DESIGNING AGAINST AGGRESSION

Creating Built Environments *That Improve Safety*

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Abstract

Building environments can contribute to safety by reducing vulnerability to crime and by reducing aggression within occupants. This review draws on a wide range of literature to identify elements of a lighting, noise, temperature, layout, and building quality which have been shown to provoke aggressive behaviour (often by increasing mental fatigue, or influencing serotonin production), and which reduce the incidences of crime or violence. Additionally, a discussion on demographic differences in perceptions of safety suggest the importance of a diverse approach to building interventions.

1. Introduction

The dangers an occupant faces within the built environment are many, and the role of space on minimizing crime and aggression is a factor worth more considering. While there is much research on the socio-economic causes for aggression and crime in urban spaces, this literature review aims to highlight the overlapping influence of building design, layout, and management on safety (or the lack thereof). With an interdisciplinary scope, this paper will indicate areas of the built environment that contribute to aggression, crime, violence, and danger (and the perception of it) to occupants. The goal is to collect research from a wide range of fields and critically analyse the implications of key physical features on public safety. This review attempts to focus beyond issues covered in conventional building guidelines for safety in order to add additional factors for consideration within the design process.

Fundamental theories have arisen from this topic, including the often sourced *Defensible Space Theory* presented in 1976 that focuses on creating neighborhood agency via surveillance-able building design (Reynald & Elffers 1976). Similarly, there exists the *Crime Prevention Through Environmental Design* (CPTED) guideline that built off of Newman's safe neighborhood theories and was developed by a criminologist at Florida State University (Jeffery 1971). Finally, the concept of *space syntax* is a collection of theories defining built environments into analytical spatial configurations using a set of intersecting lines, and methodology for analyzing these lines (Hillier & Hanson 1984). The development of these theories alongside increasing global population has encouraged more research into specific aspects of the built environment that may link to crime, violence, and aggression.

The impacts of building design on aggression can be divided into two main aspects - whether the building makes inhabitants aggressive and whether the building allows inhabitants to be the victim of aggression. Both are discussed within sections as they apply. Section 4, which covers diverse identities and demographic issues, mainly focuses on defending from aggression, whereas Sections 2 and 3 have aspects of both within them. Concepts will consider whether a built environment feature might contribute to the generation of aggression and violence through its psychological impacts, and whether a feature might offer defense or remove vulnerability

from crime. In this way a "safe space" is defined, with discussions on the implications of research on danger in the built environment.

2. Designing Positive/Neutral Building Stimuli

Building stimuli plays an important role as a potential instigator in aggression, violence and crime. In their work on aggression and violence in urban areas, Kuo and Sullivan stress the connection between mental fatigue and aggression, and suggest that preventing violence might best be done by reducing attentional fatigue and by designing spaces to prevent this in occupants (Kuo & Sullivan, 2001). Therefore, the following section will consider the aspects of the physical environment that are known to have an effect on mental tiredness via stimulation.

2.1 Safe Lighting

Strategies, such as CPTED, often cite the need for better lighting (specifically on the street) to reduce crime and improve safety (Reynald & Elffers 1976). Similarly, the visibility of a space is a key element of the defensibility theory (Reynald & Elffers 1976), and buildings that allow for greater visibility seem to be targeted less often for robberies than hidden ones (Chang 2011). To investigate this idea, a review of eight American, and five British studies aimed to firmly correlate brighter street lighting to a reduction in crime (Farrington & Welsh 2002). This review found some connections between improved lighting and a reduction in crime - when compared to control areas (Farrington & Welsh 2002), however, the statistical methods used have been criticized by other researchers (Marchant 2004) leaving the exact numerical benefits of street lighting still up for debate.

The safety of lighting can be difficult to control. While interventions can alter the state of the built environment, lighting "does not constitute a physical barrier to crime" (Farrington & Welsh 2002). Likewise, an increase in illumination may aid perpetrators in carrying out their crime (Farrington & Welsh 2002), and "over-illumination" within interiors has been found to be potentially dangerous to workers in an industrial setting (Leong & Seaver 2015).

However, when lighting increases visibility of a neighborhood, there is the potential that it has a psychological benefit that increases safety by changing "the perceptions, attitudes, and behavior of residents and potential offenders." (Farrington & Welsh 2002). It is possible that adequate lighting can improve the sense of ownership, security, and surveillance in residents, which can reduce the perception (and potentially the likelihood) of danger.

Further research must be conducted to carefully control for the effects of lighting directly on aggression and crime, in order to reduce the influences of *displacement* (the accidental increase in crime in adjacent areas) and *diffusion of benefits* (wherein the crime is reduced in the experimental area by unintended means) on the results (Farrington & Welsh 2002). As well, studies on the lighting spectrum effects on aggression will add detail to safe lighting recommendations. Industrial settings encourage a choice of lighting spectrum that can allow for lower wattage with the same illumination levels (Leong & Seaver, 2015), and the links between

light spectrum and serotonin generation should be analyzed for their contribution to occupant aggression (Tiihonen et al. 2017).

Overall, spaces must maintain a baseline of illumination to allow occupants to safely perform their tasks - but endlessly increasing this light level does not conclusively improve safety. With literature expanding into the psychological and wellbeing effects of lighting spectrum, mental fatigue (and its link to aggression) must be considered in locations where occupants are exposed to the lighting across a long period of time (ie. at work). Finally, building design for these lighting features must also consider the safety of maintenance and building managers - installing tether's for lighting guards, and ensuring they are ergonomically accessible will reduce the dangers to operators when relamping (Leong & Seaver 2015).

2.2 Non-aggressive Noise

The effects of noise on mental states and mental fatigue have been tested through a wide range of methods and by a variety of disciplines. Much of the work has been focused on changes to cognitive abilities when exposed to a range of noise frequencies, with one study reporting that low frequency noise contributed to mental fatigue and caused deterioration of mental health even at levels of 65-75 dBA (Abbasi et al. 2018). Similarly, noise can contribute to a sense of annoyance, especially in settings where the meaning of the sound is important (such as a presentation) (Saeki et al. 2004).

In a study of a large mall, around 10% of women and elderly people found the overall interior noise to be annoying (Hopkins 1994). The layout and operation of the mall in study caused corridors (even when appearing empty) to be channels of high volume noise that were cited to be at a level that cause occupants to lose focus and be distracted (Hopkins, 1994). This study further postulated that high levels of noise prevent the fostering of interpersonal relationships by reducing the ability to socialize via talking (Hopkins, 1994). Beyond these impacts, it has also been shown that noise levels beyond 80 dBA (measured in the mall corridors) causes people to naturally spread out and increase distance between another person (McBride 1984). The work of Cohen and Scapapan has further found that noise can cause people to behave with less consideration and sensitivity, heightened hostility and aggressive behaviour and that they are less likely to offer help to another person even at 65-85 dBA levels (Cohen & Scapapan 1984). In a study on the reactions of a crowd to white noise, it was also found by researchers in Louisiana State University that increasing noise can increase aggressive actions (Berktay & Shooter 1973).

This research paints a picture of buildings whose interior noise levels can cause occupants to be annoyed, unsocial, distant, distracted, and potentially aggressive. The implications of these behaviours on the safety of a large crowd (especially at peak business hours) are serious. Does the ambient noise in a corridor prevent occupants from clearly hearing verbal warnings - or distract them from noticing those in need of help? This interior environment can increase the vulnerability of individuals in a crowd, and intensify aggression in others simply by the building's noise distributions.

In many workplaces, noise is a common product of processes, equipment, and crowds, yet this chronic exposure can significantly impact the wellness of workers (Alimohammadi et al. 2018). In a study on 250 randomly selected male workers in an Iranian automotive factory, aggression (and more specifically, anger) was found to increase in workers when the noise levels increased, as shown in aggression scores per sound intensity in Figure 1 (Alimohammadi et al. 2018). With an average noise level of 86 dB, the industry already contained a high level of chronic noise (Alimohammadi et al. 2018). The additional factors of the age of the worker, and the length of time of their employment also correlated to how sensitive their aggression was to increasing noise (Alimohammadi et al. 2018). This study indicates that sound intensity in workplaces can contribute to greater aggression, hostility, and anger - and that there are age and length of exposure factors at play as well. Beyond simple job satisfaction, and productivity - the implications for worker safety in these potentially aggressive, noisy environments are serious. While industry work has many other difficult factors creating physical fatigue, chronic noise may add to mental fatigue and further increase the risks on workers' safety. Therefore, building design for these environments should carefully consider the placement of noisy equipment in proximity to work stations, and whether or not employees are given access to quiet spaces to reduce constant exposure to a medium-high noise throughout their shift.

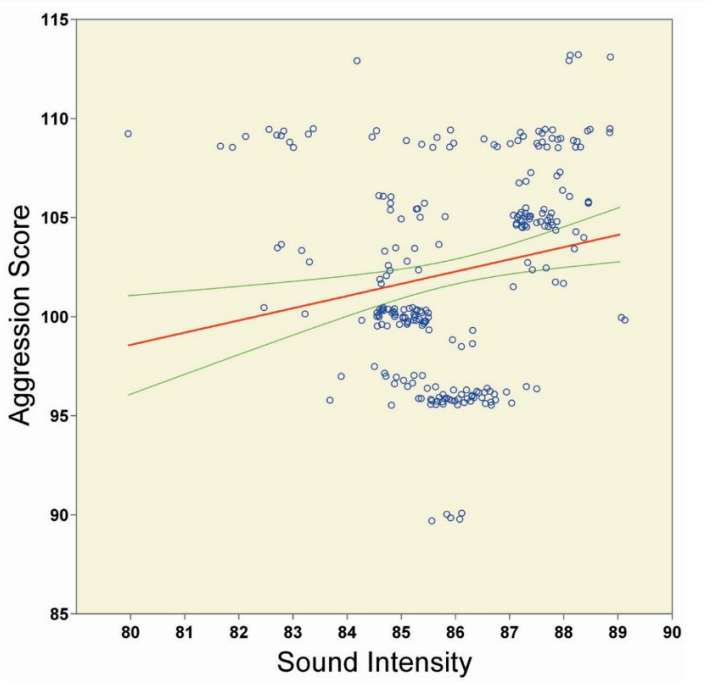

Figure 1. Sound intensity versus worker aggression score (Alimohammadi et al. 2018)

Noise can contribute to the defensibility of a space by allowing an occupant to hear distress signals, and properly interact with other people - thereby surveying their surroundings. Furthermore, chronic noise levels can instigate danger by introducing aggression and mental fatigue in people who are exposed to it. This is an important factor to consider, especially in environments that might have other distracting stimuli. Therefore, the sound levels should be thoughtfully monitored and designed to provide appropriate soundproofing in busy areas, and to

allow occupants to exist in the space without significant disturbance from emitting sources within and around the building.

2.3 Relationship Between Thermal Discomfort & Violence

There has been much research by criminologists on the relationship between seasonal ambient temperatures and crime rates around the world. Though the short term trends have some variance, there are strong correlations between rising temperatures and increased crime rates that can apply to the built environment wherein seasonal temperatures are often managed by building equipment and architectural features. Here, design choices may improve safety by reducing the likelihood of aggressive behaviour due to aggravating temperatures.

In an increasingly violent area in Chile, adolescents at school were studied to understand how their aggression frequency and intensity might be affected by seasonal temperatures. Interestingly, as the temperatures grew warmer (and the humidity increased) the frequency of aggressive behaviour was higher, but the intensity was lower than that of colder temperature seasons (Munoz-Reyes 2014). It was proposed that this trend can be related to conserving energy or resources for aggressive interactions; when there is a greater frequency of incidences, they are shorter and less intense, whereas the cold seasons can sustain more intense aggressive behaviour over fewer outbursts (Munoz-Reyes 2014). Even still, this research created important links between adolescent behaviour in a school to that of commonly studied adult criminal behaviour in society - meaning that the same trends can be applied across a wider age range (Munoz-Reyes 2014).

Such trends are repeated in a seventeen year study of temperature and violent crime in Finland. Here, the "ambient temperature explained 10% of variance in the violent crime rate" (Tiihonen et al. 2017), and incidences corresponded "to a 1.7% increase/degree centigrade," as shown in Figure 2 (Tiihonen et al. 2017). Sifting through the many corresponding factors of a season that might result in this trend, this study aimed to control for the effects of temperature separate from the effects of sunlight, and did this by measuring the changes in offenders' and non-offenders' *peripheral serotonin transporter density* since there has been much research to suggest that serotonin has a strong connection with aggression and impulsive behaviour (Tiihonen et al. 2017). With this additional metric studied - it was confirmed that increasing temperatures adjusts the serotonergic system in a person (leading to an increase in violent crime during higher temperature months) (Tiihonen et al. 2017) and that the potential temperature increases as a result of global warming - even of a "2°C increase in average temperatures would increase crime rates by more than 3% in non-tropical and non-subtropical areas." (Tiihonen et al. 2017).

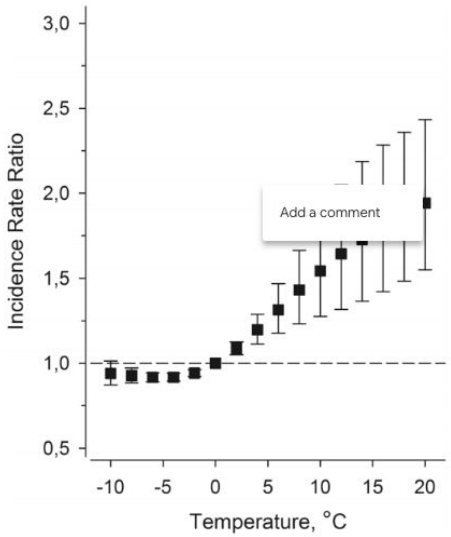

Figure 2. Violent crime incidence rate ratios ve ambient temperature in Finland (Tiihonen et al. 2017)

A twenty-four year study of 88 cities in the United States further underlined the importance of temperature in seasonal variations of crimes (McDowall 2011). Here it was found that homicide and assault occur in the same annual pattern (correlated to season) across all locations, and that all of the studied crimes (except for robbery, which peaks around winter holidays) peak in the warmest months and are minimum in the winter (McDowall 2011). Taking into account the social variations across temperature for these locations, this study identified that temperature maintains a strong influence over crime even when other factors are considered (McDowall 2011).

The literature presents a convincing case for the connection between thermal environment and aggressive behaviour, one that should be carefully considered by designers and managers of the built environment. Understanding the link between seasonal, outdoor temperatures with crime indicates that the built environment should aim to mitigate these effects in the "danger months" by providing occupants - inside and outside - with thermally comfortable spaces. Increasing shaded, and naturally cooled spaces in the public areas surrounding the building, while also giving all occupants a safe and comfortable interior temperature, can reduce the aggression and improve safety. With the potential global increases in temperature, paired with urban heat island (UHI) effects, this must become an increasing design consideration to prevent hotter urban areas from becoming 'hotspots' for crime. Designers should consider the ways in which solar heat gain, and their architectural choices increase seasonal climate effects on occupants in and around their building, and make steps to reduce ambient temperature effects, especially in warm seasons and climates.

2.4 Natural Spaces to Reduce Aggression

Biophilia has been described as a yearning for connection with other forms of life (Wilson 1984), and is commonly articulated in the built environment as the inclusion of natural elements with the purpose of recalling connections with plants and animals. This practice has been shown to

improve worker performance and psychological satisfaction - but also plays an important role in reducing crime and aggression.

With a direct focus on how the access to natural spaces (such as grass, views of trees and shrubs etc.) reduces mental fatigue - one study makes a strong case for the connection between aggression, fatigue, and nature (Kuo & Sullivan 2001). With nearly identical buildings - but varying degrees of nature - this study found that partner abuse was lower in the greener buildings, and that acts of aggression were carried out with a smaller range of tactics (whether it was psychological, physical etc.) than in the barren buildings (Kuo & Sullivan 2001). This did not account for acts of severe violence, or violence against children, but was significant with moderate and mild aggressive behaviour. The authors of this study highlighted the implications of mental fatigue on violence - as when controlled for, it explained the greenery variations (Kuo & Sullivan 2001). Similarly, the impacts of exposure to "greenspace" on adolescents in Southern California's urban neighborhoods signify an important developmental ability to nature - wherein "both short-term (1-6 month) and long-term (1-3 year) exposures to greenspace within 1,000 meters surrounding residences were associated with reduced aggressive behaviours." (Younan et al. 2016). Whether aggression is reduced by access to greenery or other direct interventions to prevent mental fatigue, it is important to emphasize the restorative value of greenery and the potential to utilize it as long-term dampener of violence in a community.

Correspondingly, a study of twelve children with ADHD in the Netherlands were tested for their reactions to the stimuli of natural versus urban environments (van den Berg & van den Berg 2010). Though there were variations, and this study was meant to support further research not make generalizing conclusions, it was found that "all children displayed problematic behaviours and concentration problems in the built environment." (van den Berg & van den Berg 2010). While all of the children's performance on concentration tasks were better in the natural setting, only one group displayed "somewhat more non-social, aggressive, inattentive, impulsive and hyperactive behaviour in the town than in the woods." (van den Berg & van den Berg 2010). This study indicates a potential link between certain built environment stimuli and the behaviours of children with ADHD - and furthers the need to understand which urban features cause mental fatigue, and which natural features help to rejuvenate.

The research presented here adds to the growing collection of work on the positive health effects of biophilic elements and urban greenery by highlighting the safety positives that are associated with occupants who are less mentally fatigued and aggressive. With this understanding comes the possibility that there are environmental factors that contribute to higher crime areas - and that these environmental factors are self-reinforcing. Is it possible that areas with greater greenery and natural beauty attract higher income renters (that are commonly associated with "safety")? Or could it be that having natural beauty creates wellness in communities that reduces aggression and allows for the prosperity of occupants? In either case, adding natural elements to risk areas, areas of high stress or mental fatigue, and developmental spaces is an important step to improve safety. With the possibility to reduce adolescent aggression and domestic violence, natural elements should not be treated as an added frill or luxury - but as a significant step in creating community safety and growth, as a way to support the vulnerable and improve the living conditions of the mentally fatigued.

3. Building Layouts & Occupant Flow for Reduced Aggression

The three theories presented in the introduction have led to a focus on the design of roads and residential areas to reduce the risk of crime. While there are some disagreements about which layout and flow is optimal for reducing crime, the data tends to show that through-access (either by roads or footpaths) can increase crime rates (Chang 2011), (Armitage 2011). The building layout features in Section 3.1 are analyzed for their potential to prevent or defend from crime, whereas Section 3.2 addresses potential layout issues that create aggression or violence.

While much of this focus seems to be on the exterior built environment, the findings on movement may be applied to interior layouts, exits and entrances, and the design of parking. The following sections will attempt to make this link, and also to discuss the importance of occupant flow (or crowding) on aggression and violence.

3.1 Designing Floor Plans To Minimize Danger

As stated previously, the general consensus is that increasing through movement can increase crime (Chang, 2011), (Armitage, 2011). This theory was strengthened by an in-depth study on crime rates and location in South Korea where the space syntax method was applied to six urban areas, and their crime rates were associated with different building and neighborhood features (Chang, 2011). The study found that "66% of all burglary rates occurred in buildings adjacent to through alleys for car and footpaths," (Chang 2011) and that the access type played a higher role in preventing crime than anti crime measures did (Chang 2011). These findings provide some indications as to the optimal orientation of buildings with respect to their surroundings to reduce their vulnerability to crime.

From space syntax terminology, *intelligibility* measures how easily an individual can go toward a chosen place - and this showed a strong correlation between burglary rates in the study in South Korea (higher intelligibility, lower burglary rates) (Chang 2011). This indicates that the layouts of buildings and neighborhoods should be designed with considerations for how easily an occupant can get around - as this will affect their safety. Specifically, there exists a link between ground floor entrances and the number of floors to crime - where low buildings with few ground floor entrances had higher crime rates than tall buildings with many entrances (Chang 2011). Having many entrances on the main floor increases intelligibility, and placing these doors within an appropriate context to nearby road conditions can further reduce the risk of crime. The results from this research suggest that building layout to prevent theft should have many entrances and exits, but that their placement should not allow easy access to through roads, alleys and footpaths - as these may be used for quick "getaways". Perhaps the best way to think about the role of intelligibility on safety in the built environment, is to design buildings that are very easy to move around in and through - but that do not allow for overly easy transportation to and from the building via roads and paths.

While CPTED has been an important development in conscientiously building safer places, there is the potential that some "features that enhanced a development's design quality could actually

heighten that development's risk of crime and anti-social behaviour." (Armitage 2011). In a review of innovative housing designs, it was shown that the accessibility of a building may increase its risk of crime, but that those within cul-de-sacs are safest (Armitage 2011). Furthermore, as the layouts of a building are updated, it may seem helpful to place parking in seperate, hidden locations to improve visibility and aesthetic quality of a design - yet this choice can come with unintended consequences (Armitage 2011). The research reveals people want to park near their home, and rear parking courts increase vulnerability to danger (Armitage 2011). Therefore, the layouts of buildings must find a balance between these complex interactions of accessibility, and remote-ness. Innovations to common layouts should be thoroughly reviewed to avoid undermining the safety of occupants.

3.2 Links Between Aggression and Crowding

The layout of the built environment can play a role in reducing crime and improving the safety of a space, and this link can blend in to the concept of crowding and spacing and its effects on a person's aggression. In a study on drinking venues in Toronto, key areas of danger were identified within the floor plan as being spaces where greater incidences of aggression and violence occurred. These spaces were not always correlated with crowding (further factors discussed in Section 4.3), but when there was greater areas of movement - or high volume flow - there tended to also be greater incidences of aggression (Graham et al. 2012). From this focus of flow and crowding, it was suggested that flow be directed in areas where there are not other risks, such as away from the top of a staircase where the movement could cause falls (Graham et al. 2012). The insights into aggression in drinking venues are paired with other factors (such as alcohol and social influences), but the crowding of moving spaces is one that can be found in many public and commercial areas.

For a broader view, one study analyzed the potential link between household crowding and areal density on political aggression. This research compared the number of occupants within a home and country to acts of civil unrest and found that crowding accounted for a "moderate amount" of the incidences (Welch & Booth 1973). While there may not be a direct causation, and the link is likely to be a complicated mix of other social, cultural and economic factors - the results indicate that how crowded a person feels - especially in their own home - is important in understanding aggression and crime (Welch & Booth 1973).

Furthermore, the effects of crowding in psychiatric wards has been found to increase the risk of patient seclusion as a result of violence and aggression (van der Schaaf et al. 2013). Having a greater density of patients increases their aggression and their disturbed behaviour, which then endangers other occupants in the building (van der Schaaf et al. 2013).

The implications from this research indicate that people in a wide range of settings feel greater aggression when crowded. This finding matches behaviour that is easily observed by many animals and humans across environments - but what may be less obvious is the role that the built environment has on crowding-induced aggression and violence. With a drive for more dense urban areas, "tiny houses," and an overall reduced footprint, it may not seem practical to include provisions for a sense of emptiness or under crowding. Yet, as the population continues to rise,

and housing prices push some urban communities into denser living spaces, designer's of the built environment must consider the potential safety risks - and design for more efficient movement and flow to reduce crowding.

Having restorative spaces can be one of these options, as well as other architectural features that increase the sense of expansiveness (ie. high ceilings). The building of residential units (across economic levels) should allow for appropriate room allocations for all potential residents to reduce incidences of violence. Occupants should be given territory and space to recover from mental fatigue and maintain their autonomy even within dense urban areas. And in communities with high crime rates, interventions should consider the need for "public vacancies" - to have large enough community areas that people are not pushed together into aggression.

4. Concerns of Diverse Occupant Groups

While diverse occupants are affected by the factors presented in previous sections, there are also some group-specific concerns missed by discussions that commonly focus on averages or status-quo's. This section aims to identify some of the safety concerns that may not always fall in the majority - or at least may not always be a common design or research focus in building design. As always, designing for the safety of vulnerable groups is best done in direct consultation with those groups to better represent their concerns, and to design innovative elements of the built environment for a diverse range of needs.

4.1 Safety for All Ages

Aggression and crime in adolescents is considered through literature on creating safer educational buildings. In a study on high schools in Kentucky, researchers identified 'hotspots' of assault and aggression within the building and surrounding area (Wilcox, Augustine & Clayton 2006). These areas of "hallways, bathrooms, cafeterias, and parking lots" (Wilcox, Augustine & Clayton 2006) were marked as having lower visibility for surveillance, but more importantly as being places that are perceived to belong to no one (Wilcox, Augustine & Clayton 2006). This study indicated a key psychological aspect of built environment for the safety of adolescents being a sense of "territoriality" - or ownership of the space (Wilcox, Augustine & Clayton 2006). When there were measures taken to increase this sense of ownership - by displaying artwork and school emblems - the levels of assault and aggression were seen to reduce in students (Wilcox, Augustine & Clayton 2006). There is a potential safety risk in having unmarked spaces that can be mitigated by improving the visibility in those spaces and increasing students' sense of territory or belonging (Wilcox, Augustine & Clayton 2006).

With the goal of understanding how the built environment impacts perceptions of safety for the elderly, a study of 273 Hispanic elders (mean age of 78.5) was undertaken in Florida, US (Brown et al. 2009). This research highlighted the importance of in-person contact for those in the older population by discovering that building features that allowed for direct interaction resulted in greater senses of social support and reduced psychological distress (Brown et al. 2009). Front porches were a key built feature that encouraged this community safety, whereas large windows and ground-floor parking (with garages that seem to replace or block a front entrance) gave the

elders a negative sense of social support (Brown et al. 2009). This indicates an interesting caveat in the CPTED and defensible space theorems - greater visibility through large windows is not directly perceived as being a safety benefit for occupants of all ages, and in the elderly studied here, this actually may have contributed to a feeling of being too exposed (Brown et al. 2009). Though there are many other potential age factors that require adequate research attention, this review of two very distinct built environment reactions shows that age can play a role in shaping the context that contributes to an occupant's safety within a space.

4.2 Improving Building Design for Commonly Targeted & Minority Groups

Safety for those typically at risk of crime may require different strategies than the typically assumed "average occupant." With high rates of assaults and aggressive behaviour towards women, transgendered people, racialized groups, and sex workers building strategies should be aimed at - or at least aware of - their concerns (Spencer et al. 2011), (Doan 2007), (Lazarus et al. 2011).

In a study on walking for leisure in high crime rate neighborhoods in the USA, 195 African American women and 95 African American men were surveyed to assess their perceived levels of safety and what impact that may have on their physical activity (Trumpeter & Wilson 2014). In this research they found that "women reported greater concerns about safety, poorer perceptions of aesthetics, and lower neighborhood satisfactions than men." (Trumpeter & Wilson 2014). Interesting sex differences were noted in the connection between these perceptions and physical activity - where the men walked more if more satisfied but the women walked less if satisfied. This research does not directly imply a negative causation between women's physical activity and their sense of security, but looking deeper at potential causes, it was suggested that walking in their neighborhoods may have made the women feel less safe in them, and so satisfaction was reported only when there was a lack of exposure (by a lack of walking) to the potential crime and aggression. This study concluded that for both men and women, physical activity could be improved by having more active walking spaces in the neighborhoods (Trumpeter & Wilson 2014), but an understated finding in this report is the trend that there were significant sex differences in perceptions of safety. These differences call for a more diverse strategy, and a further inquiry into what dangers are perceived by vulnerable groups in the built environment.

Furthermore, literature on safety in the built environment does not always differentiate between trends for those with different racial and ethnic backgrounds, and when they do they are commonly grouped with other groups and other factors (such as African Americans with low income white Americans). While there are many intersecting groups of identities that can inform a wide variety of suggestions for safer building designs, a focus specifically on the concerns of different racialized communities may offer further insights. For example, in a study across three years of New York city middle school students, there was strong evidence that a student's perception of their own safety within their school varied depending on their background (Lacoe 2014). Interestingly, the school district tended to have a degree of segregation, wherein "one racial or ethnic group makes up more than half of the student body" (Lacoe 2014), and so the context of each school might have also been segregated for groups of different racial or ethnic

backgrounds (Lacoe 2014). This research indicating "significant differences in feelings of safety between students of different racial and ethnic backgrounds, even within the same schools and homerooms," (Lacoe 2014) points to a potential broader connection between an occupants background and their perception of danger within a space.

Additional insights into the diversity of danger in spaces comes from low income women sex workers in Canada's "poorest postal code" in Vancouver. A paper on the dangers these women face in their built environments highlighted how some existing housing policies and building conditions have a significant negative impact on their safety and health (Lazarus et al. 2011). Across North America, vulnerable individuals that find themselves in unstable or homeless conditions may reside in Single Room Occupancy hotels (SROs). These buildings were developed in the 1960s and 1970s primarily for male migrant workers and travelling unemployed, they are characterized as being "old buildings, unkept and unsanitary with shared bathroom facilities, no kitchen space and rooms averaging 100ft^2" (Lazarus et al. 2011). Many of the occupants are women sex workers and they indicated that these poor housing conditions often force them back into homelessness. The dangers they face are from the prevalence of pest infestations, poorly maintained buildings, and a lack of housing regulation that often leave them vulnerable to male residences and building staff (Lazarus et al. 2011), (Knight 2013), (Casey, Goudie & Reeve 2008). Policies that prevent them from working flexible hours, and having guests over was shown to force them into more dangerous situations with street and public space based activities. Dangers at home came from violence and sexual assaults by males in the co-ed buildings - whereas women-only SROs improved safety and sense of control (Lazarus et al. 2011). The picture of poverty, and struggle depicted in this research points to a grim lack of support for the built spaces for vulnerable groups. While many of these changes are policy based, architects, engineers, and building scientists play a role in developing quality housing that minimize the dangerous effects faced by these women. Ensuring existing occupied buildings have minimum levels of sanitation, space, and security is a part of the building design profession that has often been overlooked for more high performance focuses. Yet, research on SROs in San Francisco has shown that "the conditions and characteristics of these built environments contributed to and/or exacerbated poor mental health among women," (Knight 2013) but that when there are changes to the physical and managerial environments - such as the lighting improvements shown in Figure 3 - the most vulnerable of women were able to find stability within these buildings (Knight 2013). Therefore, the retrofit, upkeep and careful management of SROs is an important area of wellness is the built environment - one that has the potential to create some stability for those that need it most.

Figure 3. Comparison of the hallway in a newly built SRO with an older SRO (Knight 2013)

Dangers faced by vulnerable groups are also associated with the layouts and building features that can affect aggression in occupants. In preventing sexual assault, and sexual based aggression, a study on drinking venues in the Toronto area identified key floor plan zones for aggressive activity (Graham et al. 2012). As previously mentioned, safety interventions should allow for uncrowded movement, and proper surveillance. But the research also found that the locations of aggression were different in venues with more older men than those with many younger women (Graham et al. 2012). With an increase in women in the venues, the aggression occurred primarily on and near the dance floor where there was also a concentration of sexual activity (Graham et al. 2012). In these locations, there are unique crowding and movement conditions that pair with lower visibility and allow for assaults. The paper suggested improving staff training to be more quick to prevent violence and aggression in these areas, but also suggested that the layout design of the venue should be improved to reduce these conditions (Graham et al. 2012). In this way, a building designer should consider the conditions vulnerable groups (including young women) face in event spaces as an important factor in planning layout, and occupant movement through the space to improve safety.

Designing safe spaces for women and marginalized groups must also evaluate whether it is seen as culturally acceptable for them to be in those places. In research on conservative communities in Egypt and Kenya where "females have much less access to, and are sometimes completely excluded from, public spaces that men can visit freely" (Brady 2005), the idea of a *gendered place* aims to describe the ways in which groups in a community are excluded from public areas (Brady 2005), (Doan 2007). Some of this exclusion is due to cultural, societal, and religious factors, but there is also a significant impact of being unwelcome and harrassed away from them (Brady 2005). When considering potential differences in how groups use public space (as is mentioned in the discussion on physical activity and neighborhood satisfaction), it is important to consider the social factors that may be keeping people out of those built environments. Consequently, the "Ishraq" program in Egypt aimed to reclaim space for girls in this community by engaging them in activities that used public spaces - such as sports (Brady 2005). The results,

however, highlighted issues of transportation and safety in these locations, since "more than 77 percent of the girls reported being 'teased or harassed' by boys when they venture outside their home." (Brady 2005). From this research, a safe space must offer some degree of privacy and confidentiality while being conveniently located, and culturally acceptable (Brady 2005). Therefore, when building community and public spaces - especially for the aim of encouraging physical activity in groups that are commonly seen as vulnerable - special care should be taken to consider the intersectional safety concerns of those groups. Designs for entrances and exits must allow occupants to feel free to enter a place without risk of harassment from those in the surrounding area. Allowing for privacy in sports complexes for users to feel safe to change into equipment, or engage in physical activity without the surveillance of those that might make them feel unwelcome can help improve the safety of vulnerable groups in public spaces.

Many groups can suffer from a gendered place, as the act of violating traditional gender norms can lead to danger within and exclusion from the built environment (Doan 2007). Research on 149 transgendered individuals aimed to identify how this group (who are vulnerable to high incidences of violence and assault) perceive their safety within urban environments, and how these places changed their living behaviours (Doan 2007). The surveys found that with the existence of a noticeably queer area "trans people feel markedly safer" (Doan 2007). Though their residences were spread across urban settings, and their visits to queer centres were only occasional, the spaces tended to improve a sense of community and support (Doan 2007).

Across the range of social, and demographic factors, ensuring the safety of vulnerable groups in communities will help to increase the safety of those within the whole. Decision makers within the built environment must consider how the diversity of users affects the interpretation, use, and perception of security of physical features. Here, there are many potentials to reduce crime by building design that is informed by the needs and concerns of groups that may be (or feel they are) uniquely vulnerable to crimes and aggression.

4.3 Building Design to Improve the Safety of Homeless & Low Income Communities

As previously mentioned, there exists a strong correlation between mental fatigue and aggression. This link is important in the lives of homeless and low income individuals because "the attentional demands of poverty are many and unremitting," (Kuo & Sullivan 2001) and these vulnerable home environments with "lack of adequate space and facilities makes purposive functioning more effortful as more problem solving is required to accomplish goals in unsupportive or inadequate settings." (Kuo & Sullivan 2001). Designing spaces for people in these groups must then include considerations for reducing mental fatigue to improve safety, by improving the built environment to compensate for other contributing factors.

The considerations in all previous sections apply to improving safety for low income communities and homeless people. Distinctions lie in the tendency for building innovations to cluster around higher income and newer developments, where those without means to may not often be able to access the benefits of health-conscious built environments. Therefore, the

primary recommendation for this group is that the retrofit and careful planning of these communities include equal consideration as other communities.

When developing spaces for homeless people, there has been some research that shows that traditional strategies of co-ed institutional buildings, and public spaces are unintentionally harmful to homeless women (Casey, Goudie & Reeve 2008), (Lazarus et al. 2011). This may be because these are designed with male occupants in mind, since "through a combination of direct assertions, choice of focus, and implied silence, homeless women are rarely acknowledged as inhabitants of public spaces in the housing and homelessness literature." (Casey, Goudie & Reeve 2008). There is a perception that due to the danger of the public and perceived vulnerability of women, that they will not occupy the same homeless spaces as men, however, in literature on homeless women in England's public space, this idea is confronted as ignoring the ways "private and institutional spaces can also represent places of danger for women," (Casey, Goudie & Reeve 2008), and that many vulnerable women may choose to live in less stable conditions in order to avoid being exposed to harassment and sexual assault which occur in these "male dominated threatening environments" (Casey, Goudie & Reeve 2008), (Lazarus et al, 2011). Therefore, designing spaces for homeless people must include considerations for gender and domestic abuse. Furthermore, allowing public spaces for homeless women to occupy will provide safety in surveillance, and encourage a sense of identity beyond homelessness (Casey, Goudie & Reeve 2008). Those surveyed said that the ability to maintain their hygiene and appearances were important for their survival and access to public spaces, they cited public mirrors and washing stations as key physical features in maintaining their sense of control over their own life (Casey, Goudie & Reeve 2008). Therefore, incorporating common facilities (like mirrors, washing bins, personal storage space, etc.) into public areas that are accessible to all, and allow appropriate visibility for defensible space, can support the safety of homeless people. Building units for homeless and low-income occupants should also allow people to maintain their own safety and dignity (possibly by having multiple, separate entrances per unit) from the employees and other occupants to reduce danger.

5. Conclusion

The expectation that complex human factors are beyond the scope of building design is challenged by this interdisciplinary review of literature on physical features that impact the safety and aggression of occupants. Mental fatigue and serotonin production are psycho-physiological elements that link to aggression and when these overlap with building elements it is possible to further link design to crime and safety. Less obvious are the connections between perceptions of safety, physical features, and demographic groups. Moreover, this review identified sex, age, and race differences in perception that suggest a safe space may not look the same for every person, and diverse consultation is needed to adequately address all issues. Still, the built environment plays an important role in creating safety across situations, and it was generally suggested that improving occupants' sense of ownership, pride, and territory has positive effects on most individuals' perceptions of their own safety.

Building features can allow for greater defense from crime (or a reduction in incidences) by improving the illumination of the space, and allowing for better flow of people. Increasing the

number of main floor doors and allowing for better access can also reduce crime - however this recommendation depends on building orientation to certain paths and types of roads nearby (since footpaths and alleyways may increase theft). Allowing for higher visibility of occupants (especially in areas of high levels of assault - like dance floors or school hallways) generally reduces acts of aggression, however, accomplishing this by introducing large windows may make people (specifically the elderly) feel less safe and more exposed. Vulnerability to crime is further reduced by building design that acknowledges the dangers within private space, and the need for vulnerable groups (ie. sex working and homeless women) to have agency and flexibility to remove themselves from their own potentially dangerous homes. This can be accomplished by improving access to public amenities such as washing stations and mirrors so that the benefits of group surveillance can allow vulnerable people more freedom. Within the public space, crime by harassment can be reduced by addressing the ways in which the built environment contributes to a sense of gender roles and cultural norms in each place. In cases where there are high levels of harassment and victimization (especially for girls in conservative areas, and transgendered people), the building design of community centres should afford privacy and safety and be designed to be welcoming to the various identities and cultures that would access them. Likewise, having a queer centre within a city can increase the sense of safety and support for trans people.

The second method to improve safety is to reduce built environment catalysts for aggressive and violent behaviour in occupants. This can be achieved by removing building stimuli that contribute to annoyance, and mental fatigue such as chronic noise and noise levels (from 65 - 86 dBA, most noted around 80 dBA). Aggression can also be reduced by carefully adjusting for seasonal temperature changes, and designing interior and exterior interventions to maintain cooler temperatures (associated with fewer incidences of aggression) and minimize a building's contribution to climate change. Likewise, since crowding and flow can cause aggression, building layouts should allow for adequate floorspace for occupants within high volume areas and private homes as well. Adding greenery may act restoratively, and there are many indications that natural elements or biophilic design reduces aggression in people of all ages. Finally, the quality of the buildings that are accessible to low income and homeless people should be improved as it is shown to increase a sense of stability, and greater access to resources can reduce the mental strain that poverty and volatility create.

Overall, this review collected relevant research on aggression and safety within the built environment with the aim to answer the question: how can building design address the complex factors that contribute to aggression and violence, and in what ways can it actively improve safety for all people? The answers were equally complex, and require effort and commitment from decision makers to adequately consider a broad enough context of impact. Yet, the implications to security within homes, workplaces, and public areas offer a hopeful potential for greater societal wellness through built safety.

6 . References

Alimohammadi, I, F A Kanrash, J Abolghasemi, H Afrazandeh, and K Rahmani. 2018. "Effect of Chronic Noise Exposure on Aggressive Behavior of Automotive Industry Workers." *The International Journal of Occupational and Environmental Medicine* 9: 170-175.

Armitage, R, L Monchuk, and M Rogerson. 2011. "It Looks Good, but What is it Like to Live There? Exploring the Impact of Innovative Housing Design on Crime." *European Journal on Criminal Policy and Research* 17: 29-54.

Berktay, H O, and J A Shooter. 1973. "How Noise Affects Aggression." *The Journal of the Acoustical Society of America* 54: 556.

Brady, M. 2005. "Creating Safe Spaces and Building Social Assets for Young Women in the Developing World: A New Role for Sports." *Women's Studies Quarterly* 35-49.

Brown, S C, C A Mason, J L Lombard, F Martinez, E Plater-Zyberk, A R Spokane, F L Newman, H Pantin, and J Szapocznik. 2009. "The Relationship of Built Environment to Perceived Social Support and Psychological Distress in Hispanic Elders: The Role of "Eyes on the Street"." *Journal of Gerontology: Social Sciences* 64: 234-246.

Casey, R, R Goudie, and K Reeve. 2008. "Homeless Women in Public Spaces: Strategies of Resistance." *Housing Studies* 23: 899-916.

Chang, D. 2011. "Social Crime or Spatial Crime? Exploring the Effects of Social, Economical, and Spatial Factors on Burglary Rates." *Envrionment and Behavior* 26-52.

Cohen, S, and S Spacapan. 1984. "The social psychology of noise." *Noise and Society* 221-245.

Dijkstra, K, M Pieterse, and A Pruyn. 2006. "Physical environmental stimuli that turn healthcare facilities into healing environments through psychologically mediated effects: systematic review." *Integrative Literature Reviews and Meta-Analyses* 166-181.

Doan, P L. 2007. "Queers in the American City: Transgendered perceptions of urban space." 14: 57-74.

Farrington, D P, and B C Welsh. 2002. "Improved Street Lighting and Crime Prevention." *Justice Quarterly* 19: 313-342.

Graham, K, S Bernards, D W Osgood, and S Wells. 2012. "'Hotspots' for aggression in licensed drinking venues." *Drug and Alcohol Review* 31: 377-384.

Hillier, B, and J Hanson. 1988. *The Social Logic of Space.* New York: Cambridge.

Hopkins, J. 1994. "Orchestrating an Indoor City: Ambient Noise Inside a Mega-Mall." *Environment and Behavior* 26: 785-812.

Jeffery, C R. 1971. *Crime Prevention Through Environmental Design.* Beverly Hills, CA: Sage Publications.

Knight, K R, A M Lopez, M Comfort, M Shumway, J Cohen, and E D Riley. 2014. "Single room occupancy (SRO) hotels as mental health risk environments among impoverished women: The intersection of policy, drug use, trauma, and urban space." *International Journal of Drug Policy* 25: 556-561.

Kuo, F E, and W C Sullivan. 2001. "Aggression and Violence in the Inner City: Effects of Environment via Mental Fatigue." *Environment and Behavior* 33: 543-571.

Lazarus, L, J Chettiar, K Deering, R Nabess, and K Shannon. 2011. "Risky health environments: Women sex workers' struggles to find safe, secure and non-exploitative housing in Canada's poorest postal code." 73: 1600-1607.

Leong, M F, and S Seaver. 2015. "Lighting Safety Considerations." *IEEE Transactions on Industry Applications* 51: 4233-4238.

Marchant, P R. 2004. "A Demonstration That the Claim That Brighter Lighting Reduces Crime Is Unfounded." *Brit. J. Criminol.* 44: 441-447.

McBride, R F. 1984. *Public Hearings on noise in Alerbta: Report and recommendations.* Edmonton: Environment Council of Alberta.

McDowall, D, C Loftin, and M Pate. 2012. "Seasonal Cycles in Crime, and Their Variability." *Journal of Quantitative Criminology* 28: 389-410.

Munoz-Reyes, J A, L Flores-Prado, and M Beltrami. 2014. "Seasonal differences of aggressive behavior in Chilean adolescents." *Journal of Aggression, Conflict and Peace Research* 6: 129-138.

Reynald, D M, and H Elffers. 2009. "The Future of Newman's Defensible Space Theory." *European Journal of Criminology* 25-46.

Schaaf, P S van der, E Dusseldorp, F M Keuning, W A Janssen, and E O Noorthoorn. 2013. "Impact of the physical environment of psychiatric wards on the use of seclusion." *The British Journal of Psychiatry* 202: 142-149.

Tiihonen, J, P Halonen, L Tiihonen, H Kautiainen, M Storvik, and J Callaway. 2017. "The Association of Ambient Temperature and Violent Crime." *Scientific Reports* 7: 1-7.

Trumpeter, N N, and D K Wilson. 2014. "Positive Action for Today's Health (PATH): Sex Differences in Walking and Perceptions of the Physical and Social Environment." *Environment and Behavior* 46: 745-767.

van den Berg, A. E, and C. G. van den Berg. 2011. "A comparison of children with ADHD in a natural and built setting." Child Care Health Dev 430-439.

Welch, S, and A Booth. n.d. "Crowding as a factor in political aggression: Theoretical aspects and an analysis of some cross-national data." *Social Science Information* 13: 151-162.

Wilcox, P, M C Augustine, and R R Clayton. 2006. "Physical Environment and Crime and Misconduct in Kentucky Schools." *The Journal or Primary Prevention* 27: 293-313.

Younan, D, C Tuvblad, L Li, J Wu, F Lurmann, M Franklin, K Berhane, et al. 2016. "Environmental Determinants of Aggression in Adolescents: Role of Urban Neighborhood Greenspace." *Journal of the American Academy of Child & Adolescent Psychiatry* 55: 591-601.