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Co-benefits of urban green infrastructure: Urban storm water management and public health improvement through landscape design interventions

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Abstract

Green stormwater infrastructure (GSWI) with careful design can not only manage stormwater runoff but also provide a range of co-benefits. Integrated planning of green infrastructure (GI) for stormwater management in urban areas can help to provide multiple benefits and contribute to healthier and livable communities. GI is also prominently featured in the contemporary urban ecological model and is considered fundamental for improving urban quality of life. On this ground, this literature review studies how health benefits are associated specifically with urban GSWIs and how these benefits can be maximised in urban areas. For which, this review with the selection of scientific articles addresses the following questions in comparison GIs. 1) What are the health co-benefits of urban GSWI? 2) Does the interaction and benefit associated with GSWIs limited to one particular type of urban physical setting or scale? 3) What are the various disciplinary research findings and the gaps associated to the promotion of health benefits of urban GSWIs? The studies on the evidence of benefits of GSWIs were discovered geographically biased towards the North American and European context, potentially contributing to a focus on certain types of settings and benefits. Although many types of benefits have been studied, benefits to active living have received much more attention than the reduction of stress, therapeutic healing, social capital and reduction of crime, and mental health and functioning, despite the potential for important consequences arising from the latter. In this review, although a small sample of sources and publications were consulted, the evidence for most benefits is correlational, and even though there are several experimental studies, little is

known about the factors responsible for delivering these benefits. Moreover, these factors may vary in importance among cultures, geographic regions and socio-economic groups, for which a broader search of literature is needed. These are the key directions for future research in planning and/or designing GSWIs that would provide or proliferate the several associated co-benefits.

Keywords: urban green infrastructure #1; stormwater management #2; public health #3;

Introduction

Green stormwater infrastructure (GSWI) utilizes natural processes to infiltrate, retain, convey and treat stormwater through different elements such as detention and retention ponds, swales, rain gardens, filter strips etc. On a bigger scale, larger park parcels, conservation lands, and community open spaces are integrated to regulate the stormwater efficiently and at the same time improve the quality of life by bringing communities closer to nature (Benedict & McMahon, 2012; Coutts, 2010). These interventions not only help to reduce the adverse impacts of stormwater flooding but also improves recreational opportunities (Peters, Lenz, & Pauleit, 2017), promotes economic savings (Vandermeulen et al., 2011) and helps conserve biodiversity (Hostetler, M., Allen, W., & Meurk, C. (2011). These interventions are vital to urban areas where lack of nature and stormwater problems are prevalent. These interventions also enhance or maximize the use or functionality of its urban public space offering multiple benefits. Therefore, besides its primary purposes, the GSWI should also be resilient (Meerow, & Newell, 2017), adaptive to climatic variations (Foster, Lowe & Winkelman, 2011; York, Goharian, & Burian, 2015) and meet different user demands while offering places of reprieve and recreation (Cox, 2018).

Drawing our focus to the main intention of the paper, green infrastructure has also been considered as one of the prominent determinants of health and wellbeing in the ecological model of health (Barton and Grant, 2006) and its important role in delivering positive effects on physical health (Ulrich, 1984; Maas et al.,2006), psychological well-being (Bodin & Hartig, 2003; Kaplan,2001), and social cohesion (Shinew, Glover & Parry, 2004). These existing reviews have generally focussed on green infrastructure providing just one type of health benefit, limited to a single discipline or have focussed on one particular type of interaction with nature. However, this literature review identifies the importance of urban "GSWI" in providing health benefits to urban residents and intends to maximise the benefits as they are highly essential for the urban areas. To maximize the health benefits of urban GSWIs, it is highly important to understand its scope in the urban physical setting and scale, the associated health benefit, the various disciplinary approaches to identify the research gap and if it is different from the already known benefits of GIs.

Materials and Methods

A search algorithm was performed to identify a set of published literature concerning the health impacts of green infrastructures dealing with stormwater management. The search was conducted in the Aalto university library database (Aalto-finna) using "green infrastructure", "stormwater" and "health", as key terms for the search in titles, keywords, or abstracts. The documents with relevant terminological combinations of urban green infrastructures, on both stormwater management and human health, were critically reviewed. Most of the search results were found related to the North American or the European context although there was no pre-assumed intention of selecting studies specific to these geographical contexts. The search was conducted in April 2018 and yielded 33 papers for review.

Results and Discussion

Out of the 33 documents, only 13 papers showed the scientific evidence of health co-benefits associated directly with GSWI interventions. The reviewed documents were analyzed according to different variables already argued as important for maximizing the benefits of GSWI in urban areas through practice and research. They are (1) Physical settings and scales, (2) Types of benefits, (3); research discipline. Within each variable, different categories were defined and for each category, a distinction was made between articles dealing with overall GI or with GI specially designed/planned for Storm water management purposes (GSWI).

1) Physical settings and scales: The green infrastructure setting as reviewed through the literature is either related to 1) GI within plot boundaries, or 2) street scale or 3) city scale. In comparison to the reviews based on green infrastructure, GSWI did not receive much weight in the plot boundary

settings due to lack of scope or public participation (Burls, 2007). Moreover, since most of the papers showed the close association of urban walkability and attractiveness with GSWI, it has received proportionately more weights in the street levels as well as the city wide interventions. However, specific papers on stress reduction and social benefits of GSWI also showed their close association with improving attractiveness and interaction. Therefore, most of the research focussed towards one type of interaction with GSWI, providing one type of benefit.



Figure 1. Literature review results correlating the types of physical settings, types of benefits, type of research disciplines.

2) Types of Benefits: The reviewed papers projected five types of benefits (Figure.1). Out of the 20 papers on GI, four showed evidence of association of all the five types of benefits together to one type of urban GI intervention. While none of the GSWI papers mentioned all types of benefits at once and were more specific to a single type of benefit. In more than half of the reviewed papers, GSWIs have proved to promote active living in urban areas. The "optimization of social capital and reduced crime" scores the second highest in the chart. However, the "reduction of stress", "therapeutic healing" and "optimization of mental health and functioning" have scored less and almost weighted the same in relation with GSWIs in the review. However, the evidences for most benefits are correlational, and even though there are several experimental studies the results were more focussed towards the related disciplinary findings.

3) Research Disciplines: The reviewed studies were either from social science, environmental science, health, planning and design, or from a multidisciplinary field of research. Based on the review, benefits of urban GSWIs have been studied more in the planning and design related discipline. Multidisciplinary approach has also gained its attention but was associated with the few newer publications. This showed the significance of the emergence of multidisciplinary approaches for exploring the multiple benefits of GSWIs and their scope in planning and designing for better urban sustainability.

Conclusion

The literature search results were found to be associated only to the North American and European context, and there is a clear bias in the literature with respect to cultural and socio-economic differences between geographic regions. It is thus difficult to determine which of the reported benefits are culture specific and which can be considered universal. Therefore, a broad range of theoretical and empirical review is still needed to further examine the important dimension of the benefits associated with GSWI.

The review has showcased health and community co-benefits along with offering solutions for a variety of important public issues. It is proved that GSWIs have the equal potential of providing multiple benefits as the GIs. However, in comparison to urban GIs, considerable empirical research to explore the role of GSWI in providing co-benefits is still needed in order to involve theoretical and methodological approaches in planning and designing of GSWI for better co-benefits. Even though the classification of GSWI to the physical settings and scale of urban areas did not provide a certain significant result, but has proved that perceiving multiple benefits of GSWIs is not limited to a particular urban physical setting or scale.

The body of literature is broad and spans several disciplines although the majority has been conducted from within the planning and design field. There is noticeable contribution of this discipline in exploring the importance of social benefits associated with the GSWI design than the social science discipline itself. Although many types of health co-benefits of GSWI have been studied, benefits to active living, stress reduction and improving social capital have received more attention as they are highly important for the urban environment since they improve walkability, attractiveness, social interactions and bring urban residents closer to nature.

Overall, this literature review has documented a broad range of the benefits of urban GSWIs. It has been shown that GSWI provides access to natural green spaces within the urban area which is important for facilitating activities that are beneficial for urban health and well-being. However, because the evidence is more inclined towards descriptive findings, mechanisms that are important for delivering these benefits are less known. Therefore, it is highly important to answer the following questions - What characteristics of GSWIs are important for providing multiple benefits?

How do these characteristics may vary in importance in different geographical

contexts with different cultures and socio-economic groups? These are important directions for future research if we need to plan and/or design GSWIs to be more effective while providing maximum co-benefits.

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