

From reverse dimension to discuss the impact of landscape architecture on public health

Wenfei Yan¹, Tian Li²

College of Landscape Architecture and Art, Jiangxi Agricultural University, Nanchang, Jiangxi

Corresponding Author: Xuejian Xiao

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Abstract: Health is an eternal pursuit for human beings and a national strategy for China. At present, most of the studies on green spaces and health focus on the aspect of green space gaining health performance. In fact, there are two dimensions of landscape architecture on health, positive and negative. In this paper, we adopt the literature review and inductive-deductive approach to systematically sort out the possible adverse effects of landscape architecture on public health in different practices of planning and design, plant use, and construction and management. Based on the results of the analysis, the adverse effects of different practices of landscape architecture are regulated in three aspects: targeted design, local adaptation and proper management, in order to improve public health and well-being from multiple dimensions.

Keywords: Green Spaces, Landscape Architecture, Public Health, Reversed Dimension

I. INTRODUCTION

Since the outbreak of the novel coronavirus pneumonia COVID-19 in 2019, there has been a significant increase in research on landscape architecture and public health by scholars at home and abroad. There are more foreign studies on public health in landscape architecture, and scholars focus on the theoretical mechanisms of green space affecting public health from different disciplinary perspectives to continuously add and improve green space health perception(Xu et al., 2021), health green indicators(Vilcins et al. 2022), green space emotional improvement(Honey-Roses and Zapata, 2023), Green space health perception, green indicators of health, green space emotional improvement, green space and infectious diseases(Lu et al., 2021), Green space and infectious diseases have become the main research content. In contrast, there are few studies on landscape architecture and public health in China, and in terms of theoretical research, Fengxia Yi et al. (Fengxia Yi and Le Zhong, 2023) in terms of theoretical studies, analysed the association between landscape architecture and public health in China in recent times based on declared data; Lingshuang Meng et al.(Lingshuang Meng et al., 2022), who systematically reviewed the impact of biodiversity on physiological health and well-being; Wenwen Huang et al.(Wenwen Huang and Guangsi, Lin 2021) and Yang Yu et al.(Yang Yu et al., 2021) summarized the mechanisms of urban green space and the pathways of urban spatial health; Yunjing Hou et al.(Yunjing Hou et al., 2015) summarised the evolution of public health in the West. In terms of empirical research, the main focus is on the design and creation of spaces based on the promotion of public health(Xiaobing Huang et al., 2022). The study focuses on the design and creation of spaces based on the promotion of public health, the performance of green plants on public health(Chun Yang et al., 2022) In this study, we focus on the spatial and temporal distribution of harmful bacteria in garden plant communities that affect public health(Zuxing Wang et al., 2021). The above review shows that most of the studies have focused on the interpretation of public health-oriented spatial design and health elements, mechanisms, pathways and performance at different types and scales in the positive dimension, while there are few studies on the reverse effect of landscape architecture on public health. However, there are two sides to everything, and the same is true for landscape architecture, and studying the adverse effects of landscape architecture on public health is an integral part of the overall improvement of public health.

Based on this, the literature review method and inductive deduction method are used to systematically summarise the adverse effects of landscape architecture on public health in three different practical processes: planning and design, landscape architecture plants, and construction and management, as a theoretical basis for regulating adverse effects by means of landscape architecture, in order to enhance the level of multi-dimensional health and well-being and actively respond to the national "Health China Strategy" This will serve as a theoretical basis for the regulation of adverse impacts by landscape architecture means, with a view to enhancing multi-dimensional health and well-being and responding proactively to the National Health China Strategy.

II. CONCEPTUAL EXPLANATION

2.1. Public Health

The progress of society has led to a higher demand for one's own health, and the destruction of the ecological environment due to industrialization has led to a concern for public health, especially with the outbreak of COVID-19 in 2020, which has once again led to a deeper reflection on public health. As early as 1946, the World Health Organization defined health as "not merely the absence of disease or infirmity, but a state of complete physical, mental and social well-being. Wei Xiao(Wei Xiao, 2004) believes that public health refers to the health of the public, which is more social and public in nature than the general concept of health and health-care. Yanan Yao(Yanan Yao and Shuhua Li, 2018) believes that the health of many individuals in a group constitutes public health. The above-mentioned scholars' definition of public health focuses on "the state of health and the social nature of human beings", and the paper conceptualizes public health as the health effects on the public of the various material elements in the landscape garden space, their organizational forms and the spatial environment they form, including three levels: physiological health, psychological health and social health effects. The paper defines public health as the health impact of the material elements, their organization and the spatial environment they form on the public, including three levels: physical health, psychological health and social health.

2.2. Inverse Dimension

There is a general consensus that green spaces created by landscape gardens are beneficial to public health. However, philosophically, there are two sides to everything, and improper human intervention in the planning, design, use of materials, construction and care of landscape gardens can also have a negative effect, and the reverse dimension is referred to here as the negative impact of landscape gardens on public health, as opposed to the positive landscape architecture for public health.

III. ADVERSE PUBLIC HEALTH IMPACTS OF LANDSCAPE ARCHITECTURE

According to the different processes of landscape architecture practice, the presence of possible negative impacts on public health is divided into 3 levels: 1) landscape garden planning and design; 2) landscape garden plants; and 3) landscape garden construction and management.

3.1. Adverse effects of landscape planning and design on public health

3.1.1. Adverse effects of landscape planning on public health

The reverse impact of landscape garden planning on public health is mainly reflected in the layout of the green space system and the plant community. Firstly, at the urban scale, the lack of a scientific and rational layout of the green space system will reduce the accessibility of parkland, reduce the frequency of access to parkland spaces or change the mode of transport for residents, and thus reduce the chance of physical activity. Bo Xie et al. (Xie et al., 2018) A study of the accessibility of parkland in Wuhan found that elderly people living in areas with high accessibility were less likely to suffer from related diseases; secondly, a single plant community species and community structure is not conducive to the reproduction of certain species in the ecosystem, which in turn leads to a lack of biodiversity, reduced tolerance of human microbiota, reduced immune function(Hahtela et al., 2013) The lack of biodiversity, reduced tolerance of human microbiota, reduced immune function and increased incidence of disease(Huili Gong and Jun Zhai, 2022) In addition, green spaces near urban arterial roads or noisy areas often have the effect of blocking external environmental noise, but if the plant mix is discontinuous or discrete it is not easy to block external noise in green spaces(Guanheng Li et al., 2017) If the planting is not continuous or discrete, it is not easy to block the green space from external noise, which can bring discomfort to visitors; and overly closed vegetation can easily cause mosquitoes and insects to breed(Minghai Ma et al., 2015). The principle is that overly dense vegetation prevents predators from accessing eggs, larvae and pupae, the predation rate of mosquitoes is reduced, mosquitoes are born, visitors are itchy after being bitten.

Tab. 1: Affecting public health of landscape architecture processes, factors and paths

Process of action	Influencing factors	Pathways of Influence
Planning	Flora	Homogeneous plant community structure → hindered reproduction of certain species in the ecosystem → loss of biodiversity → increased incidence of diseases such as allergies; Poor planting mix at the edge of the parkland → insignificant external noise barrier → negative noise impact on visitors; excessively depressed plant landscapes → discourage reptiles etc. from picking up mosquitoes → less chance of mosquitoes being fed on → mosquito breeding;
	Green space system	Poor layout of the green space system → reduced accessibility

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		→ reduced physical activity → increased chance of associated diseases;
Design	Waterscape design	small, shallow, static, non-moving water bodies → high survival rate of mosquito larvae → mosquito breeding → itching after bites
	Plant species	Excessive plant density → suitable for survival of young mosquitoes → mosquito breeding;
	Vignette design	Sharp or excessively harshly coloured landscape vignettes → psychological discomfort; No obvious warning signs at steps → easy for people to fall or trip;
	Facility layout	Compact layout of amusement facilities → potential child safety threat; Inadequate lighting system → fearfulness of pedestrians at night;
Construction	Landscape materials	with material use → susceptible to harmful volatile substances or arsenic poisoning;
	Facility handling	Lack of accessibility → increased fear among the elderly Activity equipment has not been treated accordingly → it is easy to create potential hazards in children's play activities;
Stewardship	Green space sanitation	Dirty and unhygienic environment → mosquitoes;
	Plant maintenance	easily broken branches not dealt with in time → injury to pedestrians;
Plants	Physiological aspects	Improper planting of plants containing pollen allergens → allergic reactions in susceptible people; The production of fly-hair by certain plants → contact with human skin or entry into the body via the respiratory tract → allergic reactions or respiratory diseases such as rhinitis;
	Physical	Tactile: spiky plants → prickly to pedestrians or children; Taste: toxic substance flowers and fruits → susceptible to potential danger to children; Olfaction: irritating smelling plants → causing discomfort;
	Environment	Oxidation of BVOCs → atmospheric ozone synthesis →; BVOCs react with hydroxyl (-OH) to form CH ₄ → converted to CO ₂ into the terrestrial ecosystem cycle → increased greenhouse effect;

3.1.2. Adverse effects of landscape garden design on public health

The adverse effects of landscape garden design on public health are mainly reflected in the design of water features, plants and structures and the layout of facilities. Mosquitoes are one of the most important factors that adversely affect public health in green environments, and mosquitoes need to reproduce and survive in a certain environment of water and vegetation, so plant and water feature design has a direct relationship with mosquitoes. Studies have found that mosquito larvae survival rates are higher in water features that are usually small, shallow and static, and that aquatic plants are more likely to produce mosquitoes. (Walton et al., 2012, Botello et al., 2013) Greenway M. (Greenway, 2003) In a survey of aquatic plants in 15 surface runoff artificial wetlands in Queensland, it was found that waters where *Typha orientalis* Presl and *Phragmites australis* (Cav.) Trin. ex Steud. were growing were more likely to breed mosquitoes, and Giannino J.A. (Giannino and Walton, 2004) et al. found that water onions (*Schoenoplectus* (Rchb.) Palla) were more conducive to mosquito breeding than chamomile, and Tennessen K. (K., 1993) In a study on mosquito control in artificial wetlands, it was found that mosquito species and numbers were higher in wetlands planted with a mixture of *Sparganium* L., *Juncus effusus* L. and water hyacinth than in wetlands planted with chamomile alone; in addition, a depressed vegetation landscape was more likely to cause mosquito breeding (Jiazuo Hu et al., 2020) In addition, dense vegetation prevents predators from accessing eggs, larvae and pupae (Sun Qing et al., 2008) In terms of design and layout of facilities, flowerbeds, seats and other garden features with sharp corners are likely to cause psychological discomfort and potential physical threats to visitors; green spaces with poor lighting systems at night are likely to create a sense of psychological fear among pedestrians; play equipment in children's activity areas are crowded and interfere with each other, which may cause danger due to children rushing and scrambling. (Xiaoyan Pei, 2017, Yurong Zhang, 2012) The crowded and interfering play equipment in the children's activity areas may cause danger due to children's rushing and competing.

3.2. Adverse effects of landscape planting on public health

The adverse effects on public health caused by certain organs of certain plants or by the secretion of certain chemical substances are mainly physical, physiological and environmental in nature.

3.2.1. Physical adverse impacts on public health from landscape garden plant masses

By adverse physical impact on public health from landscape architecture plants, we mean that the flowers, leaves, fruits, branches and other organs of the plant body cause harm to the sensory parts of the human body. Tactilely, plants with sharp thorns and leaves in children's play areas have a negative impact on children's safety; olfactively, plants that emit irritating odours in public spaces can irritate the mucous membranes of the respiratory tract and cause discomfort in the mind; taste-wise, plants containing toxic substances in flowers and fruits planted in children's play areas are prone to accidental ingestion by children.

Tab.2 The common physical harm plants in landscape architecture

Category	Name
Spikes, sharp leaves	Silk Orchid <i>Yucca smalliana</i> Fern., Moon <i>Rosa chinensis</i> Jacq, Rose <i>Rosa rugosa</i> , Berry <i>Ilex cornuta</i> , Prickly Cypress <i>Juniperus formosana</i> Hayata, Prickly Laurel <i>Osmanthus heterophyllus</i> (G. Don) P.S. Green, <i>Robinia pseudoacacia</i> L., <i>Phoenix hanceana</i> Naud, <i>Cunninghamia lanceolata</i> (Lamb.) Hook, <i>Erythrina variegata</i> Linn. <i>chinensis</i> (Jacq.) R. Br., <i>Cycas revoluta</i> Thunb., <i>Rosa</i> sp.
Pungent odour	Horse cherry <i>Lantana camara</i> L., acacia <i>Robinia pseudoacacia</i> L., stinkhorn <i>Ailanthus altissima</i> , eucalyptus <i>Eucalyptus robusta</i> Smith, heather <i>Photinia serrulata</i> Lindl.
Toxic substances	<i>Lycoris radiata</i> , <i>Cerbera manghas</i> , <i>Semen Strophanthi</i> Divaricati, <i>Dature Stramonium</i> , <i>Rhododendron lutescens</i> Franch. <i>indicum</i> Mill., Bellflower <i>Convallaria majalis</i> Linn.

3.2.2. Physiological adverse effects of landscape architecture on public health

The so-called adverse physiological effects of landscape plants on public health refer to a series of adverse reactions to human physiology, such as respiratory diseases or skin allergies, after the reproductive organs or secreted chemicals of landscape plants have been absorbed by human respiratory tract, skin and other tissues, commonly associated with pollen pollution and flying hairs. Pollen pollution is a common part of public environmental health. Different people have different degrees of allergic reactions to the same pollen concentration in the air and have different clinical manifestations, mainly rhinitis, asthma and conjunctivitis (Yonghua Wang, 2004). The three main types are rhinitis, asthma and conjunctivitis.

The most serious impact on human health of the flying hairs produced in the garden plants belongs to the hanging bell tree, each fruit ball of the adult hanging bell has 900 to 1200 seeds, each seed tip has 100 to 150 micro-hair, and each fruit ball has 252,000 long spiny hairs, short spiny hairs 135,000 (Hongyan Su et al., 2005) In the spring and summer of each year, the cones begin to burst and the hairs start to drift away, seriously polluting the urban ecological environment, traffic safety and public health.

Flotsam is mainly produced by the seed hairs of female poplar plants, which can fly into the eyes and nostrils of pedestrians and can cause skin irritation in susceptible people, resulting in a small rash, peeling, redness and itching, and in severe cases can stimulate respiratory diseases such as asthma and chronic bronchitis. In severe cases, it can stimulate respiratory diseases such as asthma and chronic bronchitis (Ying Yang et al., 2008).

Tab.3 The common landscape plants to breast in pollen allergy China

Genus	species	Main hazard areas
Penny	Yellow-flowered Penny <i>Artemisia annua</i> Linn. and Large-flowered Large-seeded Penny <i>Artemisia sieversiana</i> Willd. <i>F. Macrocephala</i> Pamp.	National
Stinking Toon	Stinkhorn <i>Ailanthus altissima</i> , Evergreen Stinkhorn <i>Ailanthus fordii</i> Noot., Lingnan Stinkhorn <i>Ailanthus triphysa</i> (Dennst.) Alston	National
Ragweed	Ragwort <i>Ambrosia artemisiifolia</i> L., Ragwort <i>trifida</i> <i>Ambrosia trifida</i> L.	National
Amaranthus genus	Gooseberry <i>Amaranthus tricolor</i> , Old Gun Valley <i>Amaranthus</i>	South China
Neem	<i>Melia azedarach</i> L., <i>Melia toosendan</i> Sieb. et Zucc.	South China
Xylopia	<i>Casuarina equisetifolia</i> Forst.	South China

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Mulberry	<i>Morus alba</i> L., Red mulberry <i>Acalypha wikesiana</i>	South China
Li genus	<i>Chenopodium glaucum</i> , <i>ysphania ambrosioides</i> (L.) <i>Mosyakin et Clemants</i> , <i>Rosa roxbunghii</i>	South China, Southwest China
Ricinus communis	<i>Ricinus communis</i> L., red castor <i>Ricinus communis</i> L., earthwort <i>ysphania ambrosioides</i> (L.) <i>Mosyakin et Clemants</i>	East China
Humulus spp.	Hops <i>Humulus lupulus</i> Linn., <i>Pongamia conyza canadensis</i> (L.) <i>Cronq.</i>	East China
Pendula spp.	<i>Platanus pendula</i> , <i>Platanus orientalis</i> Linn.	South West, East China
Ash tree genus	<i>Fraxinus chinensis</i> , <i>Fraxinus sogdiana</i> Bunge, <i>Fraxinus mandschurica</i> Rupr, <i>Fraxinus americana</i> , <i>Fraxinus downy ash</i> , <i>Fraxinus excelsior</i>	North China

3.2.3. Adverse environmental impacts of landscape architecture plants

BVOCs (Biogenic Volatile Organic Compounds) are low boiling point, volatile hydrocarbons synthesised in plants through secondary metabolic pathways(Xuezheng Zhang et al., 2015) They have physiological and psychological health benefits, however, the effects of BVOCs are two-fold. Studies have shown that the release of certain VOCs from plants can have a detrimental effect on humans, for example, *Syringa reticulata* releases BVOCs containing high levels of linalool, benzaldehyde and phenylacetaldehyde(Yan Gao, 2005). The release of methyl acetate and nitrogenous VOCs from pearl plum (*Sorbaria sorbifolia*) are irritating and can be highly stressful to smell for long periods of time (Yuan Gao, 2019). The smell is highly stressful. In addition, BVOCs have a negative impact on tropospheric ozone synthesis, the ecosystem carbon cycle and the formation of photochemical smog and haze.

3.3. ***Adverse impacts on public health from the creation and management of landscaped garden spaces***

Throughout the life cycle of landscape gardens, improper construction, management and maintenance have a negative impact on visitor usage, environmental health and mosquitoes and insects.

3.3.1. Adverse effects of landscape architecture spaces on public health

The adverse effects of landscape architecture on public health are mainly related to the use of materials and the safety of children. The large number of harmful volatile substances present in the various types of coating, sealing, decorative and adhesive materials used in garden construction(Ryccewicz-Borecki, 2009). The use of non-slip floor coverings can cause injuries to pedestrians in rainy weather; in children's activity areas, the use of materials or coatings of the wood preservative chromated copper arsenate (CCA) can cause arsenic poisoning (Yurong Zhang, 2012, Xiaofen Duan, 2016). The use of materials or coatings of wood with the preservative chromium copper arsenate (CCA) can cause arsenic poisoning in children's activity areas(Jinghui Wang, 2009). The use of the preservative chromium arsenate copper (CCA) or coating on wood can cause arsenic poisoning(Jing Liu, 2015). and the high temperatures generated by sunlight on metal all pose safety hazards to children's play activities (Suping Qi et al., 2013). The play equipment has no anti-corrosion treatment, the wooden parts have no anti-cracking treatment, the joints are not polished smooth, there are gaps in the play equipment and the heat generated by sunlight on the metal.

3.3.2. Adverse impacts on public health arising from the stewardship of landscape garden spaces

The adverse effects of landscape garden management on public health refer to the potential adverse effects on visitors due to the lack of human management and maintenance of the garden project after it has been put in place, mainly in the following areas. Accidental burns caused by the sudden rise in temperature of the surface of the garden space and fitness facilities due to intense solar heat radiation in summer(Olsen et al., 2019). The lack of obvious warning signs at steps or the absence of barrier-free facilities where needed makes people vulnerable to falls or trips(Mei Yang et al., 2018). The poor and dirty environment of the space encourages mosquitoes and insects, which reduces visitors' interest in entering the space and their sense of experience; the untrimmed leaves and branches pose an unpredictable risk to visitors during rainy days.

IV. STRATEGIES FOR COPING WITH ADVERSE FACTORS AFFECTING PUBLIC HEALTH IN LANDSCAPE ARCHITECTURE

Based on the adverse effects of landscape planning and design, planting and construction management on public health, three major strategies are proposed: 'targeted design', 'site-specific design' and 'proper management'. The main response strategies are.

- 1) "Targeted design" —planning and design objectives to meet specific ecological or health benefits

Only by objectively understanding the ecological habits and growth conditions of various wild animals in the city, providing habitats and breeding grounds for various birds, butterflies and bees, promoting a balanced food web food chain in the ecosystem, and enhancing the tolerance of people's immune systems, can the ecological benefits of plant groups be considered. In addition, the relationship between plant formation space and the degree of confinement should be taken into account to keep the plant community sparse and airy and to avoid excessive confinement that would be detrimental to the dispersion of particulate matter in the green space. Water bodies should be designed to be as large and deep as possible, with dynamic flowing water systems, and to reduce the use of mosquito-prone tree species in high-traffic areas or to install mosquito-repellent lights at mosquito-prone plants.

2) "Appropriate to the location" — the selection of landscape garden plant species needs to be appropriate to the location, suitable and appropriate amount

The selection of landscape garden plants should avoid poisonous thorny plants in children's play areas or plants with irritating odours in high-traffic areas. In addition, allergenic plants should be placed downwind to reduce their dispersion, and allergenic plants should not be located at roadsides, but should be screened by tall, non-allergenic plants with dense foliage, and pollen-producing plants should be used sparingly in high-traffic areas. Hover trees that produce flocculent can be used as flocculent "inhibitors" to reduce the adverse effects of flocculent, and female species are preferred for future plantings. Many landscape plants, although they have some public health disadvantages, have a good ornamental value and are frequently used in practical projects, where visitors should be warned of signs such as "pollen allergy or poisonous thorn injury".

3) "Stewardship in place" —spatial environmental health and plant landscape appearance need to be maintained in a timely manner

In the process of landscape garden construction, the use of materials that produce volatile and harmful substances should be minimized and the use of low-carbon recycled and recyclable materials should be promoted. The surface of children's playgrounds should be treated with anti-rust and anti-corrosion treatment, polished smooth, and the joints of facilities should be smoothly articulated. Hygiene problems in the garden environment should be solved in a timely manner to avoid affecting visitors' experience due to the dirty environment. Management and maintenance need to be timely and precise to avoid unsafe effects of dead branches and leaves on pedestrians under the action of natural forces.

V. CONCLUSION

Based on a review of domestic and international literature, the adverse effects of landscape architecture spaces on public health have been investigated at three levels: landscape architecture planning and design, plants, construction and management, and three major strategies have been proposed: "targeting design", "adapting to local conditions" and "management and care", It also proposes three major strategies to deal with the problem, namely "targeted design", "appropriate design" and "proper management", in the hope of providing a more comprehensive theoretical basis for landscape architecture to contribute to public health.

It should be noted that certain influencing factors have both positive and negative effects on public health, such as Zhiping Wu(Z.P. Wu, 2007) found that multi-layered composite tree, shrub and grass community structures had higher concentrations of harmful particulate matter than single lawns or shrubs, while Huili Gong (Huili Gong and Jun Zhai, 2022), For example, Zhiping Wu found that a multi-layered complex tree and shrub community structure had higher concentrations of harmful particulate matter than a single lawn or shrub, while Huili Gong found that a multi-layered plant structure was conducive to maintaining the stability of the ecosystem and reducing the incidence of allergic diseases through a study on the effects of biodiversity on the production of hay fever.

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