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Systematic reviews and meta-analysis

Gender differences in the relationship between built environment and non-communicable diseases: A systematic review

Joanna Sara Valson, V. Raman Kutty

Achutha Menon Centre for Health Science Studies, Sree Chitra Tirunal Institute of Medical Sciences and Technology, Trivandrum, Kerala, India

Significance for public health

Tackling non-communicable diseases is a major hurdle for majority of the countries worldwide. Varied built environmental conditions and facilities bear differing influences on both men and women. Women in particular face difficulties more than men in access and control over resources to deal with non-communicable disease conditions. This paper tries to bring out the differences from published literature. Moreover, this paper has attempted to review articles which have delved beyond sex differences and included other axes. The Gender Analysis Matrix developed by WHO was incorporated in this paper to aid in categorising and delineating these differences. These results would be fundamental in further primary research and help in policy and planning of non-communicable diseases.

Abstract

Non-communicable diseases are on the rise globally. Risk factors of non-communicable diseases continue to be a growing concern in both developed and developing countries. With significant rise in population and establishment of buildings, rapid changes have taken place in the built environment. Relationship between health and place, particularly with non-communicable diseases has been established in previous literature. This systematic review assesses the current evidence on influence of gender in the relationship between built environment and non-communicable diseases. A systematic literature search using PubMed was done to identify all studies that reported relationship between gender and built environment. All titles and abstracts were scrutinised to include only articles based on risk factors, prevention, treatment and outcome of non-communicable diseases. The Gender Analysis Matrix developed by the World Health Organization was used to describe the findings of gender differences. Sex differences, biological susceptibility, gender norms/ values, roles and activities related to gender and access to/control over resources were themes for the differences in the relationship. A total of 15 out of 214 articles met the inclusion criteria. Majority of the studies were on risk factors of non-communicable diseases, particularly cardiovascular diseases. Gender differences in physical access to recreational facilities, neighbourhood perceptions of safety and walkability have been documented. Men and women showed differential preferences to walking, engaging in physical activity and in perceiving safety of the neighbourhood. Girls and boys showed differences in play activities at school and in their own neighbourhood environment. Safety from crime and safety from traffic were also perceived important to engage in physical activity. Gender norms and gender roles and activities have shown basis for the differences in the prevalence of non-communicable diseases. Sparse evidence was found on how built environment

affects health seeking behaviour, preventive options or experience with health providers. Though yet unexplored in the developing or low/middle income countries, there seems to be a major role in the gendered perception of how men and women are affected by non-communicable diseases. Large gaps still exist in the research evidence on gender-based differences in non-communicable diseases and built environment relationship. Future research directions could bring out underpinnings of how perceived and objective built environment could largely affect the health behaviour of men and women across the globe.

Introduction

Non-communicable diseases (NCDs) have emerged to be the growing concern worldwide. NCDs were responsible for 68% (38 million) deaths globally in 2012.¹ Prevalence rates of risk factors of non-communicable diseases are also increasing. Inactivity levels varies among World Regions, with the highest value in the United States (43%) and lowest in Southeast Asia (17%).² The present era has also witnessed a large explosion of population, growing urbanisation and establishment of high-rise buildings. The infrastructure of the environment where people live largely affects the health of the population. Hippocrates had recognised the importance of this relationship in the fifth century B.C. *If you want to learn about the health of a population, look at the air they breathe, the water they drink, and the places where they live.* Built environment has been closely related to physical activity, travel behaviour and sedentary behaviour of individuals.³ *Built environment* refers to the man-made structures and surroundings and includes roads, neighbourhoods, recreational facilities such as parks and playgrounds, food sources, building and houses in which people live and perform activities of eating, playing educating and working.⁴ Various research studies have evidenced that built environment affects lifestyle, obesity levels, activity levels, walking behaviour and dietary behaviour of individuals. Results have shown differences for men, women, boys and girls.⁵⁻⁸ There are differences in walking behaviour, physical activity levels and health outcomes based on sex. The question *why are the results different for men and women living in similar built environment?* has not been researched in particular. This paper attempts to gather evidence from published studies on how and why the results have been different for men and women or for boys and girls across the globe, with a view to exploring research gaps. This article is based on a systematic review and the author attempts to describe the search strategy to identify articles, the inclusion and exclusion criteria for selection of articles, process of data analysis and results of the review.

Search strategy

A systematic review was done in February 2017 (13th to 28th) on PubMed database using the MeSH terms: *gender AND built environment, built environment variables, built environment measures, built environment analysis, healthy living, built environment design, built environment effects, built environment features*. All the articles till 2016 were selected. A summary of the search strategy is shown in Figure 1.

Inclusion criteria

The articles should have mentioned measurement of built environment and its features as an exposure; risk factors/ prevalence/ recovery of non-communicable diseases should have been measured as an outcome. Community-based studies were included. Full text articles available in English were selected.

Exclusion criteria

Those articles which did not measure built environment either objectively or subjectively, where there were no clear description of how built environment was captured and those which did not have measurement of non-communicable diseases or its risk factors being addressed as an outcome, were excluded from the review. Also, articles that have looked into reliability of measurement tools, those which are describing only the methodology, those which are dealing with policy analysis and pilot studies were excluded. The shortlisted articles were finally screened based on whether the articles have dealt beyond sex differences. Either how biological differences exist, or how roles and activities, or norms or values, or access to and control over resources have influenced the outcome should have been studied.

Data analyses

Country-wise distribution was mapped for the selected articles. Sample population and type of study were also examined. Mapping of studies was done onto the Gender Analysis Matrix (GAM) Framework of World Health Organization (WHO)^{9,10} as shown in Table 1. The GAM framework helps us to analyse

whether gender-based division of labour, gender roles and norms, access to and control over resources, and power make a difference to risks and vulnerability to a health problem, health seeking behaviour, ability to access health services, preventive and treatment options, experiences with health services and health providers, health outcomes, and social and economic consequences of illness. Though the matrix has been initially used to identify gaps in policies or interventions (previously attempted for tobacco,¹¹ HIV/AIDS, blindness), it is also helpful in identifying information gaps for further research. A meta-analysis was not attempted due to differences in measurements across studies.

Results

A total of 15 articles met the inclusion criteria and were selected for analysis. Majority (40%) of the studies were from United States. Cross-sectional study type was incorporated by all the studies. A summary of the articles is given in Table 2.¹²⁻²⁶ Mapping of studies onto GAM Framework showed that all articles addressed issues in the vulnerability axis and rest of the axes had not been researched regarding relationship between gender differences and built environment factors in non-communicable diseases (Table 1).

Though the search criterion was for non-communicable diseases, the articles found were related to depressive symptoms,

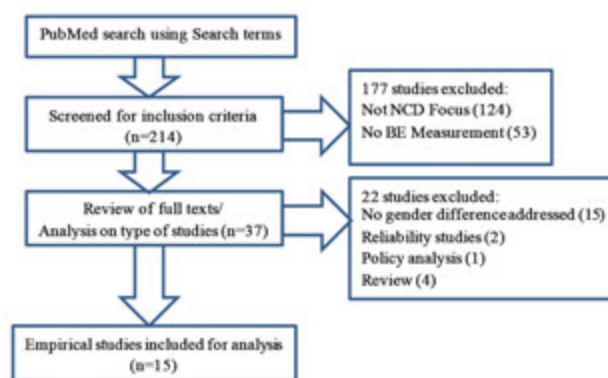


Figure 1. Flowchart showing the method used for systematic review.

Table 1. Studies mapped onto the GAM framework.

Relation between built environment and NCDs	Are there sex differences in...	How do biological differences between women/men influence their...	How do the different roles and activities of men/women affect their...	How do gender norms/values affect men and women's...	How do access to and control over resources affect men and women's...
Vulnerability: incidence, prevalence	✓	✓	✓	✓	✓
Health seeking behaviour					
Ability to access health services					
Preventive and treatment options, responses to treatment of rehabilitation					
Experiences with health services and health providers					
Outcome of health problem: e.g. recovery, disability, death					
Consequences (economic and social, including attitudinal)					

stress, physical activity and obesity. Since the number of studies in each category was insufficient to be summarised per se, the results are therefore discussed under the broad categories of mental health (depressive symptoms and stress)¹²⁻¹⁴ and Risk factors of NCDs (Physical activity/Obesity). The built environment features captured in the studies are summarised in Table 3.^{12-16,18-26}

Mental health (depressive symptoms/stress)

Sex differences

Women who lived in neighbourhoods with low green space had higher perceived levels of stress than compared to men.¹⁴ The Jamaican study revealed that depressive symptoms were also more common among women (25.6%) than among men (14.8%). It was found that women living in informal communities (communities which were unplanned and those which evolved without adequate

housing, water supply, sewerage treatment, modern waste disposal services and affordable electricity supply) were depressive in greater proportions, while the main factor that affected men was the low physical conditions (dilapidated housing, deteriorating infrastructure and high noise levels) in the urban neighbourhood in Jamaica.¹²

Biological differences

Roe *et al.* describes that there exists a differential neuro-endocrine response to the environment between men and women. Urban neighbourhoods with high green space has been directly associated with low stress levels as shown by cortisol levels in salivary samples studied among adults in Scotland. Stress in men is associated with higher cortisol levels and *high and flat* pattern of diurnal cortisol decline, while stress in women initiate low cortisol concentration and *low and flat* diurnal cortisol decline. In comparison to men, this less steep decline of diurnal cortisol levels exhibited among women depicts the chronicity of stress levels among women.¹⁴

Table 2. Summary of the studies selected for analysis.

Authors	Study setting	Objective	Outcome	Age group	Sample size	Exposure measure	Outcome measure
Burgi <i>et al.</i> , 2015 ¹⁵	Winterthur, Switzerland	Locations where children engaged in PA	Physical Activity	11-14 years	119	Objective	Objective
Hillsdon <i>et al.</i> , 2015 ²⁴	North-west region of England, UK	Distance from home where PA took place	Physical Activity	18-91 years	195	Objective	Objective
Oyeyemi <i>et al.</i> , 2014 ²⁶	Maiduguri, Nigeria	Effect of neighbourhood-level income on PA	Physical Activity	12-19 years	1006	Perceived	Subjective
Klinker <i>et al.</i> , 2014 ¹⁷	Denmark	Context-specific outdoor behaviour	Physical Activity	11-16 years	170	Objective	Objective
Mullings <i>et al.</i> , 2013 ¹²	Jamaica	Mental health effects of urban neighbourhood	Depressive symptoms	15-74 years	2848	Subjective	Objective
Klinker <i>et al.</i> , 2014 ¹⁶	Copenhagen, Denmark	Domains and sub-domains for week day PA	Physical Activity	11-16 years	367	Subjective	Objective
Li <i>et al.</i> , 2014 ²⁰	Portland, US	Neighbourhood racial concentration and obesity risks	Obesity	>18 years	17,020	Objective	Self-report
Stone <i>et al.</i> , 2014 ¹⁸	Toronto, Canada	Whether CIM and PA differ by place of residence	Physical Activity	10-12 years	856	Objective	Objective
Pelclova <i>et al.</i> , 2014 ²²	All 14 regions in Czech Republic	Relation between walking recommendations with perceived neighbourhood attributes	Physical Activity	>50 years	2839	Subjective	Self-report
Roe <i>et al.</i> , 2013 ¹⁴	Dundee, UK	Link between perceived green space and stress levels	Stress	33-55 years	104	Subjective	Objective
Duncan <i>et al.</i> , 2013 ¹³	US	Relation between built environment features and youth depressive symptoms	Depressive symptoms	9-12 th grade	1170	Objective	Self-report
Kowaleski <i>et al.</i> , 2013 ¹⁹	NHANES data, US	Influence of neighbourhood characteristics on child obesity risks	Obesity	2-11 years	1753	Objective	Objective
Hobin <i>et al.</i> , 2013 ²³	Ontario, Canada	Relation between school environment and PA	Physical Activity	9-12 th grade	21,754	Objective	Self-report
Page <i>et al.</i> , 2010 ²⁵	UK	Relation between Perception of BE and PA at outdoor play, active commuting and structured exercise	Physical Activity	10-11 years	1307	Subjective	Self-report
Grafova <i>et al.</i> , 2008 ²¹	US	Influence of neighbourhood environment on weight status	Obesity	>55 years	15,221	Subjective	Self-report

Different roles and activities

The Jamaican study states that women tend to focus more on survival of children and not on their own mental health status.¹² The authors from UK explained that greater hypocortisolemia among women in neighbourhoods with low green space was a result of chronic stress and exhaustion due to roles at home and work.¹⁴

Gender norms/values

In Jamaica, men define manhood with their own socioeconomic circumstances. When poor, they have less control over their environment and social circumstances. Hence, males were found to have a greater risk for depression when living in a poor neighbourhood with lack of personal socioeconomic resources.¹² Furthermore, informal communities with male-dominated social networks within the community were found advantageous only to the men, while women were threatened. Such neighbourhoods provided less opportunity for social interaction for women, hence social participation was low. Also, in Jamaican results, there was evidence that women had to ask men for financial assistance and further use their sexuality as part of their survival mechanism.¹² A cross-link between walkable neighbourhoods and depression was that even if the neighbourhoods were walkable, girls in US had depression due to high crime rates and busy intersections, indicating the importance of safety and privacy for the girls.¹³

Access to and control over resources

Jamaican women living in poor neighbourhoods had higher risk of depression. Their limited social resources, low flexibility for social interaction and low social participation caused a greater risk for depressive symptoms in an urban informal community. Living in a scary environment with the threat of violence and trying to protect themselves and their children might perhaps be a triggering factor for depressive symptoms among women. On the other hand, men tend to demonstrate power and influence through their economic status. Thus, low physical conditions and lack of freedom could predispose men for depression.¹² Higher green

space or park space in the immediate neighbourhood helped women to engage in physical activity and hence could lower their depressive symptoms.¹⁴

Risk factors of NCDs (physical activity/obesity)

Sex differences

Looking at locations where children engaged in PA, the Winterthur authors found that boys achieve more moderate-to-vigorous physical activity (MVPA) than girls at school playgrounds, sports facilities, at recess and during the day.¹⁵ The Denmark study pointed out that boys spend more time outdoor for MVPA than the time spent by girls. Also, half of the girls who participated in the study did not accumulate any MVPA in sports clubs and sports facilities.^{16,17} Girls had greater levels of activity on the streets as compared to the boys. Also, girls in the suburban areas had more MVPA when going to school.¹⁵ However, girls were less likely to travel to and from school or take part in outdoor activities. The Canadian study pointed out that parents permitted independent mobility for 70% of the boys as compared to 54% of girls.¹⁸ Girls in US were more at risk for obesity in neighbourhoods with poverty than boys.¹⁹⁻²¹

Men in Czech Republic were more likely to meet physical activity recommendations than women.²² Women had 43% higher risk of being obese than men while living in neighbourhoods with higher concentration of non-Hispanic African American population in the US. This was probably because African American women had the tendency to interact with women from the similar ethnic background and hence were able to maintain social cohesion among them.²⁰ On the contrary, men of American origin living in neighbourhoods with higher African-American concentration tend to have lower risk for obesity. Possible reasons were in such an environment with greater African concentration, Caucasian men were socioeconomically backward than the African-Americans and hence had a tendency to engage in heavy work-related occupa-

Table 3. Built environment features captured across studies according to outcome.

Outcome measure	Infrastructure-related	Access to services	Physical conditions	Socio-economic condition	Community variables
Depression/ Stress levels	Paved roads, side-walks, clean streets, ¹² Greenspace, ¹⁴ Community design, access to walking destinations ¹³	Social, commercial and Public services, ¹² Shopping centres, transport ¹³	Condition of house, noise level, condition of streets ¹²	Poverty index ¹²	Informal or formal ¹²
Physical Activity/ Obesity	Home setting, own and other school setting, recreational facility, streets ¹⁵ School grounds, sports facilities, clubs, playgrounds. ^{16,23} Land-use mix, ²² Street connectivity, park accessibility. ²⁰ Tree canopy cover, neighbourhood greenery, access to parks. ¹⁹ Neighbourhood including pedestrian network ²⁴	Service destinations ^{23,26}	Aesthetics ²² nuisance, ²⁵ air pollution ²¹	Socio-economic status. ^{18,20} Economic advantage and disadvantage ²¹	Immigrant concentration, residential stability ²¹ traffic and crime safety. ²² Perceived safety, social norm, constraint, ²⁵ Social cohesion ²⁰

tions or take public transport. Also, street connectivity had a protective effect for Caucasian men in Portland, which aided greater transportation and walking.²⁰

Biological differences

The authors from Switzerland claim that there is a plausible explanation that stage of maturation has an influence on the amount of physical activity; more mature children appear to be less active. Early maturation in girls might cause them to be less active at school, or during play.¹⁵

Different roles and activities

Boys are more comfortable in taking part in activities which demand more flexibility and strength or in vigorous ball games, while girls prefer activities like skipping, sedentary play or social conversation.^{15,23} Also, boys have a tendency to take part in sports and TV watching while girls tend to spend time studying, doing housework and take part in leisure activities at home.¹⁹ Men in deprived neighbourhoods in United States tend to engage in manual labour and walk for transportation since they do not own cars.²⁰ In areas with high concentration of migrants, men were found to be at greater risk of being obese. This was probably because men tend to socialise with newer immigrants, go out for social parties, taste newer foods and hence have poor diet control or time to engage in physical activities. On the other hand, women were found to be less obese in areas with high street connectivity (High street connectivity is closely linked to population density in the neighbourhood). Possible reasons indicate that women have a basic instinct to maintain relations and hence tend to socialise better when they live in neighbourhoods with denser populations.²¹

Gender norms/values

Girls in Switzerland actively commute to school (walk/cycle) when the streets are considered safe.¹⁵ Parental concerns for safety, security and traffic density were also high for girl children in Toronto and hence girls had low independence to move around in the neighbourhoods.¹⁸ Girls in US were more at risk of being overweight when they lived at areas where greater number of residents in the neighbourhood commuted long hours to work. When the parents had to travel long hours to work, they had less time to demonstrate model healthy behaviours or to accompany girls for recreation activities. Also, a low risk of being overweight among girls was found when there was higher proportion of residents in the neighbourhood who were overweight; there is a cautionary effect among parents in such an environment to be over-protective of their daughters and hence encourage healthy diet and physical activity.¹⁹ High street connectivity, low traffic and crime rates were important for Japanese men to take part in physical activity, while Japanese women preferred aesthetics and proximity to different destinations for exercise or walking. This probably denotes that men and women value different properties in the neighbourhoods to engage in walking or exercise.²² Social cohesion and socio-economic status acted as mediators for white women in Portland to take part in physical activity.²⁰ Furthermore, it has been found in UK that men tend to move away from their homes more than women in relation to being involved in low, moderate and physical activity; women might be more restricted to nearby resources or destinations due to safety issues.²⁴

Access to and control over resources

School environment plays a crucial role in encouraging girl children to take part in physical activity. They take part in physical activity more than three days per week only when a separate room

for physical activity was available at schools. Also, when facilities were accessible, girls take part in structured activities. Those schools which cater to physical needs of the girls encouraged the girls to take part in physical activity at school.^{15,23,25} Furthermore, poor neighbourhoods in US which have low physical amenities for recreation or exercise, cause lack of trust among parents to leave their daughters outside their home for physical activity and hence girls tend to stay at home and engage in household chores.¹⁹ Access to destinations, residential density and availability of infrastructures were significantly associated with physical activity or active transportation to school for boys in Nigeria, while this was not true for girls. Even if the boys had greater perceived safety, those living in high-income neighbourhoods had low leisure-time physical activity than those in low-income neighbourhoods. However, this was not true for girls.²⁶ Furthermore, boys had only the risk of being overweight when they lived in rural areas; perhaps depicting that rural neighbourhoods have less access to physical activity resources and therefore the boys engage majority of their time in watching TV or playing computer games.¹⁹ Higher air pollution levels (probably in areas with higher number of recreational facilities) were linked to reduced risk of obesity among women.²¹ Rural neighbourhoods and car ownership have also demonstrated greater physical activity among men; it can be that greater proportion of men own cars than women.

Discussion

This review attempted to capture studies related to gender differences in the relationship between built environment and non-communicable diseases. All the studies were cross-sectional in nature. Findings emphasized expected patterns of gender differences with respect to mental health or physical activity/obesity. None of the studies attempted qualitative exploration of these differences. Moreover, there was sparse evidence from developing nations. Gender differences related to access to and use of health services, health-seeking behaviour, treatment options, experience in healthcare settings, and outcomes and consequences, have not been explored. Cultural factors which are closely linked with the perception of built environment, which can largely affect the physical activity behaviours or access to destinations, have also been scarcely explored.

The reviewed articles addressed gender differences differently, while the Jamaican study brought out explicit gender differences according to gender norms/roles and access to resources, rest of the articles conveyed indications of gendered differences. Both perceived and objective measurement of built environment brought out gender differences in the relationship between built environment and mental health/physical activity/obesity. Among the reviewed articles, mental health symptoms were largely captured through subjective measures while physical activity and obesity were captured objectively. School-level and neighbourhood-level studies brought out different aspects of gender differences among boys and girls in relation to school games and recreational physical activity in the neighbourhood respectively. Therefore, both schools and neighbourhoods are important spheres of research for physical activity among children. Income-levels and ethnic backgrounds of the neighbourhood have also emerged to be influential in the gendered relationship between built environment and physical activity among men and women. Social relationships and cohesion surfaced out to be decisive for both men and women to participate in outdoor or recreational activities.

Different aspects of the built environment affect women and men positively as well as negatively as evidenced from the

reviewed articles. One reason is that gender roles/activities and norms/values cause women and men to occupy different physical as well as social spaces. With regard to mental health, the socio-economic standing of the community was a major factor for men, while cleanliness of the surroundings, paved roads/sidewalks, green space in the neighbourhood were important for women. In case of physical activity and obesity, while girls had preference for separate spaces for activities at school, women had preference for safety from harm/crime to engage in outdoor activities. In order to take part in recreational activity, women also gave importance to aesthetics and greenery in the neighbourhood, density of neighbourhoods, proximity of recreational facilities and safety from traffic. On the other hand, rural neighbourhoods and less access to recreational facilities affected young boys while young men had greater priority for access to destinations, proximity to workspace and high street connectivity to engage in transport-related walking.

Furthermore, congruent findings from the articles showed that biological factors make some impact on observed sex differences in the case of mental health as well as physical activity. However literature suggests that social constructed differences between girls/women and boys/men contribute significantly to the observed differences. The social constructed differences are related to the gender norms/ values, gender roles/activities and access to resources. While gender roles and activities have impact for women in terms of stress, lack of time and dual responsibilities at home and workplace, the most significant factors are those related to gender norms and access to and control over resources. Roles and norms affect mental health through the expectations on masculine and feminine behaviour as well as power differentials between men and women. Likewise norms affect physical activity, walking behaviour and outdoor play for both women and girls. Parental trust and concerns for safety of girl children were largely detrimental to physical activity and walking behaviours of girls. Preference of girls to have separate activity spaces in schools need to be acknowledged. Opportunities to socialise and maintain social relations also emerged to be important for women to take part in physical activity. Availability of green spaces within one's neighbourhood may improve women's ability to engage in physical activity both because they may not have the time and financial resources to go farther away or use paid gyms/recreational facilities; it may also be socialisation that physical activity defines masculinity whereas it is not so for women.

Exploring further on relationship between mental health or physical activity and perceived built environment could enlighten on greater gender differences. The strengths of this review are the robust method employed in the systematic review, and the attempt to integrate gender analysis using Gender Analysis Matrix. The use of only PubMed search engine for literature review could be a limitation.

Conclusions

Studies on chronic disease risk generally adopt a mechanistic model of risk factor leading to event. The risk factor in itself is the result of social, economic, cultural and other determinants largely beyond the control of the individual, and the *built environment* is an important mediator in this pathway from social determinants to final outcome. This review has brought out glimpses of how gender plays a major role in the relationship between built environment and non-communicable diseases. The way in which built environment affects women and men differentially implies that policies and interventions to modify NCD risk factors have to take into consideration gender differences. Smart cities and green cities

could incorporate gender-based preferences such as access to recreational resources, safety from crime and safety from traffic to engage in walking and take part in physical activity. This is a largely unexplored area; large gaps exist in the literature. This calls for further studies using qualitative and quantitative approaches to explore lived experiences of men and women, and the bring out possible modifying role played by gender.

Correspondence: Joanna Sara Valson, Achutha Menon Centre for Health Science Studies, Sree Chitra Tirunal Institute of Medical Sciences and Technology, Trivandrum, Kerala - 695011, India.

E-mail: joannavalson@gmail.com

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