0) .0	.6 (1.2) .0	43.9	.00	0.04	LWD > HWND & LWND **, HWD > HWND & LWND**
Fashion component	976	.6 (1.3) .0	.5 (1.0) .0	.6 (1.3) .0	.6 (1.2) .0	.34	.95		
Total 'Barriers' score	889	11.8 (7.8) 10.5	8.6 (6.1) 8.0	13.6 (8.2) 14.0	13.9 (6.6) 13.5	85.7	.00	0.09	LWND>HWND & HWD**, LWD > HWD*, LWD>HWND**, HWD>HWND**
Lack of time[1]	985	1.3 (1.1) 1.0	1.4 (1.2) 1.0	1.4 (1.1) 2.0	2.2 (1.2) 2.0	88.0	.00	0.09	LWND>HWND & LWD & HWD**
Easier to drive even short distances[1]	966	.6 (1.0) .0	.7 (1.1) .0	1.1 (1.3) .0	1.8 (1.3) 2.0	122.4	.00	0.13	LWND>HWND & LWD & HWD**, LWD>HWND*
Feeling unsafe from crime[2]	1002	1 (1.1) 1.0	.3 (.6) .0	1.1 (1.2) 1.0	.4 (.7) .0	121.1	.00	0.12	LWD > HWND & LWND **, HWD > LWND & HWND**
Feeling unsafe from traffic[2]	996	.4 (.8) .0	.2 (.5) .0	.5 (.9) .0	.3 (.7) .0	26.8	.00	0.02	LWD > HWND **, HWD > HWND**, LWND > HWND **
Not feeling part of the community[2]	996	.4 (.8) .0	.1 (.4) .0	.5 (.9) .0	.3 (.6) .0	37.7	.00	0.04	LWD > HWND **, LWD > LWND *, HWD > HWND**, LWND > HWND **

Area Categories: HWD= High Walkable Deprived, HWND = High Walkable Not Deprived, LWD= Low Walkable Not Deprived and LWND= Low Walkable Not Deprived, *ρ<0.0083 (95th Percentile) & **ρ<0.0016 (99th Percentile) following Bonferroni test, H = Kruskal Wallis Chi Square Statistic, η^2= effect size, [1]Correlates also variables in Psychosocial component, [2]Correlates also variables in Environment component

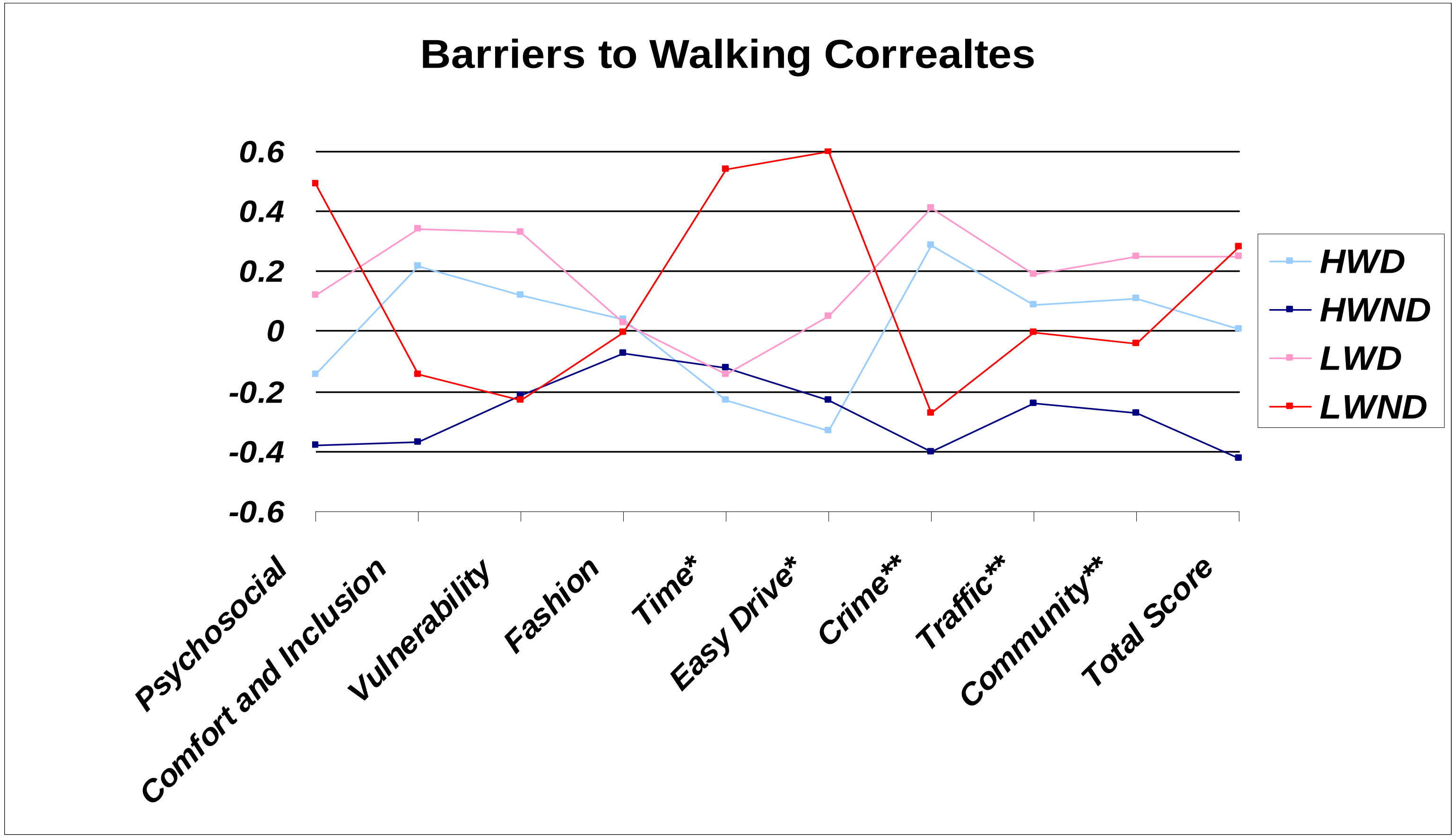


Figure 6-18: Table 6.17 Illustrated as Standardised scores for correlates preventing walking

* items are also included in Component F1, ** items are also included in Component F2, Area Categories: HWD= High Walkable Deprived, HWND = High Walkable Not Deprived, LWD= Low Walkable Not Deprived and LWND= Low Walkable Not Deprived

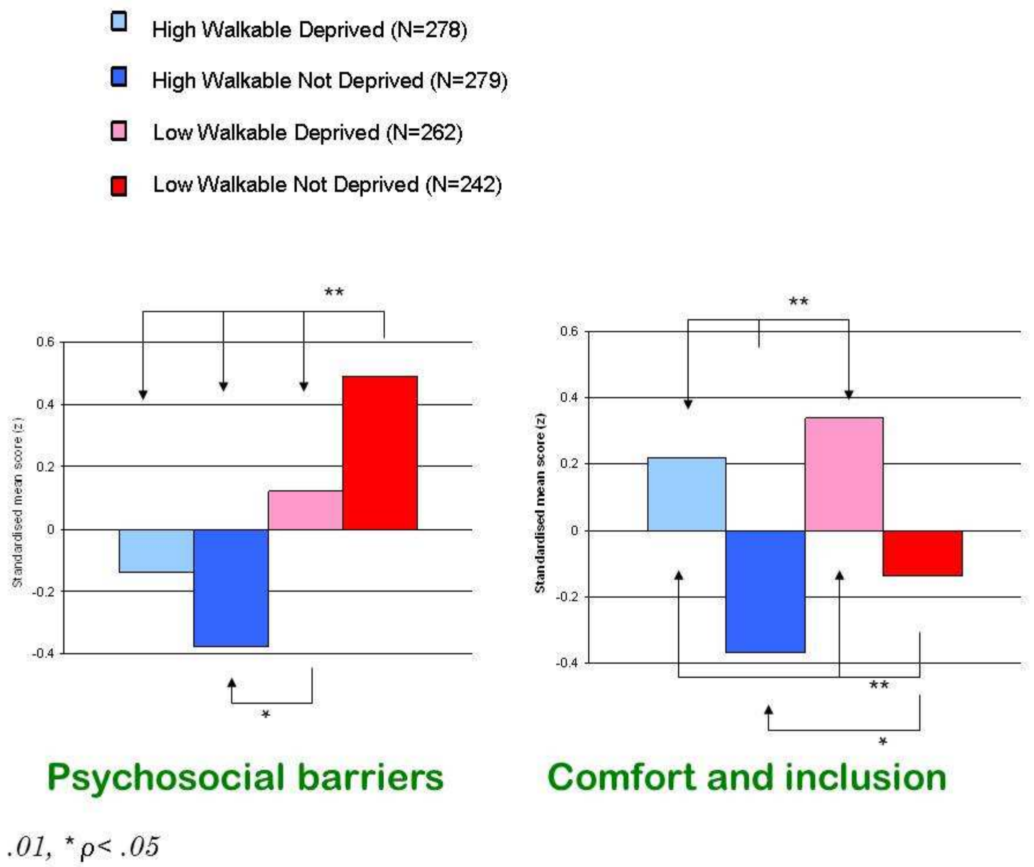


Figure 6-19: Significant differences between areas on 'Psychosocial barriers' and 'Comfort and inclusion' barriers

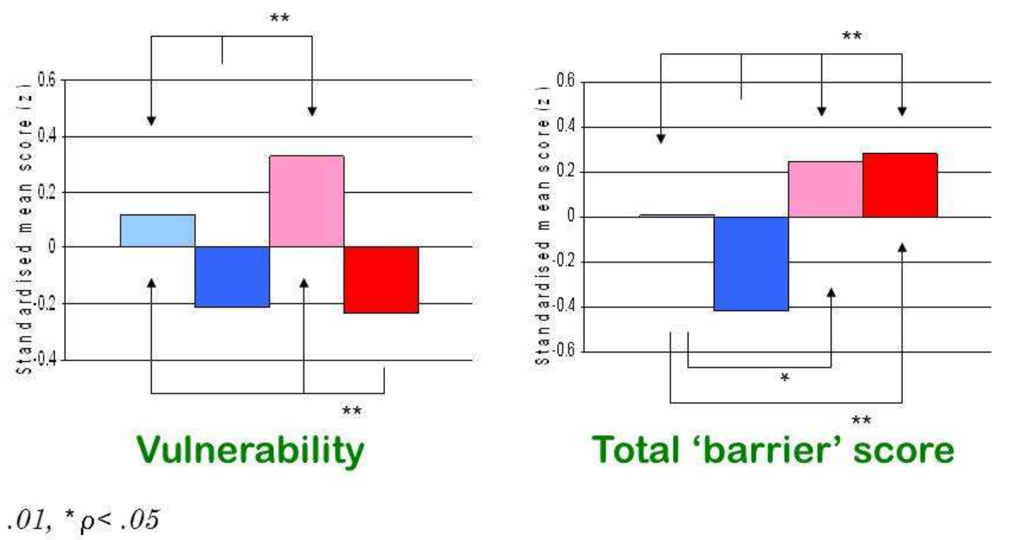


Figure 6-20: Significant differences between areas on the barrier 'Vulnerability' and the Total barrier score

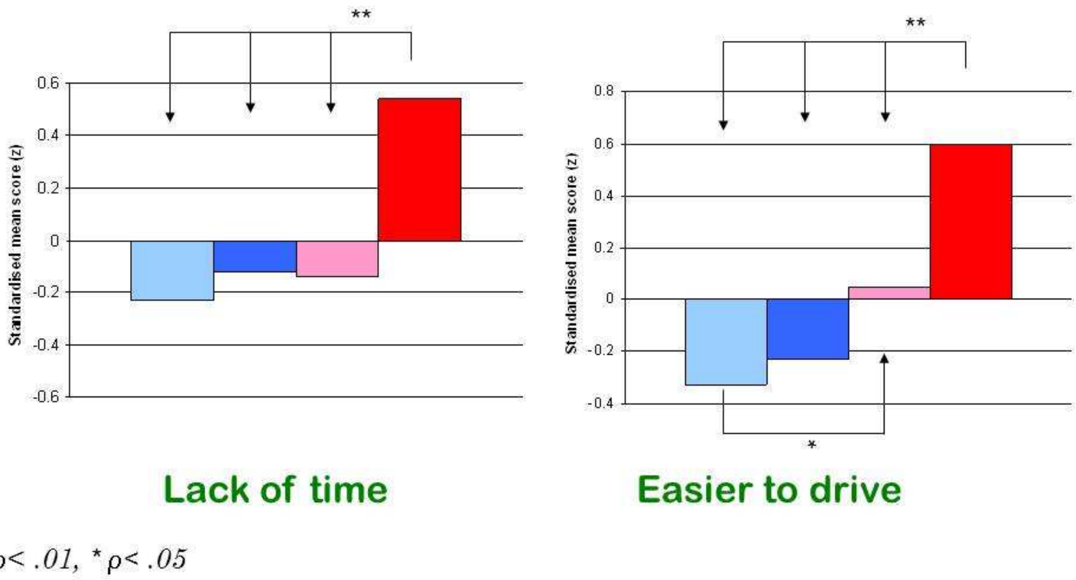


Figure 6-21: Significant differences between areas on the barriers 'Lack of time' and 'Easier to drive'

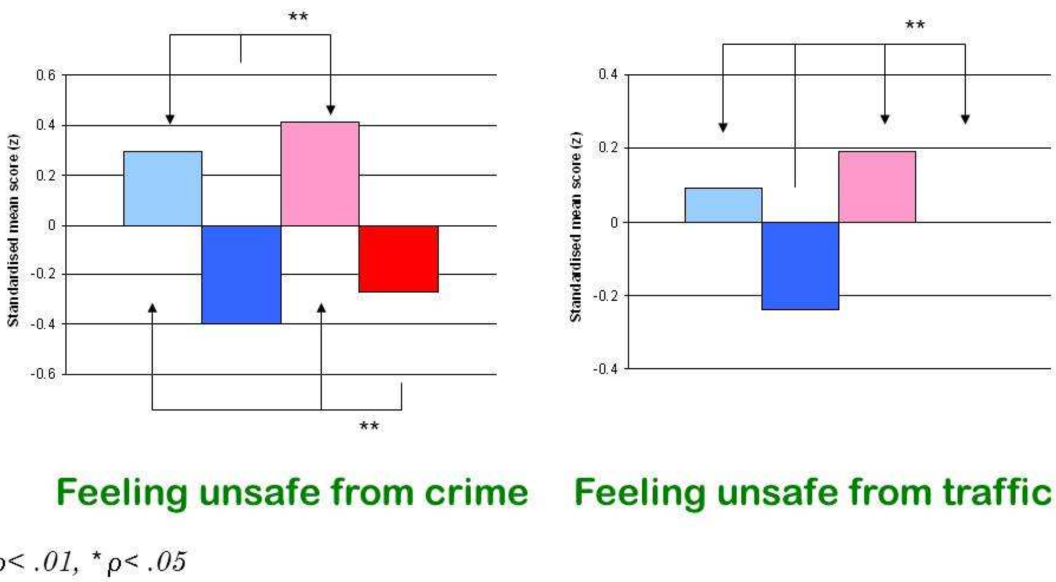
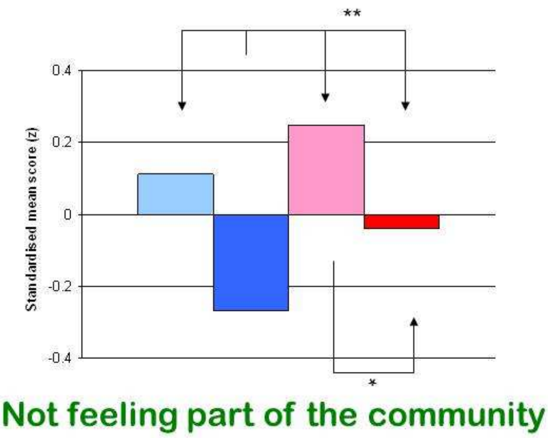


Figure 6-22: Significant differences between areas on the barriers feeling unsafe from crime and traffic



**$\rho < .01$, *$\rho < .05$

Figure 6-23: Significant differences between areas on the barrier 'Not feeling part of the community'

6.7.7 Neighbourhood Satisfaction Correlates

Significant differences are reported between area categories for all components. Due to a lower response rate to the items relating to access to workplace or place of study because of its irrelevance to a portion of the sample, constructs containing this item were calculated both with and without the item. The total satisfaction score, including access to work, was significantly higher for HWND areas (Mdn=48) than all other area categories. When access to work or place of study was removed from the scale this result held and LWND areas (Mdn=44) were also scored significantly higher than LWD areas (Mdn=42). The neighbourhood satisfaction variables loaded onto two distinct component in the PCA analysis (section 6.3.4.1.3). These two components were access and comfort. HWND areas (Mdn=4.7) scored significantly higher than all other areas on the access component score and LWND areas (Mdn=3.5) scored significantly lower than all of the other area categories. LWD areas (Mdn=3.8) also scored significantly less than HWD areas (Mdn=4.0). HWND areas had a significantly higher score for the comfort component (Mdn=4.1) than all other area categories. LWND areas also scored significantly higher (Mdn=4.0) than the deprived areas on comfort (LWD Mdn=3.3, HWD Mdn=3.2).

The neighbourhood walkability rating assigned by residents is also included on Table 6-18 The neighbourhood walkability perception scale was from 1-very walkable to 5 not at all walkable. The question prompted that walkable meant pedestrian friendly. HWND areas were scored as significantly more walkable (Mdn=1) by their residents than all other area categories. LWND areas were scored significantly less walkable (Mdn=2) than the deprived areas (Mdn=2 for both).

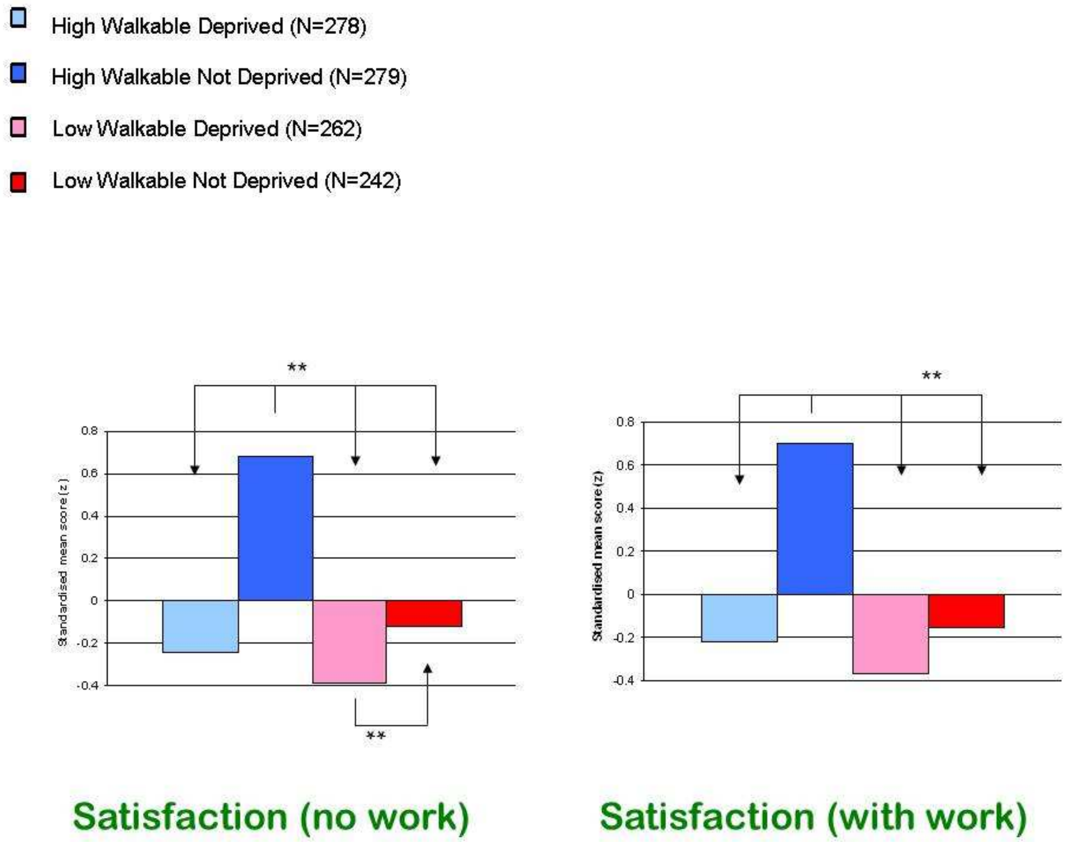
Table 6-18: Differences between area categories on neighbourhood satisfaction components

Measure (N)	N	***HWD*** Mean (sd) Median	***HWND*** Mean (sd) Median	***LWD*** Mean (sd) Median	***LWND*** Mean (sd) Median	H(3)	ρ	η^2	
Total without work	975	39.1 (7.6) 40.0	46.5 (6.4) 48.0	38.0 (7.7) 39.0	40.1 (7.2) 40.0	205.1	.00	0.2	HWND>LWND & HWD & LWD**, LWND>LWD*
Total with work	857	43.0 (8.2) 42.0	50.8 (7.3) 52.0	41.6 (8.2) 42.0	43.6 (7.8) 44.0	176.7	.00	0.2	HWND>LWND & HWD & LWD**
Access with work	890	4.0 (.7) 4.0	4.4 (.7) 4.7	3.8 (.7) 3.8	3.4 (.8) 3.5	203.8	.00	0.2	HWND > HWD & LWD & LWND **, HWD > LWD & LWND**, LWD > LWND**
Access without work	1020	4.0 (.7) 4.0	4.4 (.7) 4.6	3.8 (.8) 4.0	3.4 (.9) 3.4	232.9	.00	.2	HWND > HWD & LWD & LWND **, HWD > LWD & LWND**, LWD > LWND**
Comfort	996	3.2 (.8) 3.2	4.1 (.7) 4.1	3.2 (.9) 3.3	3.9 (.7) 4.0	228.1	.00	.2	HWND > LWND & LWD & HWD **, LWND > LWD & HWD **
Neighbourhood rating[1]	1052	2.0 (1.0) 2.0	1.2 (.5) 1.0	1.9 (.9) 2.0	1.7 (.9) 2.0	162.0	.00	0.2	HWD>HWND**, HWD>LWND*, LWD> HWND**, LWD>LWND*, LWND>HWND**

Area Categories: HWD= High Walkable Deprived, HWND = High Walkable Not Deprived, LWD= Low Walkable Not Deprived and LWND= Low Walkable Not Deprived, [1]Ratings 1- very walkable to 5 not at all walkable, *ρ<0.0083 (95th Percentile) & **ρ<0.0016 (99th Percentile) following Bonferroni test, H = Kruskal Wallis Chi Square Statistic, η^2= effect size

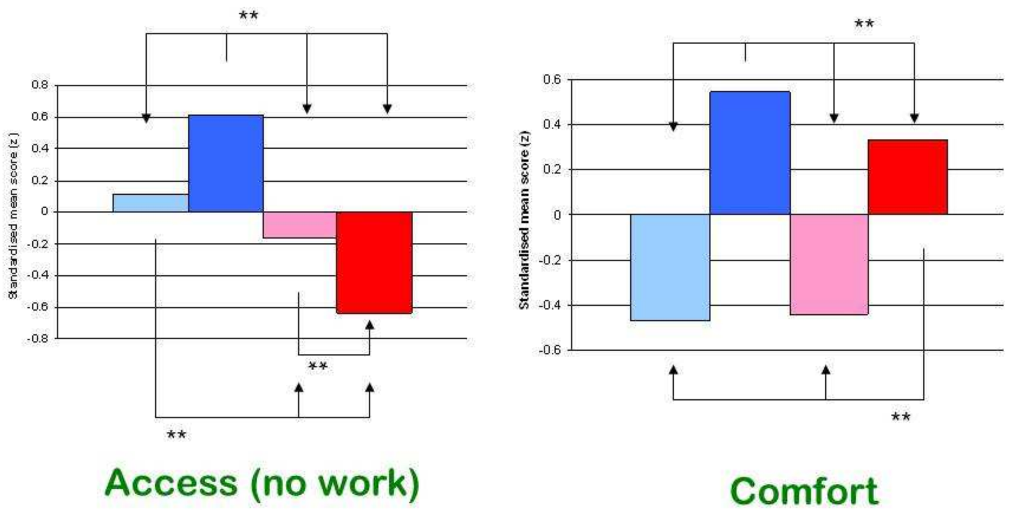
Figure 6-24: Table 6.17 Illustrated as Standardised scores for neighbourhood satisfaction components

Area Categories: HWD= High Walkable Deprived, HWND = High Walkable Not Deprived, LWD= Low Walkable Not Deprived and LWND= Low Walkable Not Deprived, *Components constructed to include the work variable as the standardised score pattern is the same as without the work variable



**ρ< .01, *ρ< .05

Figure 6-25: Significant differences between areas on satisfaction scores with and without work as a destination



**ρ< .01, *ρ< .05

Figure 6-26: Significant differences between areas on satisfaction with 'Access' and 'Comfort'

**$p< .01$, *$p< .05$

Figure 6-27: Significant differences between areas on neighbourhood walkability rating

6.8 Discussion

While associations can be drawn between environmental features and behaviours, causation cannot be determined as the data collected was from a cross sectional study, not a longitudinal study.

6.8.1 Suitability of the CGL instrument

Existing environment questionnaires reported primarily on level of agreement with the presence of functional elements within the physical environment (inter alia the presence of footpaths), with little emphasis on the respondent's perception of personal comfort or sense of place. The NEWS instrument was identified as the most suitable questionnaire for the CGL study and was amended to reflect the findings of study two. An individual's perception of the environment/space they are in or passing through is a key consideration of social cognitive theory, the interplay of personal, behavioural and environmental determinants, on an individual's decision to walk (section 2.4). The inclusion of items relating to atmosphere/vibrancy, village feel, spatial avoidance, imageability, disorder and social cohesion, among others emerged as important determinants of the walkability of an area in study two, and their assessment via the CGL instrument is a strength of this study.

The CGL questionnaire was found to have good reliability and overall consistency but further testing of the questionnaire would be beneficial as the sample size for the reliability testing was small. Objective validation of behaviours would be advantageous for instrument validation. The IPAQ question used has previously been shown to overestimate total physical activity behaviours (Lee et al. 2011, section 6.3.2.5) but has been shown to be reliable and valid for reported walking behaviour (van der Ploeg *et al.*, 2010). Emphasis is placed on reported walking and active travel results rather than physical activity scores in this study because of these findings. Environment perceptions are difficult to validate. Determining level of agreement with objective measures of the environment as a validation tool is a popular practice in public health research (Brownson *et al.*, 2009; Hoehner *et al.*, 2005; Gebel *et al.*, 2009; McCormack *et al.*, 2004), however this thesis proposes that this method should be used with caution.

The environment perceptions section of the CGL has six components and which were shown to explain 45% of the variance in the environment correlates section of the questionnaire. The development of this instrument supports the findings of study two of this thesis. The *crime and disorder*, *comfort* and *overlooking* components are comprised of items relating to the streetscape sub-themes (section 4.3.7). The *village* and *social* components are linked to sub themes of the village theme (section 4.3.5) and the *scale* component is concurrent with the scale theme in the qualitative analysis (section 4.3.3). An interesting observation was how items within the social cohesion component also weakly loaded onto the village component suggesting that the village facilitates a sense of belonging. Theme 1, considerations relating to the individual (section 4.3.2), relates to personal correlates not yet investigated in this population dataset.

In sections 2.4 and 4.3 the contextual nature of how an individual perceives their environment was discussed. Environment perceptions, described as the environment seen through a ‘series of veils’ by Kusenbach (2003, p.466). These veils are related to individual experiences, demographics and the context of the trip. For a true validation of an environment perceptions measure 'walk in time' methods[55] such as Brown and colleges study in Utah, USA (2007) and Kelly and colleagues in Leeds, UK (2011) where participants did a walk in time survey and filled in a self-report questionnaire. In this study, the similarity between the components produced in the PCA analysis and the qualitative study themes which formed the basis of the site selection criteria suggest that the CGL instrument is valid measurement tool. However, further work is needs to formalise this suggested relationship.

An additional limitation of the CGL instrument is that it has been developed for an urban context. Some variables would need to be adapted for rural environments.

6.8.2 Response rate, demographics and socioeconomic status

A high response rate was attributed to lessons learned from the pilot study resulting in a well-designed questionnaire and a flexible data collection procedure focused on respondent's convenience. Data collection times were adapted based on the observed behaviours of residents and a postcard was delivered to all homes where the door was not answered.

Home ownership correlate scores (Table 6-12) revealed that HWND areas had a greater number of households with no mortgage and with fewer households renting than the other three area categories. The higher age, duration of residency and income (although income did not differ significantly) of individuals in the HWND than LWND areas were indicative of the desirable and expensive established HWND areas. A lower duration of residency was expected in the LWND as study three (Figure 5-9) demonstrated that there were a high proportion of new builds in these areas within the last ten years. Age and duration of residency were also poorly correlated for these LWND areas (Table 6-11). The LWND areas had a significantly higher job status score and similar education level score than HWND areas yet have a lower income score. LWND areas scored significantly greater than HWND areas on job status. Both of which in turn scored significantly greater than HWD areas that scored significantly higher than LWD areas, (Figure 6-4 & 6-6). These differences may be related to the age of the residents and warrants further investigation.

[55] Qualitative research method where an interview is conducted while walking in the environment being studied

The identification of deprived areas within the GDA was validated using the self-report data collected on socio-demographic correlates in the current study. Results showed that HWD areas scored significantly higher than LWD areas on home ownership, suggesting a high proportion of renting from local authority in the LWD areas. This corresponds to observations made by the data collection team. The longer periods of residency in LWD areas may be an indication of a poverty trap in these social housing areas exasperated by mobility exclusion (Wickham 2006, p.122). A recent trend where a younger population have moved into Dublin City Centre (Howley and Clifford, 2012; Wickham, 2006) may be a contributory factor in the lower age and period of residence of HWD areas in comparison to HWND areas. Affordability may also be a contributing factor (Leinberger, 2009). This identified trend may also contribute to the lower duration of residence in HWD areas than LWD or HWND areas, as there may be a more transient renting population. A recent article in the Irish Times profiling young professionals who chose to rent long term close to the city centre, for a better quality of life and lower transport costs/time, rather than buying affordable housing in the suburbs supports this observation (Mullally, 2012). LWND and LWD areas did not differ significantly on home ownership.

The sample for this study was predominately female with a higher percentage of female respondents in low walkable areas than high walkable areas. It is possible that this is reflective of the resident population rather than a sampling error. Kelleher and colleagues (2003) obtained a 45.5% male response rate for an Irish national health survey and found that although men were relatively under represented the demographic profile was not appreciably different to the census. While Cantillon and Nolan (2001) do not quantify a proportion of female-headed poor households in Ireland, their paper was based on an understanding there is an increasing number of poor households headed by a female in Ireland. They note that this phenomena is most pronounced in the United States which McLaughlin and Sachs (1998) claim that in 1986 more than half of poor families were headed by women with no male (husband) present. A request should be made to the CSO for 2011 census small area demographics for the surveyed areas to compare to CGL response rates in future analysis.

6.8.3 Environment perceptions

The environment perceptions section of the CGL instrument did not load into distinct components. However, distinct loading was not expected as the instrument variables were not generated to measure specific physical attributes of the neighbourhood but rather a sense of place generated from a combination of the physical and social elements of an area. The items also relate to an individual's perception of an area, which is a unique perspective informed by the individual's beliefs, experiences and purpose related to the affordances the area presents them (Carmona et al. 2003; Mehta 2008, Section 2.4). Therefore, although two individual's perceptions of the same area may not match because of these individual's characteristics and experiences, the collective score attributed to an area by a group of residents gives a measure of the 'sense of the place'. Considering this, it was interesting that two of the four items measuring a specific functional item, footpaths and pedestrian crossings, did not load onto any construct. During site visits and data collection it was observed that Dublin neighbourhoods have footpaths but do not necessarily have a connected system or a system that reflects pedestrian desire lines. It was also noted that footpaths were not well maintained, an observation made in the focus group study (section 4.3.6). The other two specific functional items, presence of a buffer and wide roads, loaded onto the scale construct. The constructs from the PCA analysis discussed below are reflective of interpretations of place and will form a basis for investigations into their influences on behaviours. The similarities between the qualitative themes from study two and the constructs from the PCA analysis mentioned in section 6.5.1 are also useful for comparison of studies in this mixed methods project.

The crime and disorder construct explained 17.6% of the perceptual environment question variance. This construct which reflects physical disorder, negative social milieu on the streetscape, spatial avoidance and the local crime rate, was found to be associated with an area's deprivation status. This result supports previous research (Sallis *et al.*, 2009; Neckerman *et al.*, 2009; Kamphuis *et al.*, 2010; Foster and Giles-Corti, 2008) and ecological models (section 2.4) which state that an individual's environment influences are from both social and physical environments. The inclusion of social indicators when measuring walkability perceptions is therefore essential.

The village construct, which explained 9.6% of the perceptual environment question variance, reflects diversity, vibrancy, imageability and livability, all of which contribute to the image and perception of an area (Montgomery, 1998; Gehl, 2010; Ewing and Handy, 2009). The comfort construct, which explained 4.1% of the environment question variance and had weak reliability and acceptable internal consistency, exhibited a similar pattern between area categories to the village construct where HWND area scores were much greater than the other area categories (Figure 6-8). The scale construct, demonstrated a clear association with walkability. This was consistent with Ewing & Handy's (2009) results where scale constituted over 40% of their urban design walkability construct. Section 4.3.3 of this thesis highlighted that scale and density are not mutually exclusive. Density has a positive but inconsistent relationship with walkability (section 2.7.1.1). The moderate reliability and low but acceptable internal consistency of the scale construct in the CGL instrument warrants further investigation and development. The construct is indicative of negative 'carchitecture' scale (section 4.3.3). Positive human scale is the opposite of this but also relates to the liveable village where everyday services are available in a close proximity (section 4.3). While HWD areas score significantly higher than the low walkable areas for the village construct, HWD areas are still significantly lower than HWND. The complex interplay of social characteristics, scale and the village on the walkability and walking behaviour of an area needs to be explored further using a statistical model which can consider all of these elements in its analysis. Walkability research has predominately focused on selecting high or low walkable study areas objectively and investigating if socio-economic status is related to walking behaviour in these areas (Sallis *et al.*, 2009; Van Dyck *et al.*, 2010; Cerin *et al.*, 2009b). While other studies have reported findings of lower aesthetic scores or higher visual disorder scores in lower socio-economic status areas (Kamphuis *et al.*, 2010) no research findings were identified from studies that considered both streetscape disorder and objective GIS measures in city-wide site selection. The site selection methods used for the New York urban design based walkability study do consider both, however the method relies on extensive GIS datasets (Neckerman *et al.*, 2009).

LWND areas were different to HWND for all correlates of the environment except for perceptions of crime and disorder. LWND areas scored low on the social construct, destinations, scale, comfort, public transport and permeability. However, the crime and disorder results were favourable (negatively loaded, therefore perceived as safe and little or no disorder). Individuals may choose to live in areas that reflect low levels of crime and disorder for a variety of reasons, although neighbourhood satisfaction scores were significantly lower for LWND areas than HWND areas (Figure 6-25). Further research should establish if demographics and psychosocial correlates have an influence on an individual's decision to live in these areas.

The higher HWD public transport score is most likely due to the radial structure of the Dublin transportation network (Wickham, 2006; Harrison and Connor, 2012). Suburban and outer city HWND areas were villages built along old public transport routes (McManus, 2002). LWD areas were observed to have good public transport links (section 5.7). LWD areas differ to LWND areas, while they have similar village and scale scores; the presence of destinations, permeability, public transport and the social construct all have more favourable scores for LWD areas. LWD areas do have a lower crime and disorder score indicating a greater perceived safety risk. These results may be indicative of the planning processes behind these areas. The local authority social housing developments (LWD areas) were planned and built rather than developer driven like the LWND areas. These LWD areas are older as social housing is no longer built in specialised estates but in regenerated urban areas and policies have been implemented to integrate social housing into established not deprived areas (DEHLG 2007). HWD areas show similar trends to HWND areas, except for crime and disorder, but do not score as high as the HWND areas. These results support the observations made earlier in this thesis that the area characteristics vary between the four area categories predominantly due to the morphology and era in which the areas were constructed (section 5.8). This makes direct comparison between high and low walkability very difficult because of the complexity of the elements contributing walkability, and the contextual nature and interplay between these elements.

6.8.4 Behaviours

Car ownership and usage appears to be influenced by both the walkability of the area and whether or not the area is deprived (Figure 6-16). Residents of not deprived areas were found to own more cars than those living in corresponding deprived areas (i.e.

HWND > HWD and LWND > LWD), supporting previous research (Sallis and colleagues, 2009). Residents of low walkable areas were found to spend more on motor fuel than their counterparts in high walkable areas controlling for deprivation category (i.e. LWD > HWD and LWND > HWND). Considering that LWD areas have lower incomes than HWD areas (Table 6.12) a greater proportion of the household spend was on motor fuel. However, owning a car may be a transportation necessity in a low walkable area to travel to work and therefore the ownership of a car, or numerous cars, within a household may indicate a requirement rather than a choice based on affluence. A poverty trap, whereby an individual living in a low walkable area (isolated and badly serviced by public transport) cannot afford a car but cannot get to work without one, to earn money to buy one, a concept James Wickham referred to in his book on Dublin's transport crisis (2006).

High walkable areas were associated with a significantly higher number of minutes of active transport consistent with international research (Sallis *et al.*, 2009). A significant difference was not found between high and low walkable areas for walking for recreation, Table 6.15, despite a greater perception of available places to go for a walk Table 6.14. No significant differences in total reported physical activity were found between area categories. These results warrant further research. Because of concerns previously discussed on the validity and reliability of the IPAQ instrument for measuring physical activity (section 6.5.1) emphasis is placed on reported minutes active transport or walking for recreation rather than the total physical activity score.

An average mode choice score was calculated for the relevant trips taken to a list of neighbourhood destinations. This measure was included to reflect the habitual behaviours other than the journey to work. The availability of the POWCAR data for Ireland has resulted in an over-emphasis on travel to work and school transport data. The average mode choice score is also a proxy for livability[56]. The mode score, percentage active travel and percentage public transport trips was very different for LWND areas than other areas (Figure 6.3). Walkability and deprivation both appear to influence these behaviours. It is possible that mode choice may be a question of feasibility, a basic requirement for neighbourhood walking (Alfonzo, 2005; Mehta,

[56] A liveable area is one where all your weekly needs can be serviced either on foot or by taking short public transport trips from your home (section 4.3.5.1)

2008). There may be no option to walk or cycle to a destination in a low walkable environment because of the distance or it may be the only option available to a deprived household if they cannot afford a car. The trip may take a long time but if they are not working this may be feasible for them. The percentage public transport trips to destinations measure is somewhat flawed as listed destinations may be within walking distance. Further contextual analysis of the behavioural data is necessary to build a clearer picture of transport behaviours. These scenarios warrant further investigation in a statistical model.

6.8.5 Barriers to walking

Results from the barriers to neighbourhood walking instrument show that high walkable areas present less barriers to walking than low walkable areas. However, area deprivation does play a role in the perceived barriers, particularly those in the comfort and inclusion sub-component of the instrument which explains 12.6% of the questions variance. Further investigation is warranted linking the findings of neighbourhood crime and disorder construct to the likelihood of not walking in the neighbourhood based on the perception of being unsafe from crime. This in turn needs to be considered in the context of respondent's demographic, social cohesion and quality of life correlates. No instrument was found which measured the perceived barriers to neighbourhood walking. These findings will inform the linkage between the perception of the built environment and behaviours, rather than an assumption that measurements are related.

6.8.6 Neighbourhood satisfaction

Residents of high walkable not deprived areas were the most satisfied with their neighbourhood and rated their neighbourhood more walkable than all other areas. This satisfaction was contributed to by a comfort factor which related to area deprivation and an access score which reflected the walkability status of the surveyed areas. Both the social and physical environment contributes to neighbourhood satisfaction as hypothesised by the environment model (section 2.4).

6.9 Agreement with Hypotheses

The following hypotheses were formulated with respect to living in high walkable not deprived neighbourhoods:

1) Perceptions of the physical environment will vary between the four area categories of HWND (high walkable not deprived), HWD (high walkable deprived), LWND (low walkable not deprived) and LWD (low walkable deprived) ***– Accepted***

2) That those living in LWND and LWD areas will report less minutes active travel, for recreation and less total physical activity per week than those living in HWND and HWD areas. ***– Partially Accepted (Nuances exist)***

> ***(a)*** LWND and LWD areas reported less minutes active travel than HWD areas and LWND areas also reported less minutes active travel than HWND areas. HWND areas and LWD areas did not differ significantly. ***– Partially Accepted***
>
> ***(b)*** HWND areas reported more minutes walking for recreation than LW areas, this was not replicated for HWD areas ***– Partially Accepted***
>
> ***(c)*** There were no significant difference reported between groups for total physical activity **- Rejected**

3) That those living in LWND and LWD areas will own more cars, and spend more on motor fuel, than those living in HWND and HWD areas. ***– Partially Accepted (Nuances exist)***

> ***(a)*** LWND areas reported owning more cars and spending more on motor fuel than all other area categories
>
> ***(b)*** HWND areas reported owning more cars and spending more on motor fuel than both high and low walkable deprived areas

4) That the correlates that predict walkability will differ based on area category of residence, reflecting poorer neighbourhood satisfaction, less access to local services and higher barriers to walking in LWND and LWD areas in comparison to HWND and HWD. ***–Accepted***

6.10 Conclusion

Following study four of this project it can be concluded that

1) The CGL instrument is reliable and valid
2) The recruitment method used yielded a very positive response rate.
3) Perceptions of the environment differ between area categories; however the deprivation of the area can influence perceptions.
4) The behaviours of residents differ between area categories; however further investigation is required to determine the role of influences other than the structural environment.

6.11 Further Work

The cross-sectional population study generated a substantial and complex dataset which would benefit from a detailed analysis approach to control for different variables and to allow generalisation across the different types of neighbourhoods. Further reliability and validity testing should also be carried out on the CGL instrument.

7 Conclusions and Recommendations

7.1 Introduction

The purpose of this thesis was to explore the term walkability and give an account of the method development and preliminary findings of the CGL study. This section (i) summarises the study conclusions derived from the thesis content, (ii) outlines a conceptual model of walkability based on the study findings, (iii) discusses the applicability and impact of this research and (iv) makes recommendations for future work.

Throughout this project the relevance and transferability of the both methods used and the study findings were at the forefront of my mind. Based on my experience as a practitioner, I gave particular consideration for the real-world implementation of the findings. On reflection, the lessons I learnt at each stage of the project were necessary to truly appreciate the complexity of multidisciplinary research. For example, texts which I dismissed as irrelevant in the early stages of my literature review became very relevant as my knowledge base and understanding expanded. An adaptive approach was also required to work within the constraints of available data and resources. This resulted in a project which can potentially be replicated in any geographic area, including those with limited GIS data. Discussions in this chapter are informed by both the research findings and my knowledge and experience as a practitioner.

7.2 Walkability

A key finding in the exploration of the term 'walkability' was that it means different things to different people, but also different things to the same person in different contexts. However, patterns were identified. These patterns, or themes, were subsequently used to inform the development of a multidisciplinary walkability criteria that can be used as a framework for further research and in practice. This is important because it was also established that an individual's perspective on what constitutes a walkable environment can be influenced by their professional and/or personal circumstances, and the context of the trip being considered. In a practical sense, to effectively translate research findings and guidelines and policies from diverse but relevant professions, the information needs to be in a format which is comprehensible to all relevant multidisciplinary parties. This issue of translation was raised by Jackson and colleagues in their recent commentary article on 10 years of health and built environment research (2013). Translation remains a key challenge. Considerations for the practical implementation of walkability, as the multidisciplinary concept identified in this thesis, are outlined in this section.

This thesis established that the walkability of an area is influenced by both the physical and the social characteristics of a neighbourhood and how they are perceived (Figure 7.1). These characteristics can be determined objectively and/or subjectively. An individual's perception of their environment is the interpretative level of the physical environment on which an individual makes their behavioural decisions. It is subjective in nature, and therefore difficult to verify. To effectively measure walkability and investigate the relationship between the environment and behaviours subjective data is critically important. Therefore, this thesis contends that it is imperative that researchers or practitioners working in this area consider the use of both objective and subjective measures.

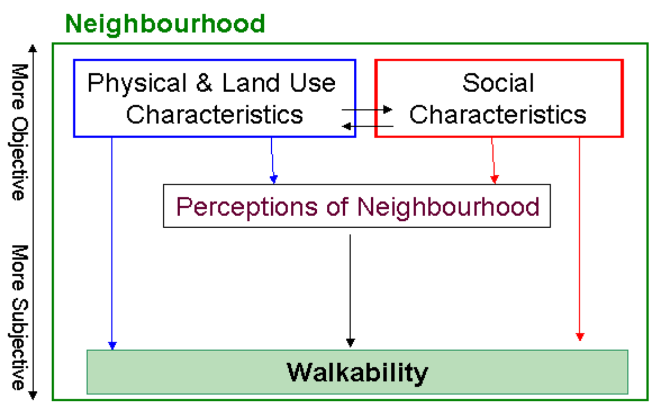


Figure 7-1: Proposed Neighbourhood Walkability Model

The morphological process, that shapes the physical characteristics of a neighbourhood, was observed to be influenced by the age of the area and the city zone (inner city, outer city or suburbs). The social characteristics reflect the socio-economic profile of the area's residents and the social cohesion/ sense of community within an area (Figure 7.2). Preliminary findings from the CGL study suggest a relationship between the age of an area and social cohesion. The developer built suburban estates, generally built between 2000 and 2010, characterised as low walkable not deprived areas, were found to have significantly lower social cohesion scores than all other (older) areas. The morphological process was influenced by the era of an area's (i) initial construction and (ii) subsequent development. This is a reflection of the planning, housing, transportation and social policies that were in effect during the area's evolution. This level of influence from policy on the physical and social environment, and resultant influence on behaviours, is consistent with the socio-ecological model therefore confirming its relevance for walkability research. Policy makers should be made aware of the relevance of these policies on walkability and hence the health, well-being and carbon emissions of residents as identified by the preliminary result of the CGL study and other walkability research. Walkability should be considered at three spatial levels: macro city scale, meso neighbourhood scale and micro streetscape scale. Because of the nature of their work practices or training, walkability stakeholder professions may not understand, nor be concerned with, all these levels of influence, but to undertake a comprehensive walkability planning, building or research project consideration should be given to all levels.

Returning to first principles to generate a list of relevant environment correlates was a key strength of this study. The list was compiled from a review of multidisciplinary literature and a mixed methods research study to explore their relevance. The generated list allowed for a more holistic examination of neighbourhood walkability. As a reference tool this list can facilitate greater cooperation across disciplines by creating a better awareness of what can influence neighbourhood walkability, resident's behaviours and their resultant health and carbon footprint. The findings can also highlight the importance of multidisciplinary considerations and collaborations, in particular how results are communicated. It is acknowledged that the list used is not exhaustive. However, it provides a framework which enables progression in the research area. The key influential environment features for walkability identified in study two of this thesis were: (i) scale, (ii) the village, (iii) permeability and (iv) the streetscape. Figure 7.2 illustrates these elements and their influences. An additional correlate relating to a perception of crime and disorder, identified as an important element of walkability in study four, is included in the diagram. This correlate is associated with the social characteristics of a neighbourhood.

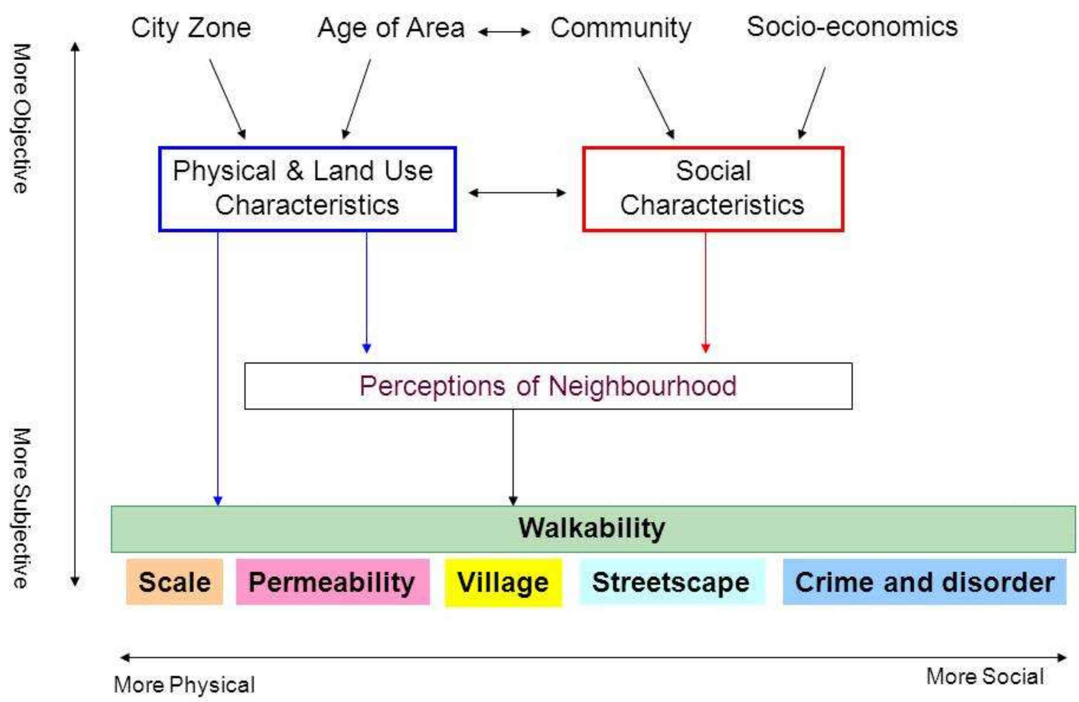


Figure 7-2: Neighbourhood Walkability model with CGL correlates and influences

7.2.1 Scale

An environment scale which is perceptually comfortable relative to the size of, or distance to, the human body is positive for walkability. Scale should be considered at all spatial levels, macro, meso and micro. The urban design concept scale is also contextual. Large scale environments with a dominance of natural features were perceived as positive for recreational walking whereas, a smaller human scale was preferable for walking within urban areas. Areas that have a large scale to facilitate large roads and car parks, termed as carchitecture in this thesis, are negative for walkability. Scale and density are not mutually exclusive and it is possible that positive associations between transportation walking and density identified by Frank and colleagues (2010, 2005) may be a proxy measure of scale. Macro level density is easy to measure using GIS, however these density measures do not consider micro level considerations such as the area's context or crowding. Scale is a concept which warrants further investigation in walkability research because of the findings of both this study and work undertaken by Ewing and colleagues (Ewing *et al.*, 2006b; Ewing and Handy, 2009; Ewing *et al.*, 2013). It also requires an explanation or translation for practitioners and those outside the urban design and architecture professions.

7.2.2 The Village

The village concept refers to both a social community and the physical structure of the neighbourhood. It is a meso level area where all your weekly needs can be serviced within a 10-minute walk with good public transport links onto other areas. In the CGL population study items which loaded onto the village component included measures of imageability, variety, diversity (people and places), day and night uses in an area and a place to go for a recreational walk. Villages can occur in urban as well as rural settings. Greenwich Village in New York City is an example. These villages are not dependent on density but compactness. Macro level land use diversity, which has been shown to be positive for walkability and social cohesion (Leyden, 2003), is a comparable measure but does not necessarily reflect functional urban fabric boundaries. Walkable villages were described as being built when people walked, reflective of the era of their morphology. While mixed use developments are advocated in recent residential planning policy (DECLG, 2009) mixed uses alone do not create a walkable environment. These areas need to be in human scale environments, accessible to residential populations through permeable routes along attractive streetscapes which promote and facilitate social interactions.

7.2.3 Permeability

Permeability is the perceptual measure of the connectivity of an area. An area can be more or less permeable for physical and social reasons (Hess, 1994). A perceived threat or a physical structure which inconveniences a user, such as a pedestrian bridge with long ramps, may render a functionally connected route/ area impermeable. This can result in spatial avoidance or a decision to take an alternative mode of transport. A well connected neighbourhood is a primary element of walkability; however it also needs to be permeable. A well connected area has sufficiently wide footpaths and suitable road crossings which reflect pedestrian desire lines to facilitate pedestrian movement.

7.2.4 The Streetscape

The streetscape is the interface between the individual and the physical environment. It is of critical importance for walkability as individuals collect their perceptual cues about the area at this micro level. These cues inform behaviour decisions (Bell *et al.*, 2001). The street should provide visual interest, signs of activity, transparency and have a pleasant atmosphere (or sense of place) relative to the area's context (Gehl, 2010; Carmona *et al.*, 2003). It should be devoid of visual disorder. The perception of crime and disorder was found to be negative for walkability and linked to neighbourhood deprivation in study four.

7.2.5 The Individual

As mentioned earlier in this chapter; walkability means many things to different people, but also different things to the same person depending on the trip context. Therefore, when assessing the walkability of an area consideration needs to be given to a variety of trips; the functional trip for transport, the recreational walk for exercise and the neighbourhood amble. An individual's response to an environment will depend on their mood also. Alternative routes should be available through vibrant and quiet parts of an area. The design of functional elements of the streetscape, inter alia footpaths and road crossings, must consider individuals with mobility difficulties and buggies (Study two).

In summary, walkability has elements which can be measured objectively but it also has subjective elements which should also be considered. The walkability criteria developed in this study are not a defined set of rules for quantitative measurement but rather a framework for consideration. This framework can be utilised by policymakers and multidisciplinary teams as a common platform for reference, and also form a basis for future walkability research. In order to ensure the concepts are understood, and therefore implemented within the correct contexts, steps should be taken to educate and inform relevant professionals, policy makers and researchers.

7.3 Study Method Development

The literature review undertaken at the beginning of this study identified diversity in the definitions and interpretations of walkability, and how the concept was measured by different professional and research communities. These differences where confirmed using a quantitative study outlined in study one of this thesis. The diversity in how walkability was interpreted and adopted by the various groups has implications for policymakers, local authorities tasked with neighbourhood design and the research community. It was clear from these findings that an understanding of walkability which considered the varied perspectives was required. A key strength of study one was the professional diversity of the sample. A limitation was a potential self-selection bias; where the survey may have been predominately completed by those with an interest in walkability. The study gave a solid justification to further research into the multidisciplinary nature of walkability.

The complex picture of walkability that emerged from the reviewed literature and results of study one presented a challenge of how to proceed with the study. This was compounded by the identification of limitations of the methods used to identify walkable areas for cross sectional studies. It also identified a possible disconnect between the quantitative and qualitative walkability research communities. Because of the acknowledged importance of both qualitative and quantitative measures of walkability a mixed methods approach was adopted. Qualitative data was collected from multidisciplinary groups using a phenomenological study which used socio-spatial recall as a foundation for discussion. The findings of this study informed both the development of the walkability criteria and the site selection process. While participant's reasons for selecting areas as high or low walkable differed there was little disagreement on the selected areas. Strengths of study two were that; (i) areas selected by participants provided common reference points for discussion, (ii) socio-spatial recall allowed for discussions to reflect both professional and personal views based on experience which ensured a holistic and transferable walkability criteria and (iii) the level of detail in the collected data was very informative, particularly on how features of the environment were interpreted by different individuals. Limitations of this study include; (i) a lack of disagreement on the areas selected within the focus groups may be due to a participation bias with only those concerned with pedestrian welfare attending and (ii) the use of socio-spatial recall rather than physically being in the areas may make the data less dependable.

The selection of sites suitable for the population study based on the criteria developed from study two presented the greatest challenge in this research. A selection method was developed where a shortlisting process was applied to the areas identified in study two. Limitations of the available GIS spatial data compounded the site selection difficulties. The strength of adaptive methodology used in the site selection process was that it utilised diverse professional knowledge to encapsulate perceptions of the environment as well as objective measures of the environment. Limitations of this study were; (i) there was a lack of deprived areas on high walkable lists from study two and (ii) the details of the study may be difficult to replicate. Only two of the high walkable areas identified in the focus group study were deprived. Because of this, additional areas had to be identified by the research team based on the developed walkability criteria. Criteria scores for high walkable deprived areas were significantly lower than high walkable not deprived areas. The role of visual disorder on the streetscape and its association with deprivation was a key factor in this limitation. In general, the international studies that adopt a high/low walkable, high/low socio-economic status approach to site selection using objective GIS do not account for streetscape features (Van Dyck *et al.*, 2010). The mixed methods approach to site selection used in this study controls for the subjective measures of the streetscape. It is possible that the desirability of high walkable neighbourhoods results in higher property prices (Leinberger, 2009) thus resulting in only affluent high walkable neighbourhoods. Areas may also be desirable because of this affluence. Further work should be undertaken on the relationship between walkability, desirability and affordability in residential selection.

Dublin is a low to medium density city with a population of 1.3 million. The size of the city made an exercise that relies on socio-spatial recall feasible. A regional approach may be beneficial to replicate this study in larger cities. This method also used a list of areas derived from a focus group study that involved 26 individuals each contributing two hours of their time. Outdated GIS data on street and path networks meant audits and mapping exercises were also undertaken by the researcher. While smaller multidisciplinary groups could be enlisted to generate a list of areas, and creating partnerships with local authority GIS teams could reduce time demands associated with auditing and mapping, the study would not technically be replicated. While the results may be potentially difficult to replicate the new methodology presents options to studies in smaller spatial geographies and cities like Dublin who have inconsistent and/or unsuitable GIS datasets, which is many cities and towns. This is a considerable benefit to the research field.

Study four of this thesis is a cross sectional study in the identified areas using a survey instrument developed to reflect the findings of the literature review and study two of this thesis. The instrument consisted of both validated measures and researcher developed questions which were found to have good reliability and overall consistency. While face validity exercises were undertaken during the questionnaire development process further validity and reliability testing of the questionnaire would be beneficial. The questionnaire included items on the environment, behaviours and personal information consistent with the social cognitive theory (Figure 7-3). An active recruitment method which focused on respondent's convenience yielded a positive response rate. Preliminary analyses using univariate statistics were undertaken on the cross sectional data. A conceptual model was generated based on the thesis' findings to facilitate future multivariate analysis. An average mode choice score was also developed as a proxy measure of mobility habits and choices made to access basic services.

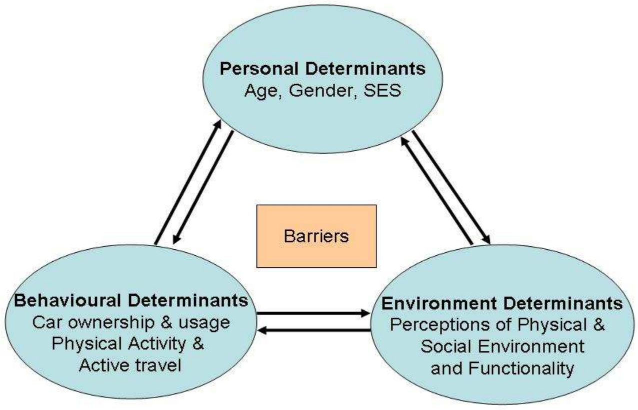


Figure 7-3: Social Cognitive Theory (SCT) with correlates

In summary, the mixed method approach used in this thesis allowed a comprehensive examination of walkability and its physical, social and perceptual elements. The adaptive approach to site selection enabled consideration of many elements and contexts which traditional GIS site selection methodologies neglect. The approach also presents an alternative approach to site selection in areas which have limited or inconsistent GIS information, which is a commonly reported limitation (Badland *et al.*, 2009; Van Dyck *et al.*, 2010; Kamphuis *et al.*, 2010).

7.4 Walkability and Behaviours

The preliminary findings of the cross sectional study confirmed that perceptions of the environment differ between the four area categories confirming that walkability is influenced by both the physical and social environment. The identified differences in perceptions validated the site selection methodology. The behaviours of residents differed between the area categories also. High walkable areas presented fewer barriers to walking than low walkable areas.

High walkable areas were associated with significantly more minutes of active transport than low walkable areas consistent with international research. This was not replicated for recreational walking where residents of high walkable not deprived areas walk significantly more for recreation than all other groups. This finding is interesting considering that the high walkable deprived areas selected were all within close proximity to recreational walking facilities, similar to the high walkable not deprived areas. These univariate results do not consider age, ability, time or other potential barriers to walking and need to be repeated using multivariate methods. Public health research has predominately used minutes of moderate or vigorous physical activity to identify or validate walkable areas. These measures do not encompass the people who wish to amble or meander around their local neighbourhoods. A measure of total minutes walking, independent of trip purpose or intensity, will give a greater understanding of a neighbourhood's functionality and comfort for people of all ages and abilities to walk in their neighbourhoods or greater city regions. Similarly, an investigation into the relationship between neighbourhood classification and sedentary behaviour may also provide findings of relevance for public health researchers and policymakers. The reviewed literature suggested that the positive health benefits of walkable areas go beyond increased minutes of physical activity (section 1.4). Further work is required to investigate the association between walkable neighbourhood and wellbeing. Multivariate statistics will also facilitate an investigation into if the psychosocial barriers to neighbourhood walking are compounded by walkability and neighbourhood satisfaction.

Car ownership and usage appears to be influenced by both walkability and deprivation with car owners in deprived areas spending more on fuel than areas in their corresponding walkability status.

In summary, a neighbourhood's walkability does influence the behaviour of its residents. Multivariate analysis is required to further explore these behaviours. The next section of this chapter outlines a proposal for undertaking this analysis.

7.5 The CLG Model

The Cleaner, Greener, Leaner Model is a conceptual model of the relationship between a neighbourhood environment and the behaviours of the residents of the neighbourhood (Figure 7-4). It is based on the social cognitive theory (Figure 7-3) and the neighbourhood walkability model (Figure 7-1) which is based on the socio-ecological model. This model proposes pathways which should be investigated in the CGL cross sectional data informed by the behavioural models reviewed at the beginning of this thesis. These pathways include consideration for mobility and exercise habits, perceived barriers to behaviours and the availability of a car.

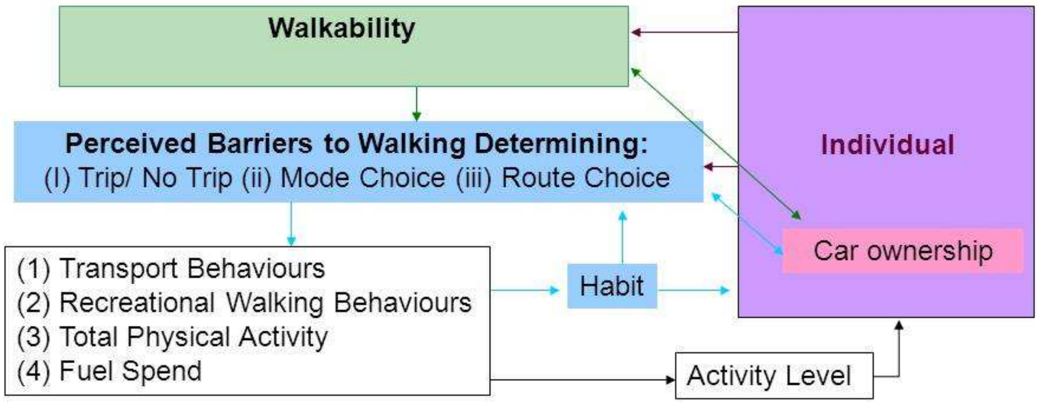


Figure 7-4: CGL model schematic reflecting SCT

An expanded schematic of the model is outlined in Figure 7-5. This model shows how environment perceptions will be controlled for age, gender and mobility limitations using multivariate statistics. The relationship between individual correlates (inter alia life satisfaction, individual socio-economic profile and health) and neighbourhood perceptions will be considered within the context of the environment in which they reside. These investigations will further inform the research field investigating the role of the environment on behaviours. It is proposed that this investigation will be undertaken using a structural equation model.

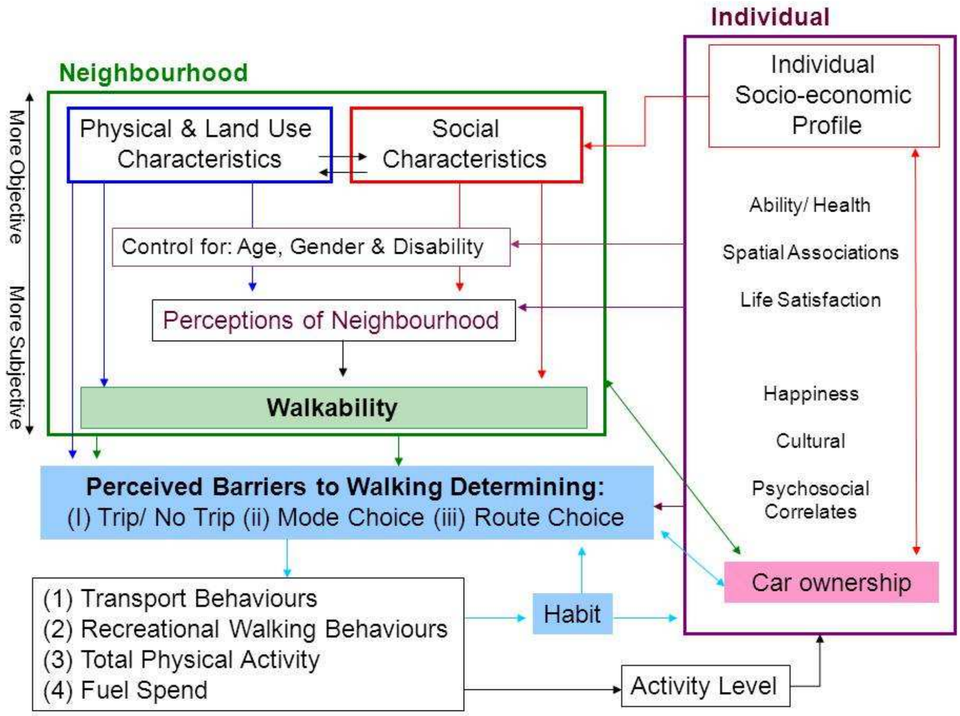


Figure 7-5: The CGL model

7.6 Research Impact and Applicability

This research presents opportunities not just for the advancement of walkability as a research subject but also opportunities for the practical implementation of the concept in a multidisciplinary forum. The walkability criteria were developed to assign a walkability score to areas based on the physical and land use characteristics but can be further implemented into practice. Because of the nature of their work practices or training, walkability stakeholder professions may not be interested in all of the items on the list of walkability criteria, but consideration should be given to all levels when undertaking a project. Walkability, or the potential impact of a project on the walkability of a region/ neighbourhood/ street, should be reflected upon at each stage of the design process (policy, planning, design, construction and usage). The criteria consider all three levels of interest for planners, designers and policy makers; the macro city scale, the meso neighbourhood scale and the micro street scale.

The research is of current relevance in Ireland as there has been a seismic change in how designers, planners and engineers are expected to approach streetscapes following the publication of the Design Manual for Urban Roads and Streets (DMURS) document (DTTAS &DECLG, 2013). The implementation of this policy document is mandatory on all roads and streets with a speed limit of 50kph or lower. It calls for a balanced approach to 'movement' (of motorised vehicles, cyclists and pedestrians) and 'place' (the streetscape) by collaboration through multidisciplinary teams (Figure 7-6). My recent experience as a practitioner is that there is confusion amongst stakeholders on how to implement the DMURS document. The findings of the CGL study, in particular the walkability criteria, present an opportunity to assist in the implementation of the policy. It does this by providing a common platform for reference using practical examples.

The criteria could form the framework for a 'walkability impact assessment' (WIA), similar to an environmental impact statement[57] which are often requested by planning authorities for proposed schemes or developments. Similarly, because of the relevance of walkable neighbourhoods for population health a WIA could be incorporated into a Health Impact Assessment (HIA)[58] such as those undertaken by the Institute of Public Health (www.publichealth.ie/whatishealthimpactassessment).

[57] Environmental Impact Assessment (EIA) is the process by which the anticipated effects on the environment of a proposed development or project are measured. If the likely effects are unacceptable, design measures or other relevant mitigation measures can be taken to reduce or avoid those effects. The document from this process is called an Environmental Impact Statement (EIS). (www.epa.ie/monitoringassessment/assessment/eia/)

[58] Similar to EIA's described under footnote 55 but where effects on public health are measured.

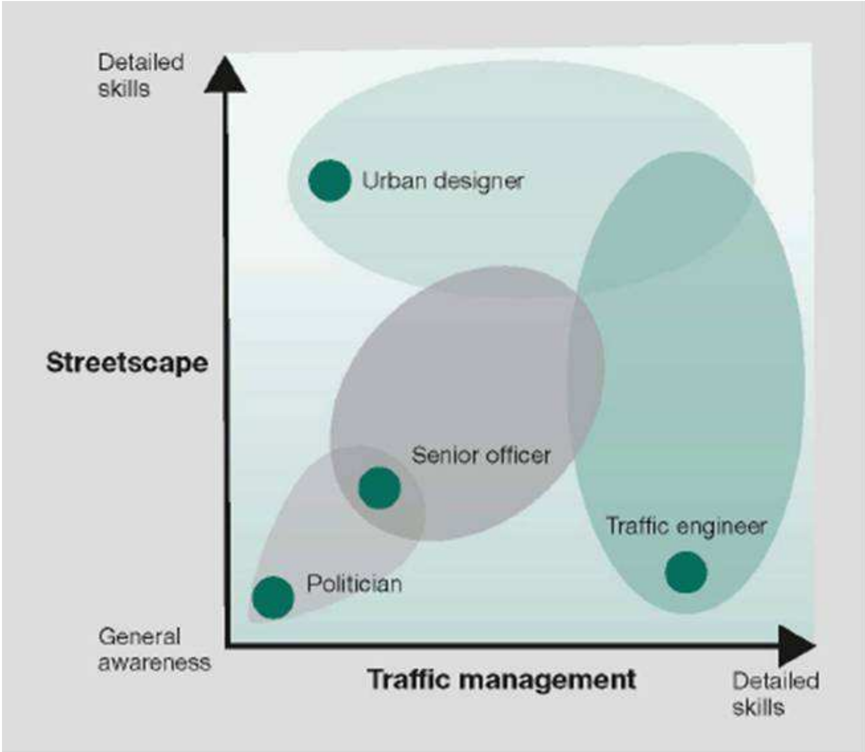


Figure 7-6: DMURS Multidisciplinary teams diagram (DTTAS &DECLG, 2013)

The publication of the CGL results from the multivariate analysis will greatly benefit advocates, public health researchers and practitioners and public representatives to translate the importance of the built environment for physical activity behaviours and health. The contextual relevance of the information, which makes it translatable to a multidisciplinary audience using suitable terminology, should increase the impact of the findings on policy development and implementation.

In an academic context this research provided a framework for (i) multidisciplinary research, (ii) a walkability criteria which considers both the objective and subjective neighbourhood elements which influence walkability and (iii) adaptive methodologies which can be used in areas, cities or regions which have limited spatial information all of which were identified limitations of current walkability research.

While this research is not without limitations it provides a framework to enhance further research and application of walkability in academia and practice.

7.7 Recommendations

Key recommendations from this thesis are:

(i) Repeating study one of this thesis on a larger sample that would allow for factor analysis to be undertaken on the data. This would be beneficial to understand the key concerns of professional groups when considering walkability in their work.

(ii) The walkability criteria developed in this thesis should be disseminated to professionals who have an influence on walkability, advocates and researchers. This could improve communication and collaboration in multidisciplinary walkability design, policy development, promotion and research. An executive summary of the CGL study findings with practical examples, with explanations of associated concepts, would be of particular benefit to multidisciplinary design teams.

(iii) This thesis was conducted using an entirely Irish based sample and in an Irish city. Further work to establish the transferability of the study findings would be valuable.

(iv) The site selection process used in this study was developed to address the specific needs and limitations of this project. Further work should be done to explore how the method could be repeated at a more economical scale or adapted for future studies.

(v) The CGL questionnaire should undergo additional reliability and validity testing.

(vi) The importance of understanding people's experience of place and streetscapes is an important element of walkability research. Street level audit information and/or walk-in-time qualitative data from the surveyed areas would complement the collected cross sectional data.

(vii) Multivariate statistical studies should be undertaken on the cross sectional data to determine the role of the environment and the individual on physical activity and mobility behaviours.

8 References

Alfonzo, M. (2005). 'To Walk or Not to Walk? The Hierarchy of Walking Needs'. *Environment and Behavior*, 37 (6), pp.808–836

Allender, S., Cavill, N., Parker, M. and Foster, C. (2009). '"Tell us something we don't already know or do!"- The response of planning and transport professionals to public health guidance on the built environment and physical activity'. *Journal of Public Health Policy*, 30 (1), pp.102–116

Amárach Research and South Dublin County Council. (2009). *Adamstown Residents Survey (Report S8-184)*. (February), Dublin, Ireland [Online]. Available at: http://www.adamstown.ie/index.php?option=com_docman&task=doc_view&gid=13&Itemid=280.

Amekudzi, A. and Meyer, M. D. (2006). 'Considering the Environment in Transportation Planning: Review of Emerging Paradigms and Practice in the United States'. *Journal of Urban Planning & Development*, 132 (1), pp.42–53

American Planning Association. (n.d.). *What do planners do?* [Online]. Available at: http://www.planning.org/aboutplanning/whatisplanning.htm#2 (Accessed: 17 May 2010).

Anderson, J. (2004). 'Talking whilst walking: a geographical archaeology of knowledge'. *Area*, 36 (3), pp.254–261

Appleyard, D. (1981). *Livable Streets*. 1st ed. Berkeley, USA: University of California Press

Araya, R., Dunstan, F., Playle, R., Thomas, H., Palmer, S. and Lewis, G. (2006). 'Perceptions of social capital and the built environment and mental health'. *Social Science & Medicine (1982)*, 62 (12), pp.3072–3083

Badland, H. M. and Schofield, G. M. (2005). 'Transport, urban design, and physical activity: an evidence-based update'. *Transportation Research Part D: Transport and Environment*, 10 (3), pp.177–196

Badland, H. M., Schofield, G. M., Witten, K., Schluter, P. J., Mavoa, S., Kearns, R. a, Hinckson, E. A, Oliver, M., Kaiwai, H., Jensen, V. G., Ergler, C., McGrath, L. and McPhee, J. (2009). 'Understanding the Relationship between Activity and Neighbourhoods (URBAN) Study: research design and methodology.'. *BMC Public Health*, 9, pp.224

Bandura, A. (1977). 'Self-efficacy: toward a unifying theory of behavioral change.'. *Psychological Review*, 84 (2), pp.191–215

Bell, P. A., Greene, T. C., Fisher, J. D. and Baum, A. (2001). *Environmental Psychology*. 5th ed. Howell, P. and Tomiak, M. (eds.). Orlando, FL., USA: Harcourt College Publishers

Bentley, I., Alcock, A., Murrain, P., McGlynn, S. and Smith, G. (1985). *Responsive Environments, A manual for designers*. Oxford, UK: Elsevier

Bergman, P., Grjibovski, A. M., Hagströmer, M., Sallis, J. F. and Sjöström, M. (2009). 'The association between health enhancing physical activity and neighbourhood environment among Swedish adults - a population-based cross-sectional study.'. *The International Journal of Behavioral Nutrition and Physical Activity*, 6, pp.8

Biddle, S. J. H., Markland, D., Gilbourne, D., Chatzisarantis, N. L. D. and Sparkes, A. C. (2001). 'Research methods in sport and exercise psychology: quantitative and qualitative issues'. *Journal of Sports Sciences*, 19, pp.777–809

Biddle, S. J. H. and Mutrie, N. (2008). *Psychology of Physical Activity; Determinants, Well-Being and Interventions*. 2nd ed. London: Routledge

Boarnet, M. G. (2006). 'Planning's Role in Building Healthy Cities'. *Journal of American Planning Association*, 72 (1), pp.5–9

De Bourdeaudhuij, I., Sallis, J. F. and Saelens, B. E. (2003). 'Environmental correlates of physical activity in a sample of Belgian adults.'. *American Journal of Health Promotion*, 18 (1), pp.83–92

Brennan Ramirez, L. K., Hoehner, C. M., Brownson, R. C., Cook, R. A., Orleans, C. T., Hollander, M., Barker, D. C., Bors, P., Ewing, R., Killingsworth, R., Petersmarck, K., Schmid, T. L. and Wilkinson, W. (2006). 'Indicators of activity-friendly communities: an evidence-based consensus process.'. *American Journal of Preventive Medicine*, 31 (6), pp.515–524

Brown, B. B., Werner, C. M., Amburgey, J. W. and Szalay, C. (2007). 'Walkable Route Perceptions and Physical Features: Converging Evidence for En Route Walking Experiences'. *Environment and Behavior*, 39 (1), pp.34–61

Brownson, R. C., Chang, J. J., Eyler, A. A., Ainsworth, B. E., Kirtland, K. A., Saelens, B. E. and Sallis, J. F. (2004a). 'Measuring the Environment for Friendliness Toward Physical Activity: A Comparison of the Reliability of 3 Questionnaires'. *American Journal of Public Health*, 94, pp.473–483

Brownson, R. C., Hoehner, C. M., Brennan, L. K., Cook, R. A., Elliott, M. B. and Mcmullen, K. M. (2004b). 'Reliability of 2 Instruments for Auditing the Environment for Physical Activity'. *Journal of Physical Activiy and Health*, 1 (3), pp.191–208

Brownson, R. C., Hoehner, C. M., Day, K., Forsyth, A. and Sallis, J. F. (2009). 'Measuring the built environment for physical activity: state of the science.'. *American Journal of Preventive Medicine*, 36 (4 Suppl), American Journal of Preventive Medicine, pp.99–123

De Bruijn, G.-J., Kremers, S. P. J., Singh, A., van den Putte, B. and van Mechelen, W. (2009). 'Adult active transportation: adding habit strength to the theory of planned behavior.'. *American Journal of Preventive Medicine*, 36 (3), pp.189–194

Burden, D. (2010). *the early history of walkability* [Online]. Available at: http://zh-cn.facebook.com/note.php?note_id=372888981843&comments&ref=mf.

Burden, D. and Florida Department of Transportation. (1995). *Twelve Steps to Walkable Communities*

Burns, R. B. and Burns, R. A. (2008). *Business Research Methods and Statistics Using SPSS*. 1st ed. London, Great Britain: SAGE Publications

Cantillion, S. and Nolan, B. (2001). 'Poverty within households: measuring gender differences using nonmonetary indicators'. *Feminist Economics*, 7 (1), pp.5–23

Carmona, M., Heath, T., Oc, T. and Tiesdell, S. (2003). *Public Places, Urban Spaces: The Dimensions of Urban Design*. 1st ed. Kent, UK: Architectural Press

Caulfield, B. (2012). 'An examination of the factors that impact upon multiple vehicle ownership: The case of Dublin, Ireland'. *Transport Policy*, 19 (1), Elsevier, pp.132–138 [Online]. doi:10.1016/j.tranpol.2011.08.003.

Cerin, E., Conway, T. L., Saelens, B. E., Frank, L. D. and Sallis, J. F. (2009a). 'Cross-validation of the factorial structure of the Neighborhood Environment Walkability Scale (NEWS) and its abbreviated form (NEWS-A).'. *The International Journal of Behavioral Nutrition and Physical Activity*, 6, pp.32

Cerin, E. and Leslie, E. (2008). 'How socio-economic status contributes to participation in leisure-time physical activity.'. *Social Science & Medicine*, 66 (12), pp.2596–2609

Cerin, E., Leslie, E. and Owen, N. (2009b). 'Explaining socio-economic status differences in walking for transport: an ecological analysis of individual, social and environmental factors.'. *Social Science & Medicine*, 68 (6), Elsevier Ltd, pp.1013–1020

Cerin, E., Leslie, E., Owen, N. and Bauman, A. (2008). 'An Australian Version of the Neighborhood Environment Walkability Scale: Validity Evidence'. *Measurement in Physical Education and Exercise Science*, 12 (1), pp.31–51

Cerin, E., Macfarlane, D. J., Ko, H.-H. and Chan, K.-C. a. (2007). 'Measuring perceived neighbourhood walkability in Hong Kong'. *Cities*, 24 (3), pp.209–217

Cervero, R. (2002). 'Built environments and mode choice: toward a normative framework'. *Transportation Research Part D: Transport and Environment*, 7 (4), pp.265–284

Cervero, R. and Kockelman, K. (1997). 'Travel Demand and the 3 D's: Density, Diversity and Design'. *Transportation Research Part D: Transport and Environment*, 2 (3), pp.199–219

Chin, G. K. W., Van Niel, K. P., Giles-Corti, B. and Knuiman, M. (2008). 'Accessibility and connectivity in physical activity studies: the impact of missing pedestrian data.'. *Preventive Medicine*, 46 (1), pp.41–45

Cicchetti, D. V. (1994). 'Guidelines, Criteria, and Rules of Thumb for Evaluating Normed and Standardized Assessment Instruments in Psychology.'. *Psychological Assessment*, 6 (4), pp.284–290

City of Portland. (1998a). *Portland Pedestrian Design Guide*. Portland, OR. USA: City of Portland [Online]. Available at: http://www.portlandoregon.gov/transportation/article/84048.

City of Portland. (1998b). *Portland Pedestrian Master Plan*. Portland, OR. USA: City of Portland [Online]. Available at: http://www.portlandoregon.gov/transportation/article/90244.

Clark, S. and Davies, A. (2009). 'Identifying and Prioritising Walking Investment through the PERS audit tool'. In: *Walk 21, More Footsteps, Less Carbon*, 2009, New York, USA: Walk 21, pp.1–12

Clifton, K. J., Livi Smith, A. D. and Rodriguez, D. (2007). 'The development and testing of an audit for the pedestrian environment'. *Landscape and Urban Planning*, 80 (1-2), pp.95–110

Coakley, L. (2003). '"I don"t relax until I'm home' Women's fear of violent crime in public space in Cork'. *Irish Geography*, 36 (2), pp.178–193

Coleman, K. J., Rosenberg, D. E., Conway, T. L., Sallis, J. F., Saelens, B. E., Frank, L. D. and Cain, K. (2008). 'Physical activity, weight status, and neighborhood characteristics of dog walkers.'. *Preventive Medicine*, 47 (3), pp.309–312

Congress of the New Urbanism. (2001). *Charter of the New Urbanism* [Online]. Available at: http://www.cnu.org/sites/www.cnu.org/files/charter_english1.pdf.

Cowan, R. and Rodgers, L. (2005). *The Dictionary of Urbanism*. 1st ed. Wiltshire, UK: Streetwise Press

Craig, C. L., Marshall, A. L., Sjöström, M., Bauman, A. E., Booth, M. L., Ainsworth, B. E., Pratt, M., Ekelund, U., Yngve, A., Sallis, J. F. and Oja, P. (2003). 'International physical activity questionnaire: 12-country reliability and validity.'. *Medicine and Science in Sports and Exercise*, 35 (8), pp.1381–1395

Creswell, J. W. (1998). *Qualitative Inquiry and Research Design: Choosing Among Five Traditions*. 1st ed. Laughton, C. D. (ed.). California, USA: SAGE Publications

Creswell, J. W. and Plano Clark, V. L. (2007). *Designing and conducting mixed methods research*. 1st ed. Cuevas Shaw, L. and Greene, K. (eds.). Thosand Oaks, California: SAGE Publications

CSO Central Statistics Office. (2004). *Report of 2004 Census Pilot Survey*. Dublin, Ireland [Online]. Available at: http://www.cso.ie/en/media/csoie/census/documents/2004_census_pilot_test_report.pdf.

CSO Central Statistics Office. (2006). *Census of Population of Ireland Form 2006*. (April), Dublin, Ireland: Central Statistics Office, pp.1–24 [Online]. Available at: http://www.cso.ie/en/media/csoie/census/documents/censusform_2006.pdf.

Cullen, G. (1964). *The Concise Townscape*. Oxford, UK: The Architectural Press

Cutt, H., Giles-Corti, B. and Knuiman, M. (2008). 'Encouraging physical activity through dog walking: why don't some owners walk with their dog?'. *Preventive Medicine*, 46 (2), pp.120–126

Czogalla, O. (2010). *Parameters determining route choice of pedestrians in walkable networks. PQN Final Report B. 1. 10*. London, UK, pp.171–190 [Online]. Available at: http://www.walkeurope.org/uploads/File/publications/PQN Final Report part B1.pdf.

Darker, C. D., Larkin, M. and French, D. P. (2007). 'An exploration of walking behaviour--an interpretative phenomenological approach.'. *Social Science & Medicine*, 65 (10), pp.2172–2183

Day, K., Boarnet, M. G., Alfonzo, M. and Forsyth, A. (2006). 'The Irvine-Minnesota Inventory to measure built environments, development.'. *American Journal of Preventive Medicine*, 30 (2), pp.144–152

Department for Environment Community and Local Government. (2009). *Guidelines for Planning Authorities on Sustainable Residential Development in Urban Areas*. Dublin, Ireland: The Stationary Office, Dublin

Department for Transport Tourism and Sport (DTTAS) and Department for Environment Community and Local Government (DECLG). (2013). *Design Manual for Urban Roads and Streets*. Dublin, Ireland

Department for Transport UK. (2007). *Manual for Streets*. London, UK: Thomas Telford Publishing

Department of Health (UK). (2004). *At least five a week: Evidence on the impact of physical activity and its relationship to health. A report from the Chief Medical Officer*. London

Department of Health and Children and Health Service Excutive. (2009). *The National Guidelines on Physical Activity for Ireland.* Dublin, Ireland: Department of Health and Children, Health Service Executive.

Department of the Environment Heritage and Local Government (DEHLG). (2007). *Delivering Homes, Sustaining Communities: Statement on Housing Policy*. Dublin, Ireland

Department of Transport. (2009). *Smarter Travel. A Sustainable Transport Future. A New Transport Policy for Ireland 2009-2020*. Dublin, Ireland: Department of Transport, pp.1–68

Department of Transport (UK). (2011). *Shared Space: Local Transport Note 1/11*. Norwich, UK: The Stationary Office, pp.1–58 [Online]. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/3873/ltn-1-11.pdf.

Van Deurs, C. R. (2009). 'Key Quality Indicators'. In: *Walk 21, More Footsteps, Less Carbon*, 2009, New York, USA

Do, A. (2002). 'Walking the safety walk'. *Public Roads*, 66 (2), pp.2–5

Van Dyck, D., Cardon, G., Deforche, B. and De Bourdeaudhuij, I. (2009). 'Lower neighbourhood walkability and longer distance to school are related to physical activity in Belgian adolescents.'. *Preventive Medicine*, 48 (6), Elsevier Inc., pp.516–518

Van Dyck, D., Cardon, G., Deforche, B., Sallis, J. F., Owen, N. and De Bourdeaudhuij, I. (2010). 'Neighborhood SES and walkability are related to physical activity behavior in Belgian adults.'. *Preventive Medicine*, 50 Suppl 1, Elsevier Inc., pp.S74–9

Edwards, P. and Tsouros, A. (2006). *Promoting physical activity and active living in urban environments. The role of local governments*. Copenhagen, Denmark: WHO (World Health Organisation) Regional Office for Europe

Elwood, S. A. and Martin, D. G. (2000). '“Placing” Interviews: Location and Scales of Power in Qualitative Research'. *Professional Geographer*, 52 (4), pp.649–657

EPA Environmental Protection Agency. (2013). *Strive Programme* [Online]. Available at: http://www.epa.ie/researchandeducation/research/striveprogramme/ (Accessed: 21 June 2013).

Ewing, R., Bartholomew, K., Burden, D., Zimmerman, S. and Brown, L. (2013). *Pedestrian - & Transit - Orientated Design*. 1st ed. Washington, DC, USA: Urban Land Institute and American Planning Association

Ewing, R., Brownson, R. C. and Berrigan, D. (2006a). 'Relationship between urban sprawl and weight of United States youth.'. *American Journal of Preventive Medicine*, 31 (6), pp.464–474

Ewing, R. and Handy, S. L. (2009). 'Measuring the Unmeasurable: Urban Design Qualities Related to Walkability'. *Journal of Urban Design*, 14 (1), pp.65–84

Ewing, R., Handy, S. L., Brownson, R. C., Clemente, O. and Winston, E. (2006b). 'Identifying and Measuring Urban Design Qualities Related to Walkability'. *Journal of Physical Activiy and Health*, 3 (Suppl 1), pp.S223–S239

Field, A. (2009). *Discovering Statistics using SPSS*. 3rd ed. London, UK: SAGE Publications

Forsyth, A., Oakes, J. M., Schmitz, K. H. and Hearst, M. (2007). 'Does Residential Density Increase Walking and Other Physical Activity?'. *Urban Studies*, 44 (4), pp.679–697

Forsyth, A., Schmitz, K. H. and Oakes, J. M. (2003). *Twin City Walking Survey* [Online]. Available at: http://www.activelivingresearch.org/node/10619.

Forsyth, A. and Southworth, M. (2008). 'Cities Afoot—Pedestrians, Walkability and Urban Design'. *Journal of Urban Design*, 13 (1), pp.1–3

Foster, S. and Giles-Corti, B. (2008). 'The built environment, neighborhood crime and constrained physical activity: an exploration of inconsistent findings.'. *Preventive Medicine*, 47 (3), pp.241–251

Foster, S., Giles-Corti, B. and Knuiman, M. (2010). 'Neighbourhood design and fear of crime: a social-ecological examination of the correlates of residents' fear in new suburban housing developments.'. *Health & Place*, 16 (6), Elsevier, pp.1156–1165

Frank, L. D. and Engelke, P. O. (2001). 'The Built Environment and Human Activity Patterns: Exploring the Impacts of Urban Form on Public Health'. *Journal of Planning Literature*, 16 (2), pp.202–218

Frank, L. D., Kerr, J., Sallis, J. F., Miles, R. and Chapman, J. (2008). 'A hierarchy of sociodemographic and environmental correlates of walking and obesity'. *Preventive Medicine*, 47 (2), pp.172–178

Frank, L. D., Saelens, B. E., Powell, K. E. and Chapman, J. E. (2007). 'Stepping towards causation: do built environments or neighborhood and travel preferences explain physical activity, driving, and obesity?'. *Social Science & Medicine*, 65 (9), pp.1898–1914

Frank, L. D., Sallis, J. F., Saelens, B. E., Leary, L., Cain, K., Conway, T. L. and Hess, P. M. (2010). 'The development of a walkability index: application to the Neighborhood Quality of Life Study.'. *British Journal of Sports Medicine*, 44 (13), pp.924–933

Frank, L. D., Schmid, T. L., Sallis, J. F., Chapman, J. E. and Saelens, B. E. (2005). 'Linking objectively measured physical activity with objectively measured urban form: findings from SMARTRAQ.'. *American Journal of Preventive Medicine*, 28 (2 Suppl 2), pp.117–125

Frömel, K., Mitás, J. and Kerr, J. (2009). 'The associations between active lifestyle, the size of a community and SES of the adult population in the Czech Republic.'. *Health & Place*, 15 (2), pp.447–454

Frumkin, H., Frank, L. D. and Jackson, R. J. (2004). *Urban Sprawl and Public Health*. 1st ed. Washington, DC, USA: Island Press

Gebel, K., Bauman, A. and Owen, N. (2009). 'Correlates of non-concordance between perceived and objective measures of walkability.'. *Annals of Behavioral Medicine: a publication of the Society of Behavioral Medicine*, 37 (2), pp.228–238

Gehl, J. (2006). *Life Between Buildings: Using Public Space*. 6th ed. Copenhagen, Denmark: Danish Architectural Press

Gehl, J. (2010). *Cities for People*. 1st ed. Washington, D.C.: Island Press

Gibson, W. J. and Brown, A. (2009). *Working with Qualitative Data*. 1st ed. Wiltshire, UK: SAGE Publications

Giles-Corti, B., Broomhall, M. H., Knuiman, M., Collins, C., Douglas, K., Ng, K., Lange, A. and Donovan, R. J. (2005). 'Increasing walking: how important is distance to, attractiveness, and size of public open space?'. *American Journal of Preventive Medicine*, 28 (2 Suppl 2), pp.169–176

Giles-Corti, B. and Donovan, R. J. (2002). 'The relative influence of individual, social and physical environment determinants of physical activity.'. *Social Science & Medicine*, 54 (12), pp.1793–1812

Giles-Corti, B., Timperio, A., Cutt, H., Pikora, T. J., Bull, F. C. L., Knuiman, M., Bulsara, M., Van Niel, K. and Shilton, T. (2006). 'Development of a reliable measure of walking within and outside the local neighborhood: RESIDE's Neighborhood Physical Activity Questionnaire.'. *Preventive Medicine*, 42 (6), pp.455–459

Godin, G. (1994). 'Theories of Reasoned Action and Planned Behaviour: Usefulness for Excercise Promotion'. *Medicine and Science in Sports and Exercise*, 26 (11), pp.1391–1394

Golden, S. D. and Earp, J. A. L. (2012). 'Social ecological approaches to individuals and their contexts: twenty years of health education & behavior health promotion interventions.'. *Health Education & Behavior: The official publication of the Society for Public Health Education*, 39 (3), pp.364–372

Government of Ireland. (2007). *Ireland National Development Plan 2007-2013: Transforming Ireland, A better Quality of Life for All*. Dublin, Ireland: The Stationary Office, Dublin, pp.1 [Online]. Available at: http://www2.ul.ie/pdf/932500843.pdf.

Greene, J. C., Caracelli, V. J. and Graham, and W. F. (1989). 'Toward a Conceptual Framework for Mixed-Method Evaluation Designs'. *Educational Evaluation and Policy Analysis*, 11 (3), pp.255–274

Grey, T., Siddal, E. and O'Shea, E. (2012). *Shared Space , Shared Surfaces and Home Zones from a Universal Design Approach for the Urban Environment in Ireland. Key Findings & Recommendations*. Dublin, Ireland [Online]. Available at: http://universaldesign.ie/files/shared_space/shared_space_exec_summary.pdf.

Guerra, E., Cervero, R. and Tischler, D. (2011). *The Half-Mile Circle: Does It Best Represent Transit Station Catchment?* (July), Berkeley, USA, pp.15 [Online]. Available at: http://www.its.berkeley.edu/publications/UCB/2011/VWP/UCB-ITS-VWP-2011-5.pdf.

Gustafson, P. (2001). 'Meanings of Place: Everyday Experience and Theoretical Conceptualizations'. *Journal of Environmental Psychology*, 21 (1), pp.5–16

Haase, T. and Pratschke, J. (2008). *New Measures of Deprivation for the Republic of Ireland.* Dublin, Ireland

Hamilton-Baillie, B. (2008). 'Towards shared space'. *Urban Design International*, 13 (2), pp.130–138

Hamilton-Baillie, B. (2009). 'Shared Space Concepts and Principles'. *Presented at Engineers Ireland 19th March 2009*

Handy, S. L. (1996). 'Methodologies for exploring the link between urban form and travel behavior'. *Transportation Research Part D: Transport and Environment*, 1 (2), pp.151–165

Handy, S. L., Boarnet, M. G., Ewing, R. and Killingsworth, R. E. (2002). 'How the built environment affects physical activity: views from urban planning.'. *American Journal of Preventive Medicine*, 23 (2 Suppl), pp.64–73

Harrison, O. and Connor, D. O. (2012). 'Measuring Rail Station Catchment Areas In The Greater Dublin Area'. In: *Proceedings from ITRN 2012*, (August), 2012, Newtownabbey, Northern Ireland

Hart, J. and Parkhurst, G. (2011). 'Driven to excess: Impacts of motor vehicles on the quality of life of residents of three streets in Bristol UK'. *World Transport Policy & Practice*, 17 (2), pp.12–30

Healthier Scotland and Living Streets. (2012). *" Reclaim Your Streets " A Community Empowerment Toolkit Living Streets Scotland* [Online]. Available at: http://www.livingstreets.org.uk/sites/default/files/content/library/toolkits/Reclaim Your Streets Toolkit.pdf.

Henson, C. (2000). 'Levels of Service for Pedestrians'. *ITE Journal*, 70 (9), pp.26–30

Hess, P. M. (1994). *Evaluating Pedestrian Environments: Proposals for Urban Form Measures of Network Connectivity with case studies in Wallingford, Seattle and Crossroads in Bellevue, Washington.* University of Washington

Hesse-Biber, S. N. and Leavy, P. (2011). *The practice of qualitative research*. 2nd ed. Knight, V. and Habib, L. (eds.). Thosand Oaks, California: SAGE Publications

Hillsdon, M., Panter, J., Foster, C. and Jones, A. (2006). 'The relationship between access and quality of urban green space with population physical activity.'. *Public Health*, 120 (12), pp.1127–1132

Hoehner, C. M., Brennan Ramirez, L. K., Elliott, M. B., Handy, S. L. and Brownson, R. C. (2005). 'Perceived and objective environmental measures and physical activity among urban adults.'. *American Journal of Preventive Medicine*, 28 (2 Suppl 2), pp.105–116

Howley, P. and Clifford, B. (2012). 'The transformation of inner Dublin: exploring new residential populations within the inner city'. *Irish Geography*, 42 (2), pp.225–243

Hume, C., Ball, K. and Salmon, J. (2006). 'Development and reliability of a self-report questionnaire to examine children's perceptions of the physical activity environment at home and in the neighbourhood'. *International Journal of Behavioral Nutrition & Physical Activity*, 6 (13), pp.1–6

Humpel, N., Owen, N. and Leslie, E. (2002). 'Environmental Factors Associated with Adults' Participation in Physical Activity: A Review'. *American Journal of Preventive Medicine*, 22 (3), pp.188–199

Ingold, T. (2004). 'Culture on the Ground: The World Perceived Through the Feet'. *Journal of Material Culture*, 9 (3), pp.315–340

IPAQ Core Group. (2002). *International Physical Activity Questionnaire - Long Form 7 Days Self Administered Format*. [Online]. Available at: http://www.ipaq.ki.se/downloads.htm.

Ipsos MRBI. (2011). *Irish Sports Monitor 2011 Annual Report* [Online]. Available at: http://www.irishsportscouncil.ie/Media/Latest_News/2012/Irish_Sports_Monitor_2011_Final_Report.pdf.

Irish Planning Institute. (n.d.). *Careers in Planning* [Online]. Available at: http://www.irishplanninginstitute.ie/careers-in-planning/ (Accessed: 1 July 2010).

Jackson, R. J., Dannenberg, A. L. and Frumkin, H. (2013). 'Health and the built environment: 10 years after.'. *American Journal of Public Health*, 103 (9), pp.1542–1544

Jacobs, J. (1993). *The Death and Life of Great American Cities*. 3rd ed. New York, USA: Random House

Kamphuis, C. B., van Lenthe, F. J., Giskes, K., Huisman, M., Brug, J. and Mackenbach, J. P. (2009). 'Socioeconomic differences in lack of recreational walking among older adults: the role of neighbourhood and individual factors.'. *The International Journal of Behavioral Nutrition and Physical Activity*, 6, pp.1

Kamphuis, C. B. M., Mackenbach, J. P., Giskes, K., Huisman, M., Brug, J. and van Lenthe, F. J. (2010). 'Why do poor people perceive poor neighbourhoods? The role of objective neighbourhood features and psychosocial factors.'. *Health & Place*, 16 (4), Elsevier, pp.744–754

Kelbaugh, D. (2000). 'Three Paradigms: New Urbanism, Everyday Urbanism, Post Urbanism--An Excerpt From The Essential COMMON PLACE'. *Bulletin of Science, Technology & Society*, 20 (4), pp.285–289

Kelleher, C. C., Friel, S., Nic Gabhainn, S. and Tay, J. B. (2003). 'Socio-demographic predictors of self related health in the Republic of Ireland: findings from the National Survey on Lifestyle, Attitudes and Nutrition, SLÁN'. *Social Science & Medicine*, 57, pp.477–486

Kelly, C. E., Tight, M. R., Hodgson, F. C. and Page, M. W. (2011). 'A comparison of three methods for assessing the walkability of the pedestrian environment'. *Journal of Transport Geography*, 19 (6), Elsevier Ltd, pp.1500–1508

King, A. C., Satariano, W. a, Marti, J. and Zhu, W. (2008). 'Multilevel modeling of walking behavior: advances in understanding the interactions of people, place, and time.'. *Medicine and Science in Sports and Exercise*, 40 (7 Suppl), pp.S584–93

King, A. C., Stokols, D., Talen, E., Brassington, G. S. and Killingsworth, R. (2002). 'Theoritical Approaches to the Promotion of Physical Activity Forging a Transdisciplinary Paradigm'. *American Journal of Preventive Medicine*, 23 (2S), pp.15–25

Kingham, S., Pearce, J. and Zawar-Reza, P. (2007). 'Driven to injustice? Environmental justice and vehicle pollution in Christchurch, New Zealand'. *Transportation Research Part D: Transport and Environment*, 12 (4), pp.254–263

Kitzinger, J. (1994). 'The methodology of Focus Groups : the importance of interaction between research participants'. *Sociology of Health and Illness*, 16 (1), pp.103–121

Krueger, R. . A. (1997). *Analyzing & Reporting Focus Group Results. The Focus Group Kit Volume 6*. 1st ed. California, USA: SAGE Publications

Kumar, P. (2009). 'Pedestrain Perception: The Value of Design'. In: *More Footprints, Less Carbon Walk 21*, 2009, New York, USA: Walk 21

Kusenbach, M. (2003). 'Street Phenomenology: The Go-Along as Ethnographic Research Tool'. *Ethnography*, 4 (3), pp.455–485

Landis, B. W., Vattikuti, V. R., Ottenberg, R. M., Mcleod, D. S. and Guttenplan, M. (2001). *Modeling the Roadside Walking Environment: A Pedestrian Level of Service TRB Paper 01-0511*. (01), Lutz, FL, USA, pp.1–27

Lee, C. and Moudon, A. V. (2004). 'Physical Activity and Environment Research in the Health Field: Implications for Urban and Transportation Planning Practice and Research'. *Journal of Planning Literature*, 19 (2), pp.147–181

Lee, C. and Moudon, A. V. (2006). 'Correlates of Walking for Transportation or Recreation Purposes'. *Journal of Physical Activiy and Health*, 3 (Suppl 1), pp.S77–S98

Lee, C., Moudon, A. V. and Courbois, J.-Y. P. (2006). 'Built environment and behavior: spatial sampling using parcel data.'. *Annals of Epidemiology*, 16 (5), pp.387–394

Lee, I.-M., Shiroma, E. J., Lobelo, F., Puska, P., Blair, S. N. and Katzmarzyk, P. T. (2012). 'Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy.'. *Lancet*, 380 (9838), Elsevier Ltd, pp.219–229

Lee, P. H., Macfarlane, D. J., Lam, T. H. and Stewart, S. M. (2011). 'Validity of the International Physical Activity Questionnaire Short Form (IPAQ-SF): a systematic review.'. *The International Journal of Behavioral Nutrition and Physical Activity*, 8, pp.115

Lee, R. E., Booth, K. M., Reese-Smith, J. Y., Regan, G. and Howard, H. H. (2005). 'The Physical Activity Resource Assessment (PARA) instrument: evaluating features, amenities and incivilities of physical activity resources in urban neighborhoods.'. *The International Journal of Behavioral Nutrition and Physical Activity*, 2, pp.13

Leinberger, C. (2009). 'The Structural Shift in Building the Built Environment'. In: *More Footprints, Less Carbon Walk 21*, 2009, New York, USA: Walk 21

Van Lenthe, F. J. and Kamphuis, C. B. M. (2011). 'Mismatched perceptions of neighbourhood walkability: need for interventions?'. *Health & Place*, 17 (6), Elsevier, pp.1294–1295

Leslie, E., Coffee, N., Frank, L. D., Owen, N., Bauman, A. E. and Hugo, G. (2007). 'Walkability of local communities: using geographic information systems to objectively assess relevant environmental attributes.'. *Health & Place*, 13 (1), pp.111–122

Leslie, E., Saelens, B. E., Frank, L. D., Owen, N., Bauman, A., Coffee, N. and Hugo, G. (2005). 'Residents' perceptions of walkability attributes in objectively different neighbourhoods: a pilot study.'. *Health & Place*, 11 (3), pp.227–236

Leyden, K. M. (2003). 'Social capital and the built environment: the importance of walkable neighborhoods.'. *American Journal of Public Health*, 93 (9), pp.1546–1551

Litwin, M. S. (1995). 'How to Measure Survey Reliability and Validity'. In: Fink, A. (ed.), *The Survey Kit*, 1st ed, USA: SAGE Publications

Lo, R. H. (2009). 'Walkability: What is it?'. *Journal of Urbanism: International Research on Placemaking and Urban Sustainability*, 2 (2), pp.145–166

Lovasi, G. (2009). 'Walkability and Obesity in NYC: An examination of differences by scale and subpopulation'. In: *More Footprints, Less Carbon Walk 21*, (October), 2009, New York, USA: Walk 21

Lovasi, G. S., Neckerman, K. M., Quinn, J. W., Weiss, C. C. and Rundle, A. (2009). 'Effect of individual or neighborhood disadvantage on the association between neighborhood walkability and body mass index.'. *American Journal of Public Health*, 99 (2), pp.279–284

Lynch, K. (1965). *Image of the City*. 2nd ed. Cambridge, Mass., USA: M.I.T. Press

Lysaght, K. and Basten, A. (n.d.). *Violence, fear and "the everyday": negotiating spatial practice in the city of Belfast*. Belfast, Northern Ireland, pp.1–17 [Online]. Available at: http://www.qub.ac.uk/c-star/pubs/Violence fear and the everyday.pdf.

Manaugh, K. and El-Geneidy, A. (2011). 'Validating walkability indices: How do different households respond to the walkability of their neighborhood?'. *Transportation Research Part D: Transport and Environment*, 16 (4), Elsevier Ltd, pp.309–315

Mayor of London. (2004). *Making London a walkable city. The Walking Plan for London*. (February), London, UK: Transport for London [Online]. Available at: http://www.tfl.gov.uk/assets/downloads/walking-plan-2004.pdf.

Mays, N. and Pope, C. (2000). 'Assessing quality in qualitative research'. *British Medical Journal*, 320 (January), pp.50–52

McCormack, G. R., Giles-Corti, B. and Bulsara, M. (2008). 'The relationship between destination proximity, destination mix and physical activity behaviors.'. *Preventive Medicine*, 46 (1), pp.33–40

McCormack, G. R., Giles-Corti, B., Lange, A., Smith, T., Martin, K. and Pikora, T. J. (2004). 'An update of recent evidence of the relationship between objective and self-report measures of the physical environment and physical activity behaviours.'. *Journal of Science and Medicine in Sport / Sports Medicine Australia*, 7 (1 Suppl), pp.81–92

McDonnell, S., Ferreira, S. and Convery, F. (2006). 'Impact of Bus Priority Attributes on Catchment Area Residents in Dublin, Ireland'. *Journal of Public Transportation*, 9 (3), pp.137–162

McGinn, A. P., Evenson, K. R., Herring, A. H. and Huston, S. L. (2007). 'The relationship between leisure, walking, and transportation activity with the natural environment.'. *Health & Place*, 13 (3), pp.588–602

McLaughlin, D. K. and Sachs, C. (1998). 'Poverty in female-headed households: residential differences'. *Rural Sociology*, 53 (3), pp.287–306

McLeroy, K. R. (1988). 'An ecological perspective on health promotion programs'. *Health Education Quarterly*, 15 (4), pp.351

McManus, R. (2002). *Dublin 1910 - 1940: Shaping the city and suburbs.* 1st ed. Cornwall, England: FOUR COURTS PRESS LTD.

Mehta, V. (2008). 'Walkable streets: pedestrian behavior, perceptions and attitudes'. *Journal of Urbanism: International Research on Placemaking and Urban Sustainability*, 1 (3), pp.217–245

Millington, C., Ward Thompson, C., Rowe, D., Aspinall, P., Fitzsimons, C., Nelson, N. and Mutrie, N. (2009). 'Development of the Scottish Walkability Assessment Tool (SWAT).'. *Health & Place*, 15 (2), pp.474–481

Montgomery, J. (1998). 'Making a city: Urbanity, vitality and urban design'. *Journal of Urban Design*, 3 (1), pp.93–116

Morgan, D. L. (1997a). *Planning Focus Groups. The Focus Group Kit Volume 2*. 1st ed. California, USA: SAGE Publications

Morgan, D. L. (1997b). *The Focus Group Guidebook. The Focus Group Kit Volume 1*. 1st ed. California, USA: SAGE Publications

Morris, J. N. and Hardman, A. E. (1997). 'Walking to health'. *Sports Medicine*, 24 (2), pp.96

Moudon, A. V. and Lee, C. (2003). 'Walking and bicycling: an evaluation of environmental audit instruments.'. *American Journal of Health Promotion*, 18 (1), pp.21–37

Moudon, A. V., Lee, C., Cheadle, A. D., Garvin, C., Johnson, D. B. and Schmid, T. L. (2007). 'Attributes of Environments Supporting Walking'. *American Journal of Health Promotion*, 21 (5), pp.448–459

Moudon, A. V., Lee, C., Cheadle, A. D., Garvin, C., Johnson, D., Schmid, T. L., Weathers, R. D. and Lin, L. (2006). 'Operational Definitions of Walkable Neighborhood: Theoretical and Empirical Insights'. *Journal of Physical Activiy and Health*, 3 (Suppl 1), pp.S99–S117

Mullally, U. (2012). 'Up and down the property lader'. *The Irish Times*, June, Dublin, Ireland [Online]. Available at: www.irishtimes.com/business/sectors/commercial-property/up-and-down-the-property-ladder-1.1068323?page=1.

National Roads Authority (NRA). (2004). *Road Safety Audit Guidelines*. Dublin, Ireland, pp.65

National Roads Authority (NRA). (2007). *Traffic and Transport Assessment Guidelines*. Dublin, Ireland

Neckerman, K. M., Lovasi, G. S., Davies, S., Purciel, M., Quinn, J., Feder, E., Raghunath, N., Wasserman, B. and Rundle, A. (2009). 'Disparities in urban neighborhood conditions: evidence from GIS measures and field observation in New York City.'. *Journal of Public Health Policy*, 30 Suppl 1 (2009), pp.S264–85

NICE NHS National Institute for Health and Clinical Excellence. (2008). *Physical activity and the environment; NICE public health guidance 8*. (April 2009) [Online]. Available at: http://www.nice.org.uk/nicemedia/live/11917/38983/38983.pdf.

Ogilvie, D., Mitchell, R., Mutrie, N., Petticrew, M. and Platt, S. (2008). 'Perceived characteristics of the environment associated with active travel: development and testing of a new scale'. *International Journal of Behavioral Nutrition & Physical Activity*, 5 (32), pp.1–11

Ordnance Survey Ireland. (2007). *Discovery Series No. 50, Fifth Edition, Scale 1:50 000*. Dublin, Ireland: Ordnance Survey Ireland

Owen, N., Humpel, N., Leslie, E., Bauman, A. and Sallis, J. F. (2004). 'Understanding environmental influences on walking; Review and research agenda.'. *American Journal of Preventive Medicine*, 27 (1), pp.67–76

Oxford University Press. (n.d.). *Oxford Dictionaries Online* [Online]. Available at: http://oxforddictionaries.com/ (Accessed: 9 October 2010).

Pallant, J. (2010). *SPSS Survival Manual*. 4th ed. Maidenhead: McGraw-Hill

Panter, J. R. and Jones, A. P. (2008). 'Associations between physical activity, perceptions of the neighbourhood environment and access to facilities in an English city.'. *Social Science & Medicine*, 67 (11), Elsevier Ltd, pp.1917–1923

Pikora, T. J., Bull, F. C. L., Jamrozik, K., Knuiman, M., Giles-Corti, B. and Donovan, R. J. (2002). 'Developing a reliable audit instrument to measure the physical environment for physical activity.'. *American Journal of Preventive Medicine*, 23 (3), pp.187–194

Pikora, T. J., Giles-Corti, B., Bull, F. C. L., Jamrozik, K. and Donovan, R. J. (2003). 'Developing a framework for assessment of the environmental determinants of walking and cycling.'. *Social Science & Medicine*, 56 (8), pp.1693–1703

Van der Ploeg, H. P., Tudor-locke, C., Marshall, A. L., Craig, C., Hagströmer, M., Sjöström, M. and Bauman, A. (2010). 'Reliability and Validity of the International Physical Activity Questionnaire for Assessing Walking'. *Research Quarterly for Exercise and Sport*, 81 (1), pp.97–101

Pobal. (2010). *Pobal Strategic Plan 2010-2013* [Online]. Available at: https://www.pobal.ie/Publications/Documents/Pobal Strategic Plan 2010 - 2013.pdf.

Pope, C., Ziebland, S. and Mays, N. (2000). 'Analysing qualitative data'. *British Medical Journal*, 320 (January), pp.114–116

PPS Project for Public Spaces. (n.d.). *01_Place_Diagram-Converted3-530x453* [Online]. Available at: http://www.pps.org/reference/grplacefeat/ (Accessed: 11 June 2013).

Punter, J. (1991). 'Participation in the Design of Urban Space'. *Landscape Design*, (200), pp.24–27

Purciel, M., Neckerman, K. M., Lovasi, G. S., Quinn, J. W., Weiss, C., Bader, M. D. M., Ewing, R. and Rundle, A. (2009). 'Creating and validating GIS measures of urban design for health research.'. *Journal of Environmental Psychology*, 29 (4), Elsevier Ltd, pp.457–466 [Online].

Räsänen, M., Lajunen, T., Alticafarbay, F. and Aydin, C. (2007). 'Pedestrian self-reports of factors influencing the use of pedestrian bridges.'. *Accident; analysis and prevention*, 39 (5), pp.969–973

Reger-Nash, B., Bauan, A., Cooper, L., Chey, T. and Simon, K. J. (2006). 'Evaluating communitywide walking interventions'. *Evaluation and Program Planning*, 29 (3), pp.251–259

Road Safety Authority (RSA). (2009). *National Pedestrian Safety Action Plan 2010 - 2014*. Dublin, Ireland: RSA, pp.33 [Online]. Available at: http://www.rsa.ie/Documents/Road Safety/Leaflets/Leaf_booklets/pedestrian_safety_actionplan.pdf.

Russell, J. A. and Lanius, U. F. (1984). 'Adaption level and the affective appraisal of environments'. *Journal of Environmental Psychology*, 4, pp.119–135

Saelens, B. E. and Handy, S. L. (2008). 'Built environment correlates of walking: a review.'. *Medicine and Science in Sports and Exercise*, 40 (7 Suppl), pp.S550–66 [Online]. doi:10.1249/MSS.0b013e31817c67a4.

Saelens, B. E. and Sallis, J. F. (2002a). *Neighborhood Environment Walkability Scale (ANEWS) - Abbreviated*. pp.1–6 [Online]. Available at: http://www.activelivingresearch.org/search/site?f[0]=bundle%3Acontent_tools_and_measure.

Saelens, B. E. and Sallis, J. F. (2002b). *Neighborhood Environment Walkability Scale (NEWS)* [Online]. Available at: http://www.activelivingresearch.org/node/10649.

Saelens, B. E., Sallis, J. F., Black, J. B. and Chen, D. (2003a). 'Neighborhood-based differences in physical activity: an environment scale evaluation.'. *American Journal of Public Health*, 93 (9), pp.1552–1558

Saelens, B. E., Sallis, J. F. and Frank, L. D. (2003b). 'Environmental Correlates of Walking and Cycling: Findings From the Transportation, Urban Design, and Planning

Literatures'. *Annals of Behavioral Medicine: a publication of the Society of Behavioral Medicine*, 25 (2), pp.80–91

Sallis, J. F. (2009). 'Measuring physical activity environments: a brief history.'. *American Journal of Preventive Medicine*, 36 (4 Suppl), Elsevier Inc., pp.S86–92

Sallis, J. F. (n.d.). *Test-retest Reliability Coefficients for Individual Items of the Neighbourhood Environment Walkability Scale (NEWS)* [Online]. Available at: http://www.drjamessallis.sdsu.edu/Documents/NEWS_individual_item_reliability.pdf.

Sallis, J. F., Bauman, A. and Pratt, M. (1998). 'Environmental and Policy Interventions to Promote Physical Activity'. *American Journal of Preventive Medicine*, 15 (4), pp.379–397

Sallis, J. F., Saelens, B. E. and Frank, L. D. (1997). *Reference List for NQLS 1* [Online]. Available at: http://www.ipenproject.org/documents/methods_docs/Surveys/NQLS1strefs.pdf.

Sallis, J. F., Saelens, B. E. and Frank, L. D. (2001). *Reference List for NQLS 2*. (1997), pp.1–3 [Online]. Available at: http://www.ipenproject.org/documents/methods_docs/Surveys/NQLS2ndrefs.pdf.

Sallis, J. F., Saelens, B. E. and Frank, L. D. (n.d.). *Neighbourhood Quality of Life Survey 1*. pp.1–27 [Online]. Available at: http://www.drjamessallis.sdsu.edu/measures.html.

Sallis, J. F., Saelens, B. E., Frank, L. D., Conway, T. L., Slymen, D. J., Cain, K. L., Chapman, J. E. and Kerr, J. (2009). 'Neighborhood built environment and income: examining multiple health outcomes.'. *Social Science & Medicine*, 68 (7), Elsevier Ltd, pp.1285–1293

Sauter, D. and Tight, M. R. (2010). *Measuring walking: Towards internationally standardised monitoring methods PQN Final Report B.4.2.* London, UK, pp.7–30

Sauter, D. and Wedderburn, M. (2008). 'Measuring Walking. Towards Internationally Standardised Monitoring Methods of Walking and Public Space'. In: *8th International Conference on Survey Methods in Transport*, 2008, Annecy, France

Schurch, T. W. (1999). 'Reconsidering urban design: Thoughts about its definition and status as a field or profession'. *Journal of Urban Design*, 4 (1), pp.5–28

Shaffery, G. (2011). 'Townscape'. In: *Landscape Character Assessment Training*, 2011, The Heritage Council [Online]. Available at: http://www.heritagecouncil.ie/fileadmin/user_upload/Planning/LCA_CPD/LCA_CPD_Sep_2011/Grainne_Shaffrey_Townscape_presentation_LCA_Sep_2011.pdf.

Shenton, A. K. (2004). 'Strategies for ensuring trustworthiness in qualitative research projects'. *Education for Information*, 22, pp.63–75

Sim, J. (1998). 'Collecting and analysing qualitative data: issues raised by the focus group.'. *Journal of Advanced Nursing*, 28 (2), pp.345–352

Smith, J. A., Flowers, P. and Larkin, M. (2009). *Interpretative Phenomenological Analysis: Theory, Method and Research*. 1st ed. London, UK: SAGE Publications

Southworth, M. (1997). 'Walkable Suburbs?: An evaluation of Neotraditional Communities at the Urban Edge'. *Journal of the American Planning Association*, 63 (1), pp.28–44

Southworth, M. (2005). 'Designing the Walkable City'. *American Society of Civil Engineers Journal of Urban Planning and Development*, 131 (4), pp.246–257

Southworth, M. and Ben-Joseph, E. (1995). 'Street Standards and the Shaping of Suburbia'. *Journal of the American Planning Association*, 61 (1), pp.65–81

Southworth, M. and Owens, P. M. (1993). 'The Evolving Metropolis Studies of Community , Street Form at the Urban Edge'. *Journal of the American Planning Association*, 59 (3), pp.271–287

Spielberg, F. (1989). 'The Traditional Neighborhood Development: How Will Traffic Engineers Respond?'. *ITE Journal*, 59

Spittaels, H., Foster, C., Oppert, J.-M., Rutter, H., Oja, P., Sjöström, M. and De Bourdeaudhuij, I. (2009). 'Assessment of environmental correlates of physical activity: development of a European questionnaire.'. *The international journal of behavioral nutrition and physical activity*, 6, pp.39

Stangl, P. (2008). 'Evaluating the pedestrian realm: instrumental rationality, communicative rationality and phenomenology'. *Transportation*, 35 (6), pp.759–775

Stokols, D. (1992). 'Establishing and Maintaining Healthy Environments Toward a Social Ecology of Health Promotion'. *American Psychologist*, 47 (1), pp.6–22

Stonor, T., Campos, M. B. de A., Chiaradia, A., Takamatsu, S. and Smith, A. (2003). 'Towards a "Walkability Index"'. In: *European Transport Conference 2003 (8th -10th Oct)*, 2003, London, UK: Association for European Transport

Teddlie, C. and Tashakkori, A. (2009). *Foundations of mixed methods research: Integrating quantitative and qualitative approaches in the social and behavioural* *sciences*. 1st ed. Knight, V. and Connelly, S. (eds.). Thosand Oaks, California: SAGE Publications

The Housing Corporation and English Partnerships and Lyewelyn-Davies. (2000). *Urban Design Compendium* [Online]. Available at: www.urbandesigncompendium.co.uk.

Thompson, B. (2004). *Exploratory and Confirmatory Factor Analysis*. 1st ed. MI, USA: American Psychological Association

Thornton, L. E., Pearce, J. R. and Kavanagh, A. M. (2011). 'Using Geographic Information Systems (GIS) to assess the role of the built environment in influencing obesity: a glossary.'. *The international journal of behavioral nutrition and physical activity*, 8 (1), BioMed Central Ltd, pp.71

TRB. (1985). *Highway Capacity Manual Special Report 209 (First Printing 1971)*. Washington, D.C., USA

TRB. (2005). *Does the Built Environment Influence Physical Activity? Examining the Evidence TRB Special Report 282 Committee on Physical Activity, Health, Transportation and Land use.* Washington, D.C.: Transportation Research Board [Online]. Available at: www.TRB.org.

Tu, C. C. and Eppli, M. J. (1999). 'Valuing New Urbanism: The Case of Kentlands'. *Real Estate Economics*, 27 (3), pp.425–451

U.S. Department of Health and Human Services: Centers for Disease Control and Prevention: National Centre for Chronic Disease Prevention and Health Promotion. (1996). *Physical Activity and Health: A Report of the Surgeon General*. Atlanta, GA [Online]. Available at: http://www.cdc.gov/nccdphp/sgr/pdf/sgrfull.pdf.

US Department of Transportation. (2002). *Pedestrian Facilities User Guide - Providing Safety and Mobility*. McLean, VA [Online]. Available at: http://katana.hsrc.unc.edu/cms/downloads/PedFacility_UserGuide2002.pdf (Accessed: 27 June 2012).

Valentine, G. (1989). 'The Geography of Women's Fear'. *Area*, 21 (4), pp.385–390

Warburton, D. E. R., Nicol, C. W. and Bredin, S. S. D. (2006). 'Health benefits of physical activity: the evidence'. *Canadian Medical Association Journal*, 174 (6), pp.801–809

Watkins, M. W. (2000). *Monte Carlo PCA for Parallel Analysis*. State College, PA. USA: Ed & Psych Associates

Weinstein Agrawal, A., Schlossberg, M. and Irvin, K. (2008). 'How Far, by Which Route and Why? A Spatial Analysis of Pedestrian Preference'. *Journal of Urban Design*, 13 (1), pp.81–98

WHO Regional Office for Europe. (2006). *Physical activity and health in Europe: evidence for action*. Copenhagen, Denmark [Online]. Available at: http://www.euro.who.int/__data/assets/pdf_file/0011/87545/E89490.pdf.

Wickham, J. (2006). *Gridlock: Dublin's transport crisis and the future of the city.* 1st ed. Dublin, Ireland: New Island

Younger, M., Morrow-Almeida, H. R., Vindigni, S. M. and Dannenberg, A. L. (2008). 'The built environment, climate change, and health: opportunities for co-benefits.'. *American Journal of Preventive Medicine*, 35 (5), pp.517–526

Zhu, X. and Lee, C. (2008). 'Walkability and safety around elementary schools economic and ethnic disparities.'. *American Journal of Preventive Medicine*, 34 (4), pp.282–290