Green space benefits for health and well-being: A life-course approach for urban planning, design and management

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Abstract

In recognition that the coming century will see a substantial majority of the world's population living in urban areas, the World Health Organisation and the United Nations have developed policy frameworks and guidance which promote the increased provision of urban green space for population health. However, these undertakings do not provide specific guidance for urban policy in terms of the particular design attributes required to tackle lifestyle illnesses and to promote well-being in urban populations. Furthermore, green spaces have generally been treated as a homogenous environment type. In order to address these weaknesses, this paper collates and reviews the evidence linking health, well-being and green space using a life-course approach. The literature generally endorses the view that urban green spaces, as part of the wider environmental context, promote health and well-being across the life course. Based on the evidence, cohort-specific and cross-cutting design interventions are identified and a general integrated green space framework for health and well-being is proposed. This analytical lens facilitates distillation of a vast quantum of research and the formulation of specific planning and design guidance for the provision of more inclusive green spaces that respond to the varying needs of people across all life-course stages.

Introduction

Across the globe, urban policy-makers are increasingly exploring the links between urban planning and public health as concerns rise on the impacts of urban environments on health outcomes and healthy lifestyles. For example, the recent *Habitat III* Agenda (United Nations General Assembly, 2016) places promoting human health and well-being as a key urban goal for the 21st Century, while the European Union has been linking health and the urban environment for more than a decade, illustrated by its *Thematic Strategy on the Urban Environment* with a primary aim to 'improve the environmental performance and quality of urban areas to secure a healthy living environment for Europe's urban citizens' (CEC, 2006; 4). In part, these initiatives echo the early roots of modern urban planning which emerged in the late 19th and early 20th Century to tackle slum conditions in Europe's industrial cities (Barton, 2010). However, the renewed interest in health and urban planning inter-relationships today reflects the growing evidence that the environment is one of the key determinants of

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health and well-being alongside inherited characteristics and socio-economic variables (Barton, 2009). Despite this interest, Crawford (2010) notes that close working relationships between urban planners and public health practitioners are remarkably scarce. Moreover, while studies of the environmental and place-based determinants of health and studies of subjective measures of well-being have increased significantly over the last decade, from a planning and design perspective this evidence-base is often piecemeal (e.g. focused on a specific cohort), and translating public health knowledge into urban planning and design interventions and actual proposals remains problematic. In this paper, we address this disconnect by exploring the role of urban green spaces in providing benefits for health and well-being.

Within the academic literature, over the past 10-15 years, there has been a re-emergence of interest examining the impact of the environment on health in advanced economies, with a considerable expansion of theoretical and empirical studies investigating the role of contextual factors in the production and maintenance of health variations (Cummins, Curtis, Diez-Roux, & Macintyre, 2007)[2]. While there is a longstanding recognition of the negative impacts on health of environmental 'bads' such as poor air quality and the distribution of various forms of pollution, more recently increasing attention has focused on the potential positive influence on health of environmental 'goods', such as well-designed and walkable cities, access to 'nature'/biodiversity and the distribution of urban green space (Lake & Townshend, 2006). 'Lifestyle illnesses' such as heart disease, obesity, diabetes, osteoporosis, mental illness and some cancers are increasingly attributed to the poor quality of the environment in our cities (Barton, 2010; Berke, Koepsell, Moudon, Hoskins, & Larson, 2007; Corkery, 2015; Coutts, 2016; Frank, Andresen, & Schmid, 2004; Gast, Frenken, Van Leest, Wendel-Vos, & Bemelmans, 2007; Gregg, Pereira, & Caspersen, 2000; Lake & Townshend, 2006; Latkin & Aaron, 2003). The literature generally endorses the view that urban green spaces, as part of the wider environmental context, promote health and well-being in cities (Ellaway, Macintyre, & Bonnefoy, 2005; Gascon et al., 2016; Giles-Corti et al., 2005; Giles-Corti & Donovan, 2003; Kaczynski & Henderson, 2007; Maas, Verheij, Groenewegen, de Vries, & Spreeuwenberg, 2006; Takemi Sugiyama, Francis, Middleton, Owen, & Giles-Corti, 2010; Tzoulas et al., 2007; WHO, 2016) and provide health services as part of a wider array of ecosystems services (Jackson, Daniel, McCorkle, Sears, & Bush, 2013; Lennon & Scott, 2014; Pretty et al., 2011). These health services are understood to range from direct positive effects on mental and physical health from increased biodiversity, to improved well-being resulting from increased

[2] Understanding the environment as a 'contextual effect' on health implies that similar individuals will have a different health status in different types of places (whereas the 'compositional effects' on health concern individual characteristics within places) (Omariba, 2010).

exposure to nature, physical activity and social engagement in green spaces (Sandifer, Sutton-Grier, & Ward, 2015).

In response to the identified health benefits, high-level policy frameworks and guidance documents have increasingly promoted the creation of health supporting urban environments through the increased provision of urban green space (see for e.g., UN General Assembly, 2015; WHO, 2010; WHO, 2012, 2013). More recently, *Habitat III*, the United Nations' New Urban Agenda adopted in October 2016, identifies the improvement of human health and well-being as a key priority urban goal. Signatories to the agenda committed to the promotion of a safe, healthy, inclusive, and secure environment in cities and human settlements, specifically highlighting the importance of the creation and maintenance of well-connected and well-distributed networks of green spaces to improve physical and mental health, urban liveability and to enhance resilience to environmental risks. While such policy guidance clearly supports an emphasis on green space provision for population health and well-being, it does not provide detailed guidance for urban policy in terms of the specific attributes required to tackle lifestyle illnesses in multiple cohorts. This is partly consequent on the aggregation and homogenisation of different spatial typologies in much planning and design policy into a measure of so called "green space", without further qualification as to type or quality of such spaces. Of particular significance is how this homogenisation fails to account for the health benefits afforded to different users by different types of green space distributions and configurations (Bedimo-Rung, Mowen, & Cohen, 2005; Bowler, Buyung-Ali, Knight, & Pullin, 2010; Hartig, Mitchell, De Vries, & Frumkin, 2014; Jorgensen & Gobster, 2010; Velarde, Fry, & Tveit, 2007). Furthermore, where locational and demographically specific design guidelines for the planning, design and maintenance of green open space do exist in local contexts, the extent to which they reflect or respond to empirical evidence relating to the green space-health relationship can be disputed. Indeed, the health benefits they assert may instead emerge from designs and practices founded on ecosystems protection, flood mitigation or landscape beautification. Such motivations do not necessarily correspond with improved amenity or health benefits.

This paper addresses these issues by collating and reviewing the large quantity of evidence linking health, well-being and green space, and distilling it in a manner that renders it both accessible and useful for those involved in the planning and design of urban green spaces. This is achieved by adopting a novel life-course approach to examine the evidence for health and well-being benefits accruing from green space from prenatal development through childhood, adolescence, adulthood and old age. A literature search was undertaken using research databases including Scopus, Web of Science and Google Scholar. 'Green-space'

and ‘health’ search terms and their variants were applied and identified articles were grouped by life-course stage. In order to ensure that all key empirical studies were included, comprehensive review articles were subsequently identified and their references were cross-checked with the initial articles. Finally, the most recent articles in quality peer reviewed journals citing these review articles were identified. Informed by the evidence collated and reviewed hereunder, we propose planning and design interventions for each cohort group. Following this, we synthesise the key findings from the review of cohort-specific studies to formulate a series of cross-cutting interventions for health promoting urban green space. We conclude by suggesting a path for future research and practice. It is intended that this approach can facilitate the formulation of site specific planning guidance for the provision of more inclusive green spaces that respond to the varying needs of people across all life-course stages.

Green space and health across the life-course

Numerous studies have investigated whether there is an association between people’s access to green space or nature and personal levels of activity. More specifically, studies have examined how the design of the public realm encourages people to be more physically active, if it contributes to improved health outcomes, or if it attracts people to be more active (Coombes, Jones, & Hillsdon, 2010; S. de Vries, Verheij, Groenewegen, & Spreeuwenberg, 2003; Hillsdon, Panter, Foster, & Jones, 2006; Kessel et al., 2009; Ord, Mitchell, & Pearce, 2013). The majority of such studies have found that living in proximity to urban green space is generally associated with increased physical activity, positive health behaviours and improved health outcomes (Ellaway et al., 2005; Gascon et al., 2016; Giles-Corti et al., 2005; Giles-Corti & Donovan, 2003; Kaczynski & Henderson, 2007; Maas et al., 2006; Takemi Sugiyama et al., 2010; Tzoulas et al., 2007). However, rather than definitively verifying the trope that living close to any urban green space results in positive health behaviours, results have often varied by population cohort (see for e.g. S. de Vries et al., 2003; Gascon et al., 2016; Maas et al., 2006) and their perceptions of green space (Ord et al., 2013; Van Dyck, Cardon, Deforche, & De Bourdeaudhuij, 2011; WHO, 2016).

Furthermore, propensity to spend time outdoors is known to track from childhood. For example, Ward Thompson, Aspinall, and Montarzino (2007), identified a strong relationship between frequent childhood visits to green space and being prepared to visit such places alone as an adult. Consideration of such ‘tracking’ is important from a health standpoint since childhood inactivity has been identified as a key risk factor in many chronic diseases of later life (Marmot & Brunner, 2005; Wichstrøm, von Soest, & Kvalem, 2013), and early socially-

stimulating environments have been shown to strongly inform later emotional well-being and cognitive capacity (Danner, Snowdon, & Friesen, 2001; Jenkins et al., 2008). In order to better understand the evidence in a manner which is accessible for planning and urban design professionals, a life-course approach is advanced in order to provide a more nuanced account of green space and health relationships and how these translate to practice and design beyond a one dimensional focus on quantity of provision.

Prenatal development

The potential benefits of green space to human health have been traced right back to the prenatal condition. The effect of greenness on pregnancy and birth outcomes has been studied extensively and positive associations between greenness and the birth weight of babies have been observed across the majority of studies (Agay-Shay et al., 2014; Dadvand, de Nazelle, et al., 2012; Dadvand, Sunyer, et al., 2012; Dadvand, Wright, et al., 2014; Hystad et al., 2015; Markevych, Fuertes, et al., 2014). Studies have also linked increased exposure of pregnant mothers to green space with lower odds of a child being small for gestational age or preterm/premature (Hystad et al., 2015) and lower infant mortality risk (Kihal-Talantikite et al., 2013). Some studies have modelled complex exposures, including air pollution (Dadvand, Sunyer, et al., 2012), neighbourhood walkability, and noise (Hystad et al., 2015) with associations between increased greenness and improved birth outcomes identified (James, Banay, Hart, & Laden, 2015). Perhaps of greatest interest to planning are the mechanisms by which green space exposure of pregnant mothers potentially influences positive birth outcomes. Research undertaken by Dadvand, Sunyer, et al. (2012) revealed that exposure by pregnant women to green space and nature may have affected birth outcomes by altering their levels of physical activity, reducing maternal stress, enhancing social contacts among mothers, reducing maternal noise and air pollution exposure, and moderating ambient temperatures. The majority of analyses have adjusted for race, maternal age, season of conception, area-level socio-economic factors, and child's sex with consistent results identified (James et al., 2015).

While studies broadly indicate that there is strong evidence for associations between surrounding greenness and improved developmental and birth outcomes, a number have identified potential variability between socio-economic and cultural groups. For example, Dadvand, de Nazelle, et al. (2012) only identified increased birth weights among the lowest educated who had higher surrounding green space or lived close to a major green space. Furthermore, stronger associations between greenness and birth outcomes were variously observed among those whose parents had lower education and lower socio-economic status

(Agay-Shay et al., 2014; Dadvand, Sunyer, et al., 2012), as well as for mothers of white race as compared to immigrants (Dadvand, Wright, et al., 2014). However, on balance the evidence suggests that maternal interactions with and within green spaces are beneficial for prenatal development and birth outcomes. Table 1 summarises the key issues and, based on the evidence, suggests general planning and design interventions.

Table 1
Issues and Interventions in planning and designing green spaces for health and well-being in prenatal development

Issues	References	Interventions
Positive associations between greenness and birth weight.	(Hystad et al., 2015; Kihal-Talantikite et al., 2013; Markevych, Fuertes, et al., 2014)	Maximise greenness in the urban residential environment (views of: trees, shrubbery, green spaces, etc.)
Exposure by pregnant women to green space alters their levels of physical activity, reduces maternal stress, enhances social contacts among mothers, reduces maternal noise and air pollution exposure, and moderates ambient temperatures.	(Agay-Shay et al., 2014; Dadvand, Sunyer, et al., 2012; Hystad et al., 2015)	Safe and accessible walkways with regular seating areas should be provided for moderate exercise and social interaction. Green spaces should be of sufficient size, located at a distance from noise sources and include appropriate planting regimes to supply seated 'quiet areas' for rest and relaxation.
Increased birth weights among the lowest educated and lower socio-economic status who have higher surrounding green space or live close to a major green space.	(Agay-Shay et al., 2014; Dadvand, Sunyer, et al., 2012)	Provide well-distributed accessible green space in areas characterised by social deprivation. Park design should encourage use by pregnant women through the provision of attractive walkways and the frequent provision of park furniture, as well as amenities such as clean public toilets.
Stronger associations between greenness and birth outcomes for mothers of white race as compared to immigrants.	(Dadvand, Wright, et al., 2014)	Planning and design professionals should engage with pregnant women from immigrant and minority groups to identify barriers and opportunities for green space usage.

Childhood

A growing number of studies have suggested that children increasingly suffer from a "nature-deficit disorder" (Louv, 2005) due to a reduction in time spent playing outdoors, potentially a result of increased use of technology, parental and societal fears for child safety (Derr, Chawla, Mintzer, Cushing, & Van Vliet, 2013; Derr & Lance, 2012; Godbey, 2009; Mustapa, Maliki, & Hamzah, 2015), and aversion to nature (Bixler & Floyd, 1997). In this context, studies

have investigated multiple aspects of childhood health in terms of green space exposure, both physical and psychological.

Research has shown that green space exposure may influence the propensity to develop cardiovascular disease at any age, through the mediation of physical activity (Blair & Morris, 2009), stress, social engagement (Albus, 2010), noise, and air pollution exposure (Hu, Liebens, & Rao, 2008). For example, Markevych, Thiering, et al. (2014) undertook a cross-sectional analysis of the effects of residential greenness on blood pressure in 10-year old children and observed lower systolic and diastolic blood pressure among children from a birth cohort who had higher residential greenness, after accounting for temperature, air pollution, noise, and urbanisation.

Other studies have explored the potential relationship between green space and health in the context of contemporary lifestyles and behaviours in children. Research by Dadvand, Villanueva, et al. (2014) found that surrounding greenness was associated with 11-19% lower relative prevalence of overweight/obesity and excessive screen time (i.e. watching t.v., playing computer games etc.). In a study by Almanza, Jerrett, Dunton, Seto, and Pentz (2012), higher odds of physical activity was identified amongst 8-14 year olds when in greener areas compared to less green areas. Adding further weight to this body of evidence, a prospective study including children and youth aged 3-16 years by Bell, Wilson, and Liu (2008) found that higher greenness was significantly associated with lower Body Mass Index (BMI) values after 24 months. A greater quantum of greenness was also associated with lower odds of children and youth increasing their BMI over 2 years, presumably due to increased physical activity or time spent outdoors. In support of this assumption, an association between increased greenness of the play environment and increased playtime outdoors amongst pre-school children has been identified by Grigsby-Toussaint, Chi, and Fiese (2011). Indeed, perceived lack of green space and low playground space have been independently associated with being overweight in pre-school children (Schule, Fromme, & Bolte, 2016).

A number of studies have also considered greenness in relation to developmental behavioural outcomes in children. In an examination of the impacts of environments on attention in children with Attention Deficit Hyperactivity Disorder (ADHD), Taylor and Kuo (2009) found that subjects concentrated better after a walk in the park than after a downtown walk or a walk in the neighbourhood, concluding that "doses of nature" might serve as a safe, inexpensive, widely accessible way to manage ADHD symptoms. In a prospective study of 7–10 years old primary school children, Dadvand et al. (2015) observed improved cognitive development in children exposed to green surroundings, controlling for factors such as socio-demographics and pollution. Additionally, a study by Kyttä, Broberg, and Kahila (2012), identified that 10-15

year olds were more likely to report that they had very good health when there was significant green space around their home, after controlling for neighbourhood socio-economic status. Markevych, Tiesler, et al. (2014) observed that increased distance to the nearest green space from a child's residence was positively associated with odds of hyperactivity and inattention, but this association was only statistically significant among males, thereby suggesting that the gender of the child might affect the positive health benefits accrued from nearby green space.

Further evidence suggests that there may be important distinctions among green spaces that make some more health supportive than others for children. As discussed by Wheeler et al. (2015), research from the UK indicates that different types of urban green space (using a broad typology e.g. 'sports'/'natural') may promote physical activity to different extents among children. While not focusing specifically on children, Saelens et al. (2006) identified the assessment of presence and number of design elements and sub-elements, - especially for paved footpaths and play equipment and fields and courts items – as key to understanding green space usage. 'Specific qualities' items (e.g., continuity of a trail, drainage of slide landing area) were generally rated reliably. The qualities rated across various element categories, including condition, coverage/shade, and openness/visibility also had good reliability.

Overall, the evidence clearly suggests that childhood interactions with and within green spaces are beneficial for the health of children, both physical and psychological, as well as for their social and intellectual development. Variation in association between green space benefits and the gender and socio-economic group to which a child is a member suggests the need for green space interventions which respond to these variations and attract children from all backgrounds to green space and away from television and computer screens (Lachowycz, Jones, Page, Wheeler, & Cooper, 2012; Lovasi et al., 2013; Weiss et al., 2011; Wells & Lekies, 2006). Table 2 outlines key issues identified in the literature for green space-health associations in children and sets out some design interventions to respond to these issues.

Table 2 Issues and Interventions in planning and designing green spaces for health and well-being in childhood		
Issues	**References**	**Interventions**
Childhood inactivity and disconnection from nature leads to negative physical and mental health outcomes.	(Derr et al., 2013; Derr & Lance, 2012; Godbey, 2009; Mustapa et al., 2015) (Albus, 2010; Almanza et al., 2012; Bell et al., 2008; Blair & Morris, 2009; Dadvand et al., 2015; Dadvand, Villanueva, et al., 2014; Hu et al., 2008; Kyttä et al., 2012; Markevych, Thiering, et al., 2014)	Well-equipped and well-designed green spaces should be provided to encourage physical activity and engagement with nature among children. Evidence suggests that 'designing-in' certain elements can facilitate this (e.g. paved walkways, play equipment, fields and courts).
Association between surrounding green space and cognitive, behavioural and social development in children.	(Dadvand et al., 2015; Kyttä et al., 2012; Markevych, Tiesler, et al., 2014)	Maximize greenness in the design of the urban residential environment (e.g. incorporating trees, shrubbery and flowerbeds into the streetscape), and supply a well distributed variety of accessible pocket parks in proximity to residential units.
Increased neighbourhood vegetation associated with decreased risk for overweight children.	(Lovasi et al., 2013)	

Adolescence

A particular focus on adolescents is considered important, as this group is not only increasingly prone to physical inactivity, but studies have also shown that people are more likely to be physically active as adults if they were physically active in their late teens (Anderssen & Andersen, 2004; Gardsjord, Tveit, & Nordh, 2014). It is hence important to protect, develop and design urban green spaces with qualities that facilitate and promote physical activity in adolescence.

In '*Growing up in an Urbanising Wo*rld", L Chawla (2002) observed the neighbourhood features that teenagers valued in the 1990s compared with the 1970s remained remarkably consistent. Young adolescents reported using overgrown vacant land for exploring, creative play, and hideaways, and used parks for meeting friends, hanging out, active play, and appreciating trees and gardens (Louise Chawla, 2015). In a recent study by Woodgate and Skarlato (2015), seventy-one adolescents (12 to 19 years old) defined environments that support good health as "being outside" in a safe, clean, green, and liveable space. Indeed, multi-method evaluations continue to show that safe, accessible green spaces are highly

prized by adolescents (Derr et al., 2013; Malone, 2013). In this context, Gardsjord et al. (2014) identified 32 studies exploring which environmental characteristics contribute to physical activity among youth (age group 8–21). The characteristic most frequently reported to promote physical activity was access to green space, measured either as distance from one's home to parks and green areas, or as percentage green coverage or number of recreational facilities in the neighbourhood. The higher the amount and the closer the distance, the more the park is used with positive effect on physical activity. The second most frequently found factor was presence of informal sports facilities and other facilities for movement open to the public. Presence of such elements was generally found to have positive effects. However, these types of competitive sport facilities sometimes only attract certain groups of participants, mainly dominated by boys (Limstrand & Rehrer, 2008). As suggested by Cohen et al. (2006), girls might need other types of facilities such as attractive walkways.

Another characteristic reported to be positively related to physical activity in youth is safety, described both as absence of crime and related to features such as lighting (Gardsjord et al., 2014). Park maintenance and renovation were additional components frequently reported as important. Maintenance can be related to safety, as a well-maintained park is likely to feel safer (Kruger & Chawla, 2002). Gender differences have also been identified in the importance of safety for the use of urban parks and green spaces, with girls found to be more concerned with safety aspects than boys (Loukaitou-Sideris & Sideris, 2009).

In summary, the design of parks which promote physical and social well-being in teenagers emerges as a potentially key focus for policymakers in promoting life-long physical and psychological health and well-being through childhood, adulthood and old age. Where gender differences arise, sensitive design interventions can address different user needs by balancing dedicated play and sporting infrastructure with safe and accessible pathways, informal sheltered seating areas and improved accessibility. Table 3 identifies the key issues and interventions for the design of green spaces for 'healthy teenagers' arising in the literature.

Table 3 Issues and Interventions in planning and designing green spaces for health and well-being in adolescence		
Issues	**References**	**Interventions**
High quality neighbourhood green spaces are highly valued by teenagers. The higher the amount and the closer the distance, the more the park is used with positive effects on physical activity and social development.	(Gardsjord et al., 2014)	To encourage increased use, accessible green spaces should be provided as multi-use areas open for a range of different activities. Abundant paths for walking and bicycling that connect various activity zones and create opportunities for exercise should be provided. Drinking water sources, proximate to both facilities for movement and zones for relaxation/social engagement should be provided.
Informal and formal green spaces are used by adolescents for different purposes.	(L Chawla, 2002; Louise Chawla, 2015; Gardsjord et al., 2014)	Provide informal green spaces (i.e. wildflower meadows, scrub and untended vegetated areas) for exploring, creative play, hideaways and as important zones of shelter and relaxation for teenagers. Provide more organised spaces with pathways, seated and sheltered areas for socialising. Provide sports facilities and other facilities for movement/physical activity (e.g. fields for different ball games and gymnastic bars). These zones should also include seating possibilities.
Competitive sport facilities sometimes only attract certain groups of participants, mainly dominated by boys.	(Cohen et al., 2006; Limstrand & Rehrer, 2008)	While competitive sports facilities should be provided where possible, facilities such as walkways and paths should also be provided. Safe paths lined with carefully selected planting both leading to and within parks are potentially important for the enhancement of physical activity for adolescents of both genders through offering spaces for incidental exercise and interaction both by and between genders.
Attractive and safe green spaces are highly valued by adolescents and their parents. Furthermore, girls have been found to be more concerned with safety aspects than boys.	(Derr et al., 2013; Gardsjord et al., 2014; Kruger & Chawla, 2002; Loukaitou-Sideris & Sideris, 2009; Malone, 2013; Woodgate & Skarlato, 2015)	In general, a well-maintained park is likely to feel safer. As such, good maintenance and renovation regimes should be implemented. Paths should be kept clear and well-lit with passive and active surveillance encouraged to enable use outside daylight hours. While 'informal' areas should be natural looking, they should be overlooked to improve safety.

Adulthood

The association between increased greenness and improved health outcomes in adults has been investigated in numerous studies. In terms of physical health, cardiovascular disease (CVD) is one of the primary health effects of inactivity and stress associated with modern lifestyles. Cross-sectional research broadly supports an association between increased greenness and a range of improved cardiovascular outcomes in adults (Hu et al., 2008; Mitchell & Popham, 2008; Richardson & Mitchell, 2010). Even more convincingly, a robust prospective survival analysis by Villeneuve et al. (2012) linked higher levels of greenness with lower risk of CVD, as well as reduced risk of ischemic heart disease[3] and stroke mortality after adjustment for ambient air pollution. Further supporting the green space-physical health association, research by Astell-Burt, Feng, and Kolt (2014) found that the risk of type-2 diabetes was significantly lower in greener neighbourhoods, controlling for demographic and cultural factors, especially among participants residing in neighbourhoods with 41–60% green space land use. This association was consistent after controlling for other explanatory variables and did not vary according to neighbourhood circumstances.

In terms of behaviour, research by Takemi Sugiyama et al. (2013) identified a positive association between proximity to green spaces, in particular larger green spaces, and a higher likelihood of walking maintenance over four years. These findings are consistent with those reported in earlier cross-sectional studies examining park attributes and walking (Giles-Corti et al., 2005; Takemi Sugiyama et al., 2010), and suggest that having a park nearby or having a larger park within walking distance may help residents to maintain their walking behaviour. Furthermore, greater neighbourhood greenness or access to green space has been associated with reduced risk of: stress, propensity to psychiatric morbidity, psychological distress, depressive symptoms, clinical anxiety and depression prevalence, and mood disorder treatment in adults (Annerstedt et al., 2012; Astell-Burt, Feng, & Kolt, 2013; Astell-Burt, Mitchell, & Hartig, 2014; Sjerp de Vries, van Dillen, Groenewegen, & Spreeuwenberg, 2013; Grahn & Stigsdotter, 2003; James et al., 2015; Nutsford, Pearson, & Kingham, 2013; White, Alcock, Wheeler, & Depledge, 2013). The presence of more green space has also been linked with healthier cortisol[4] profiles while less green space typical of deprived neighbourhoods has been shown to produce higher stress and flattened cortisol profiles in

[3] Also known as coronary artery disease, ischemic heart disease is a blockage or narrowing (stenosis) of the arteries that supply blood to the heart muscle, often due to a build-up of fatty plaque inside the arteries. A severe enough blockage may cause a heart attack.

[4] Cortisol is a life sustaining adrenal hormone. Called “the stress hormone,” cortisol influences and regulates many of the changes that occur in the body in response to stress.

adults, indicating poorer capacity to recover from stress (Roe et al., 2013; Ward Thompson et al., 2012).

In order to control for the potential mediating effects of intervening variables, a number of studies have variously explored the mediating effects of physical activity, social contact, social cohesion and green space types in exploring the association between mental health and green space in adults (Sjerp de Vries et al., 2013; Fan, Das, & Chen, 2011; Maas, Van Dillen, Verheij, & Groenewegen, 2009; T Sugiyama, Leslie, Giles-Corti, & Owen, 2008). In this context, Sjerp de Vries et al. (2013) undertook analysis of the association between the quantity and quality of streetscape greenery and self-reported health and found that both quantity and quality of streetscape greenery were related to perceived general health, acute health-related complaints, and mental health in adults. Relationships were generally stronger for quality rather than for quantity. In another study, T Sugiyama et al. (2008) collected survey data relating to physical and mental health scores; perceived neighbourhood greenness; walking for recreation and for transport; social coherence; local social interaction and socio-demographic variables. Analysis revealed that after adjusting for socio-demographic variables, those who perceived their neighbourhood as highly green had 1.37 and 1.60 times higher odds of better physical and mental health, respectively, compared with those who perceived the lowest greenness.

Focusing more on green space characteristics and quality, Fan et al. (2011) observed that different components of neighbourhood green space play distinct roles in influencing stress, concluding that parks indirectly mitigate stress by fostering social support. Further exploring the potential impact of green space components on perceived health, a study by Grahn and Stigsdotter (2010) on the relationship between sensory perception of natural environments and human health found that adults identify a preference for ‘serene’ green space, followed by increased ‘space’, ‘nature’, ‘species richness’, ‘refuge’, ‘culture’, ‘prospect’ and ‘social’ dimensions. The dimensions of ‘refuge’ and ‘nature’ were found to be most strongly correlated with stress, suggesting that stressed individuals may seek out the most restorative environments. From a design perspective, the study suggests that a combination of refuge, nature and species richness could be interpreted as the most restorative environment for stressed individuals. Similarly, Astell-Burt et al. (2013) found that those in the greenest neighbourhoods were at a lower risk of psychological distress. In that study, an interaction was observed between physical activity and green space. That is, more green space did not appear to benefit mental health among the least active, but there was a protective association for the more physically active. Adding further to this growing body of evidence, recent exploratory research by Jakubec, Carruthers Den Hoed, Ray, and Krishnamurthy (2016) identified a positive trend towards improved depression markers, greater health satisfaction,

improved social relationships (in particular, love and friendship), as well as satisfaction with a sense of community and experiences of helping among adults with disabilities and their caregivers as a result of direct exposure to nature and green space.

Reflecting on this body of knowledge suggests that the green space-health association increases in complexity in adulthood. Since behaviours and attitudes towards physical activity and green space usage have been shown to develop in and track from childhood and adolescence (Danner et al., 2001; Jenkins et al., 2008), such associations (or dis-associations) would seem to be characterised by complex interactions pertaining to individual-level factors, beyond gender and socio-demographics. Nevertheless, the evidence for the green space-health association among adults is robust overall. Table 4 below sets out the key issues identified in the literature and suggests design interventions to maximise the green space-health association in adults.

Table 4
Issues and Interventions in planning and designing green spaces for health and well-being in adulthood

Issues	References	Interventions
Higher levels of green space linked with lower risk of CVD, reduced risk of ischemic heart disease, stroke mortality and type-2 diabetes.	(Astell-Burt, Feng, et al., 2014; Hu et al., 2008; Mitchell & Popham, 2008; Richardson & Mitchell, 2010; Villeneuve et al., 2012)	Maximise greenness and green space provision in the urban residential environment (trees, shrubbery, green spaces, etc). Incorporate spaces for walking, cycling and engagement with nature (e.g. wildflower borders) in such areas.
Association between proximity to green spaces – in particular larger green spaces – and a higher likelihood of walking maintenance among adults.	(Giles-Corti et al., 2005; Takemi Sugiyama et al., 2010; Takemi Sugiyama et al., 2013)	Existing walking behaviours can be maintained by providing accessible green spaces of a usable size proximate to urban residences. Such spaces should include a series of walking paths of different lengths that provide opportunity to traverse a variety of different environments (meadow, woodland, pond side etc.) and incorporate hills and plains to facilitate varying degrees of challenge.
Green space associated with reduced risk of stress, propensity to psychiatric morbidity, psychological distress, depressive symptoms, clinical anxiety and depression prevalence, and mood disorder treatment in adults.	(Annerstedt et al., 2012; Astell-Burt et al., 2013; Astell-Burt, Mitchell, et al., 2014; Sjerp de Vries et al., 2013; Nutsford et al., 2013; Roe et al., 2013; White et al., 2013)	Maximize green space provision and access in the urban residential environment. Incorporate opportunities to engage with nature for stress relief, such as the provision of pond side benches, woodland walks and edible flowerbeds.

Those in the greenest neighbourhoods found to be at a lowest risk of psychological distress and are less sedentary, suggesting an interaction between physical activity and green space.	(Astell-Burt et al., 2013; Grahn & Stigsdotter, 2010)	Increase proximity, exposure and access opportunities to a variety of different types of green spaces (sizes, configurations and attributes) to supply diversity of experiences and choice. Provide allotments to facilitate engagement with nature and potential for social interaction. Incorporate communal seating areas in parks with desirable vistas to encourage use and informal social interaction among park visitors.
The mediating effect of stress and social cohesion on green activity emphasises the potential mental and social benefits of green space.	(Sjerp de Vries et al., 2013)	
Perceived greenness associated with better physical and mental health – correlated with recreational walking and social engagement.	(Grahn & Stigsdotter, 2010; Maas et al., 2009; T Sugiyama et al., 2008)	
Improved depression markers, greater health satisfaction, improved social relationships as well as satisfaction with a sense of community and experiences of helping among adults with disabilities and their caregivers as a result of direct exposure to green space.	(Jakubec et al., 2016)	

Later life

The mechanisms through which green space affects health may ultimately affect life-span. James et al. (2015) identified a range of studies recording links between greenness and mortality. The earliest was a prospective longevity analysis by Takano, Nakamura, and Watanabe (2002), undertaken in Japan. This study asked senior citizens about characteristics of their residential surroundings. Five years later, survival rates were highest among those reporting tree-lined streets near their residence. Several analyses have subsequently examined larger scale data, including the study by Mitchell and Popham (2008) undertaken in the UK. Using a land-use dataset, this study observed a 6% lower mortality rate in administrative areas characterised by higher greenness compared to low greenness. A similar study across the UK found that cardiovascular and respiratory mortality rates decreased with increasing green space among men, but not among women (Richardson & Mitchell, 2010). Furthermore, higher rates of stroke deaths have been recorded in areas characterised by low greenness (Hu et al., 2008) and increased exposure to greenness proximate to place of residence has been linked with reduced overall non-accidental mortality among elderly inhabitants (Villeneuve et al., 2012). These findings compliment research conducted by Kweon, Sullivan, and Wiley (1998), who investigated the relationship between older adults' exposure to nearby public green spaces and their level of social integration and attachment to local community. Their study determined correlations between the use of public green space and the strength of neighbourhood social ties and sense of community for older adult residents of inner-city neighbourhoods.

With increasing frailty, going outdoors independently is often the first set of activities that elderly people find difficult to perform (Shumway-Cook et al., 2003). The resulting sedentary lifestyle is considered a genuine health risk for older people (WHO, 2003). In this context, opportunities to access a high quality outdoor environments catering for the specific needs of the elderly may play an important role in maintaining and enhancing health and well-being in later life. In their study of this issue, Takemi Sugiyama and Thompson (2007) argue that the environment which makes a choice to go out easy and enjoyable likely induces more frequent and possibly habitual use of the outdoors. Hence, planning and urban design can facilitate green space activity and recreation among older people and their caregivers by providing proximate, accessible and safe green spaces with well-maintained walking infrastructure, which is safe and wheelchair accessible. Such provision can act to encourage older people to observe, use and benefit from public green space for as long as their health condition allows. Table 5 sets out the key issues identified in the literature and suggests design interventions to maximise the green space-health association in older adults.

Table 5
Issues and Interventions in planning and designing green spaces for health and well-being in later life

Issues	References	Interventions
Higher survival rates from CDV conditions and stroke proximate to tree-lined streets and green environments.	(Hu et al., 2008; Mitchell & Popham, 2008; Takano et al., 2002; Villeneuve et al., 2012; Wilker et al., 2014)	Maximise exposure to greenness in the urban residential environment by carefully incorporating planting designs into the streetscape. Provide accessible green space of varying sizes in close proximity to residential areas (e.g. regular spatial distribution of pocket parks).
Male cardiovascular and respiratory mortality rates decrease with increasing green space.	(Richardson & Mitchell, 2010)	
Non-exercise physical activity found to reduce the risk of first time cardiovascular disease and all-cause mortality	(Ekblom-Bak, Ekblom, Vikström, de Faire, & Hellénius, 2014)	Incorporate opportunities for incidental and leisurely engagement with the environment into the design of green spaces (e.g. areas for berry picking, fragrant and colourful flowerbeds).
Relationships established between the use of green outdoor common space and the strength of neighbourhood social ties and sense of community for older adult residents of inner-city neighbourhoods.	Kweon et al. (1998)	Provide accessible walkways that vary in length, degree of difficult and that traverse various environments (e.g. open grassland, riverside etc). Such walkways should be of a high-grade finish to mitigate against falls. Provide sheltered seating areas with interesting vistas that facilitate social

		interaction, e.g. for art classes. Provide spaces for leisurely game play appropriate to elderly abilities (e.g. a bowling greens, chess tables).

Developing an integrated green space framework for health and well-being

In adopting a life-course approach, this review has identified key variations within and between population cohorts regarding the green space attributes that promote health and well-being. That is, it is demonstrated how different green space configurations afford different activities and promote different physical and psychological responses for different age groups. As such, this life-course approach facilitates a more nuanced understanding of those green space attributes that promote health and well-being than is normally evident in much research in this field consequent on such research being generally cohort specific and focused on a particular selection of variables. Hence, the remaining challenge is to synthesise this multi-cohort perspective into a green space framework for health and well-being. It is in this context that Table 6 draws together the key findings from tables 1 to 5 to identify the most pertinent evidence-based interventions that can maintain and improve population health across the life-course. The table outlines four interventions applicable across all cohorts. These are subdivided into 'planning', 'design' and 'management' interventions to facilitate ease of reference for different disciplines involved in the delivery and maintenance of green spaces. The table also identifies five interventions that span the health-promoting requirements of more than one cohort. Thus, employing this table enables those engaged in green space provision to target specific interventions that maximise benefit by catering for the needs of multiple user groups. In doing so, this framework allows practitioners to create inclusive health-promoting green spaces via interventions substantiated by a significant bank of medical, psychological and social scientific research.

Table 6 An integrated green space framework for health and well-being							
Interventions ► **Cohorts ▼**		**Cohort cross-cutting**					**Universally cross-cutting**
		Provide formal facilities for vigorous activity, such as sports courts, all-weather pitches, outdoor gymnasiums and skate parks.	Provide facilities for less vigorous physical activity that encourages social interaction and/or engagement with nature (e.g. bowling greens, sheltered outdoor class spaces, chess tables, allotments, fragrant and colourful flowerbeds).	Provide informal green spaces for exploration and adventure (e.g. wildflower meadows, scrub and untended vegetated areas, untended woodland areas).	Incorporate opportunities for incidental and leisurely engagement with the environment into the design of green spaces (e.g. areas for berry picking, fragrant and edible flowerbeds).	Provide frequent sheltered seating areas, drinking water sources and toilets.	***Planning*** Maximise streetscape greenness and green space provision in the urban residential environment (exposure, proximity and accessibility). Engage all users in park planning, with a special focus on minority groups and those in lower socio-economic classes, ensuring equal representation from each cohort to identify barriers and opportunities for green space usage. ***Design*** Provide an array of walking paths of different lengths that offer opportunities to traverse a variety of different environments, and incorporate hills and plains to facilitate varying degrees of challenge. ***Management*** Institutionalise good maintenance and renovation regimes. Paths should be kept clear and well-lit with passive and active surveillance encouraged to enable use outside daylight hours. While 'informal' areas should be natural looking, they should be overlooked to improve safety.
Life-Course Stage	**Prenatal**				✓	✓	
	Childhood	✓		✓	✓		
	Adolescence	✓		✓			
	Adulthood	✓	✓				
	Later Life		✓		✓	✓	

Conclusion

Urbanisation and the associated increasing rise of obesogenic environments are creating health and well-being challenges for the planning and design of urban environments (Davies, 2013). Concomitantly, green spaces in cities are increasingly viewed as providing locations for 'restorative' contact with nature, physical activity and social engagement, which evidence suggests positively influences well-being and triggers behavioural change towards healthier lifestyles (Beyer et al., 2014; Corkery, 2015; van den Berg, Maas, Verheij, & Groenewegen, 2010). However, current research in this field is generally limited to studies of specific cohorts and isolated variables. Consequently, there is a dearth of literature that synthesises such studies in a format that is easily deployable when seeking responses to the needs of multiple cohorts in the planning and design of green spaces. This paper has sought to address this lacuna by adopting a novel life-course approach that surveys such evidence and develops an integrated green space planning and design framework for health and well-being, providing a complementary perspective to research on gender and socio-economic differences.

In this context, however, the relationship between proximity, accessibility and green space design and health outcomes needs further investigation. In particular, future empirical research needs to focus in greater detail on the health 'services' that different types of green spaces afford to specific cohorts. For instance, while this review has considered age-cohorts across the entire life-course, these can be further divided into sub-cohorts (groups). For example, people who fall into the lower and upper end of old age (for example, a 69 year old versus an 89 year old) are distinct not only in physical but also in psychological terms (Baltes & Smith, 2003). As suggested by Takemi Sugiyama and Thompson (2007), older people in a deprived neighbourhood may also have unique problems with regard to outdoor environments. As such, it is clearly important to understand salient aspects of urban environments that have a bearing on health and quality of life for each cohort and sub-group. Knowledge from such research will help to identify and detail effective ways to plan and design healthy green spaces for all demographic and socio-economic cohorts in the contemporary city.

An enhanced evidence-base and a more nuanced understanding of the causal mechanisms and relationships are essential to developing appropriate responses and urban interventions. This is particularly the case as green space is delivered though diffuse modes – including traditional public ownership, community trusts, public-private partnerships, and increasingly by developers as a component of planning gain in the development control system. Similarly, spatial plans are often characterised by a focus on the quantum of provision or measures of accessibility and not the actual health promoting benefits of green spaces, which should be understood as part of the plan formation and Strategic Environmental Assessment (SEA)

process. This may also necessitate a sea-change in the way policy-makers 'value' land. For example, inner urban brownfield sites are often assessed in relation to their potential real estate or regeneration value (i.e. as land 'awaiting' development), when an alternative approach would be to value the land in relation to its health services potential (alongside other ecosystem services) in an effort to enhance or create new networks of urban green space (Scott et al., 2016). While high level 'aspirational' goals advancing health promoting environments, such as Habitat III, are welcome, as Barton (2010, 97) argues: 'it is all too easy for beleaguered planners under pressure from all kinds of legitimate interests to see new objectives of "mental health" or "combating obesity", as yet more rods for their backs. Understandably, professional planners can take a jaundiced view of the exponential growth of expectations placed on them by a society desperate to find solutions to intractable problems in the built environment'. In this context, this paper contributes to synthesizing the extensive evidence-base to inform critical decisions on the design and provision of green space, demonstrating the health promoting benefits of different types of green space attributes and how these can be enhanced through evidence-informed design.

Funding acknowledgement

This work was undertaken as part of the ECO-Health project, funded by the Environmental Protection Agency (EPA) and the Health Service Executive under Grant Award No. 2015-HW-MS-6, and supports the implementation of the EPA Strategic Plan 2016-2020 – 'Our Environment, Our Wellbeing' and Healthy Ireland, the national framework for action to improve the health and wellbeing of the people of Ireland.

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