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Residential open space and the perception of health benefits: How much is the public willing to pay?

Abstract

Emerging evidence suggests that residential open space (ROS) is beneficial for multiple health outcomes for urban residents. However, the general public’s understanding of and demand for the health benefits related to ROS have not been widely explored. This study aims to examine the impact of residents’ socioeconomic status and perceptions of landscape health benefits on their willingness to pay (WTP) for ROS and to evaluate the perceived monetary value of different residential landscape elements. An online survey with 1,348 respondents was conducted between August 2020 and October 2021 in China using a contingent valuation (CV) method. Respondents perceived the landscape benefits related to mental health to be higher than those related to physical and social health. The perception of landscape health benefits positively affected WTP and the WTP value of ROS. Residents’ monthly income was a significant influencing factor for WTP and the latter’s value. For individuals with positive WTP, the average annual WTP for ROS was CNY 68.98 (USD 10.81), while for all the respondents, the estimated mean annual WTP for ROS was CNY 91.75 (USD 14.38). Moreover, the estimated WTP for plants was the highest, whereas the WTP for activity spaces was estimated as the lowest. These findings may improve city planners’ and community managers’ understanding of the perceived value of residential landscapes among the public and help them make effective decisions to build healthy communities.

Keywords:
Residential open space; Health benefits; Perceptions; Willingness to pay; Contingent valuation method
1. Introduction

Urbanization is a pressing global challenge in the 21st century, and an estimated 68% of the world’s population will reside in urban areas by 2050 (United Nations, 2018). Although cities offer better access to health care services, the negative environmental impact of urban sprawl has put pressure on human health (Zhao et al., 2014; Jazani et al., 2015). Developing healthy cities has therefore become crucial for the population’s well-being. Over the past two decades, China’s residential land has expanded dramatically, along with urban expansion (Zhao et al., 2020).

Despite being the most readily accessible living environment for residents’ health, China’s residential landscape has received less attention than that of Western countries (Wu et al., 2019). Therefore, a deeper understanding and valuation of the residential landscape is needed to promote healthier cities in China.

Residential open spaces (ROSs) in housing estates offer important communal spaces to support residents’ daily outdoor activities (Sugiyama et al., 2010). An ROS is a public or semi-private green space that is usually created in connection with residential buildings and reserved from construction when land is designated for residential development (Lynch, 2021). ROS can be understood as a collective green good that is often owned by residents or housing associations and managed by estate management companies (Xiao et al., 2017; Lynch, 2021). ROSs are among the most common everyday therapeutic landscapes that can promote multiple dimensions of health (Groenewegen et al., 2012; Henderson et al., 2016; Rachele et al., 2019; Crouse et al., 2021). However, few studies have examined the degree to which residents value these spaces, how they regard their immediate living environment’s ability to promote health, or which health benefits are most recognized (Säumel et al., 2021). These factors could influence the way people experience, use, and manage ROSs (Zhang et al., 2020). Thus, examining the public’s perception...
of the health benefits of ROS is important to decipher the undiscovered health potential of these spaces.

From a housing market perspective, the presence of ROS increases the value of nearby housing, thus raising housing prices (Jones and Reed, 2018). However, ROS is a type of public and nontraded good and environmental asset that provides multiple services in a residential collective and has no market price (Fausold and Lilieholm, 1999; Yang et al., 2016). The contingent valuation (CV) method is the most common survey-based method applicable to the estimation of the monetary value of nonmarket environmental assets (Lo and Jim, 2015; Guo et al., 2020). This method investigates an individual’s willingness to pay (WTP) (Mitchell and Carson, 2013). WTP can mirror the monetary value of underlying benefits that residents perceive or expect from the environment (Liebe et al., 2011). While an increasing amount of empirical research estimates people’s WTP for green spaces using the CV method (Chen and Qi, 2018; Xu et al., 2020), it has been rarely used to measure the value of ROS. The available evidence indicates that public perception, knowledge, beliefs, sense, and awareness are the primary contributors to the WTP for a variety of environmental goods (Sun et al., 2016; Wang et al., 2018; Tian et al., 2020). However, the influence of the public’s perception of landscape health benefits on their WTP for ROS remains underexamined. Furthermore, the healing atmosphere of ROS may depend on the residents’ demand or preference for certain types of landscape elements. Thus, residents’ WTP for different types of landscape elements in ROS merit further investigation.

In this context, an online survey was conducted in China to investigate the public’s perception of landscape health benefits and to elicit respondents’ WTP for ROS using the CV method and payment-card format. This study aims to examine the impact of the public’s
socioeconomic status and perception of landscape health benefits on their WTP for ROS and to assess residents’ WTP for various types of residential landscape elements.

2. Literature review

2.1. Residential open space and health benefits

In health geography, a therapeutic landscape is a supportive environment that interweaves physical, mental, social, and spiritual components to enhance health and healing (Taheri et al., 2021). Growing evidence suggests that ROS, as one of the most common therapeutic landscapes, can provide health benefits. The World Health Organization (WHO) defines health as “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” (World Health Organization, 2014). The three dimensions of the health benefits provided by ROS are outlined below.

Research has supported the positive impact of ROS on physical health. Neighborhood characteristics, such as pedestrian infrastructure (e.g., the provision of footpaths or seating) and aesthetics (e.g., greenery), are associated with positive physical function (Rachele et al., 2019), blood pressure (Yang et al., 2019), sleep quality (Xie et al., 2020), neurological health (Min et al., 2021), respiratory health (Wu et al., 2021), and the decreased incidence of cardiovascular diseases (Liu et al., 2021b). The evidence also shows the mental health benefits of ROS, including stress reduction, attention-fatigue recovery (Detweiler et al., 2012; Crouse et al., 2021), mood regulation (Rautio et al., 2018; Chen et al., 2020), an increased perception of well-being (de Keijzer et al., 2020), and a lower risk of depression, anxiety, and aggression (Gascon et al., 2015; Liao et al., 2020). For example, a longitudinal study indicated that natural landscapes near one’s home are positively linked with better mental health, such as increased happiness and...
decreased sadness, anxiousness, and negative emotions (Van Aart et al., 2018). Furthermore, ROSs are considered crucial places for social interaction, and recent studies have shown that ROS is associated with social health. The amount and quality of neighborhood green space, its aesthetics, and perceived safety are associated with improved social cohesion, ties, and engagement (Henderson et al., 2016; Ruijsbroek et al., 2017).

Despite increasing evidence supporting the health benefits of ROS, most studies have focused on only one or two dimensions of health. Studies examining a broad range of health benefits in neighborhood environments simultaneously remain scarce (Zhang et al., 2019). While the health benefits of ROS have received increasing attention, the public’s understanding or perception of these health benefits, which may influence their behavior toward such spaces, remains unknown.

2.2. Perception and the WTP for environmental assets

Perception, a term used in human geography, refers to an individual’s view of the environment derived from the cognitive processes that sense, organize, and interpret their knowledge, experience, and information about that environment (Kaymaz, 2012; Morin, 2020). Environmental perception is an important process that shapes how people interact with their environments (Scholte et al., 2015). WTP is a behavioral intention reflecting an individual’s preference for public goods and services (Mitchell and Carson, 2013). Social cognitive theory and the theory of planned behavior propose that attitudes and perceptual determinants, including the perception of risks and benefits, can affect environmental- and health-related behaviors and actions (Bandura, 2004; López-Mosquera et al., 2014). In addition, the public’s intuitions, feelings, and knowledge generally translate into their WTP.
A growing body of literature has focused on exploring the relationship between perception and WTP for environmental assets. Some studies have shown that the WTP for environmental risk reduction depends on risk perception. For example, Istamto et al. (2014) found that individuals who were aware of the health risks of air pollution and noise reported a greater WTP to avoid health risks. Hunter et al. (2012) pointed out that respondents’ WTP for reductions in environmental health risks was strongly affected by their socioeconomic characteristics and usage of the waterbody as well as their perceptions of the risks. Alternatively, recent research has shown that WTP is affected by the perceived benefit and value of a specific landscape, which relies on the cognition of its utility and contribution to well-being (Targetti et al., 2021). Xu et al. (2020) and Tian et al. (2020), for instance, found that residents’ awareness of the economic value of urban green space and their perceptions of ecosystem service benefits increased their WTP for the conservation of those spaces in China. Perceived aesthetic benefits and the quality of the environment influenced the WTP for environmental protection and improvement (Grala et al., 2012; Liu et al., 2021a). Similarly, the perceived quality of urban parks strongly affects residents’ WTP for nearby houses (Zhou et al., 2021). Previous studies have included socioeconomic factors when determining the psychosocial factors of WTP (Lo and Jim, 2015; Zhang et al., 2021).

The perception of health benefits, or the feeling of health derived from the surrounding environments and landscapes, can motivate residents to spend time in nature and outdoor spaces for their health. However, the effect of this perception of the health benefits of everyday therapeutic landscapes on residents’ WTP has received little attention in the literature. Although understanding the WTP for specific ROS landscape elements would help identify residents’
preferences and desires, little research examines the perceived monetary value of specific ROS landscape elements.

Given the gaps in the literature, a CV survey was used to investigate residents’ socioeconomic status and perceptions of landscape health benefits and elicit their WTP for ROS and different types of residential landscape elements. A theoretical framework was developed to examine the relationship between the perception of landscape health benefits, socioeconomic status, and WTP (Fig. 1). More specifically, this study aimed to address the following questions:

1) To what extent are residents aware of the health benefits of ROS, and which dimensions of the health benefits related to the landscape are most acknowledged?

2) Do residents’ perceptions of landscape health benefits affect their willingness to pay for ROS?

3) Which types of residential landscape elements are residents willing to pay for?

Fig. 1. Theoretical framework.

3. Materials and methods
3.1. Questionnaire design

The survey was intended to elicit residents’ preferences for ROS and identify the influencing factors, such as socioeconomic status and the perception of health benefits, on their WTP for ROS. The CV method is sensitive to inappropriate implementation and introduced biases (Morrison et al., 2000; Venkatachalam, 2004). These possible methodological flaws were addressed through careful questionnaire design. The survey design and administration were conducted following the standard guidelines of the CV method to improve the validity and reliability of the study (Johnston et al., 2017). After the questionnaire was drafted, a pre-test survey was conducted with 50 randomly selected respondents to obtain the WTP bid distribution and reduce potential bias in the formal investigation. Based on the feedback from the pilot survey, we improved the clarity of the questionnaire by adding a research objective statement and modifying the question wording. The final questionnaire consisted of three parts: (1) perceptions of landscape health benefits, (2) WTP for ROS, and (3) demographic variables.

The first section of the questionnaire collected residents’ perceptions of specific health benefits related to landscape. The respondents were asked to use a 5-point Likert scale (where 1 = strongly disagree and 5 = strongly agree) to rate how strongly they agreed or disagreed with the capacity of ROS to promote physical health (e.g., improving sleep quality, lowering blood pressure, improving physical function, and reducing the risk of chronic disease), mental health (e.g., improving affect, facilitating stress recovery and attention-fatigue recovery, and reducing aggression), and social health (e.g., increasing a sense of safety and promoting social relationships, social cohesion, and communication among neighbors).
In the second section, a hypothetical market scenario was provided to explore participants’ WTP to improve ROS. The common payment card approach was used to elicit monetary values because it is a simple, efficient, and conservative form of sequential bidding. This approach avoids the starting point bias that can result from bidding games and dichotomous choice methods and can also prevent high non-response rates to open-ended questionnaires (Yang et al., 2018; Withey et al., 2019). The respondents were asked whether they were willing to pay a certain amount annually to support the improvement and maintenance of ROS for its health benefits. An increased annual property management fee was assumed to incorporate the cost. Respondents were encouraged to consider the existing residential environment and their actual payment capacity. Additionally, respondents were reminded of the importance of stating their true preferences. Those who reported positive responses were then encouraged to select the highest amount that they would be willing to pay annually for ROS. The payment card provided to the respondents presented 13 WTP levels (CNY 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 150, 200, and 250; USD 1.00 = CNY 6.47 in 2021). Moreover, the respondents were asked to state their WTP for six specific residential landscape elements, including a water feature (artificial or natural), plants (e.g., trees, lawns, and flowering plants), pathways (e.g., walking or cycling paths), rest facilities (e.g., seats and pergolas with chairs), amenity facilities (e.g., exercise facilities, swings, and slides), and activity spaces (e.g., plazas or playgrounds). Therefore, the WTP represents residents’ relative preferences for different landscape elements. If the respondents gave negative responses for their WTP (WTP = CNY 0), they were asked to select the reasons for their responses from a list to identify protest votes and true zero responses.
The third part of the survey collected demographic information about the respondents, including age, gender, education level, monthly income, job, family size, and residence location, aiming to analyze the impact of personal characteristics on their WTP.

3.2. Data collection

An online survey was made open to the public to investigate residents’ perception of landscape health benefits and their WTP for ROS. The formal survey was distributed through the Wenjuanxing website (https://www.wjx.cn/), an online survey platform in China, for 15 months between August 2020 and October 2021. Participants over the age of 18 were recruited via social media and email using a random sampling technique. The website-based survey method was utilized because it is cost-efficient and can gather a broad sample across cities with various levels of urbanization. In addition, most Chinese residents have good Internet access. China’s Internet penetration rate was 70.4% at the end of 2020 (China Internet Network Information Center, 2021). Before participants agreed to take the survey, they were informed that all the data they provided would be anonymous and only used for academic purposes. A total of 1,380 respondents completed the questionnaire. After removing incomplete questionnaires, 1,348 valid responses remained, yielding a high valid-response rate of 97.7%.

3.3. Statistical econometric models

Given the relatively high percentage of non-WTP responses among the samples, a two-stage model that differentiated between analyses of respondents’ WTP and the magnitude of the WTP was used. The first stage estimated the probability of a positive WTP response and determined the factors that affected respondents’ attitudes with a logistic model. The second
stage distinguished the factors that significantly affected the magnitude of the WTP with ordinary least squares (OLS), interval regression, and Heckman two-step models.

3.3.1. Logistic model

In the first stage, multilevel logistic regression models were used to analyze the factors affecting respondents’ WTP. The dependent variable was a binary variable that coded “0” if the respondent decided not to pay, and “1” if the respondent reported a positive WTP. The probability of respondents’ WTP can be expressed as follows:

\[ E(y_i) = P(y_i = \text{yes}|x_i') = \frac{\exp(\beta x_i')}{1 + \exp(\beta x_i')} \]  (1)

where \( P \) is the probability of a respondent being willing to pay, \( x_i'(i = 1,2, ..., n) \) is a vector of explanatory variables, \( i \) is an individual, and \( \beta \) is the coefficient to be estimated for each explanatory variable. The logistic model function can be interpreted as follows:

\[ \frac{P}{1-P} = \exp(\beta x_i') \]  (2)

\[ \logit(P) = \ln \left( \frac{P}{1-P} \right) = \alpha + \beta x_i' + \epsilon \]  (3)

where \( \frac{P}{1-P} \) is the ratio between the probability of agreeing to pay and the probability of refusing, \( \alpha \) is a constant to be estimated, and \( \epsilon \) is the random error.
3.3.2. Ordinary least squares model

The second stage of analysis determined which variables affected the magnitude of the WTP. The OLS model, excluding zero WTP, was used as the basic model. To reduce skewness, the log transformation of WTP was designated as a dependent variable:

\[ \ln(WTP_i) = \beta x_i' + \epsilon, \]  

where \( WTP_i \) is the WTP bid that the respondent chose in the payment card, which is explained by the independent variables \( x_i' \) \((i = 1,2, \ldots, n)\), \( \beta \) is the estimated coefficient in the analysis, and \( \epsilon \) is the random effect, which is assumed to be normally distributed with mean = 0 and standard deviation = 1. Due to the payment card study design and possible sample selection bias, simple OLS regression can yield biased parameter estimates, leading to unreliable inferences regarding the effects of explanatory variables on the value of public goods (Cameron and Huppert, 1989). Therefore, interval regression and Heckman two-step models were also employed for further analysis.

3.3.3. Interval regression model

Several respondents indicated no WTP in the CV survey, including both protest votes and true zero responses. Simply removing the non-WTP responses may result in selectivity bias in the WTP estimates. The protestors are assumed to have positive WTP but to be refusing to reveal their true valuation. However, respondents with positive WTP may also harbor latent protest beliefs. Therefore, omitting the negative protest responses but not those expressing positive WTP with protest beliefs is unreasonable (Lo and Jim, 2015). The protest bids were regarded as legitimate zero bids and the non-WTP responses were included in further analyses. The empirical
approach asserts that the true WTP responses that are latent and unobserved fall in the interval between the stated highest WTP value and the next higher amount on the payment card. The interval regression model was considered more appropriate for the data obtained from the payment card approach (Notaro and De Salvo, 2010; Challcharoenwattana and Pharino, 2016; Chen and Qi, 2018; Tonin, 2018). The valuation function is as follows:

\[ \log(WTP_i) = \beta x'_i + \epsilon, \]  

(5)

where \( WTP_i \) is the true WTP of respondent \( i \), \( x'_i \) denotes the vectors of the explanatory variables, \( \beta \) is the corresponding vector of undetermined coefficient, and \( \epsilon \) is the stochastic component that is normally distributed with a mean of 0 and a standard deviation of \( \sigma \). As the true WTP, \( WTP_i \), cannot be directly observed, the model places \( WTP_i \) within the interval between the specified amounts the respondents selected from the payment card as the lower threshold \( t_{li} \) and the next higher amount from their selection as the higher threshold \( t_{hi} \). The probability of the respondents’ true WTP is given by the following equation:

\[ \Pr(t_{li} \leq WTP_i < t_{hi}) = \Pr[(\log t_{li} - \beta x'_i)/\sigma \leq z_i < (\log t_{hi} - \beta x'_i)/\sigma], \]  

(6)

where \( z_i \) is the standard normal random variable. The joint probability density function for \( n \) independent observations can be interpreted as a likelihood function defined by \( \beta \) and \( \sigma \) (Tonin, 2018). The log-likelihood function for the interval regression model can be written as follows:

\[ \log L = \sum_{i=1}^{n} \log [\Phi(z_{hi}) - \Phi(z_{li})], \]  

(7)

where \( \Phi(\cdot) \) is the cumulative density function of the standard normal distribution and \( z_{hi} \) and \( z_{li} \) represent \( (\log t_{hi} - \beta x'_i)/\sigma \) and \( (\log t_{li} - \beta x'_i)/\sigma \), respectively. Estimates of the parameter vectors of \( \beta \) and \( \sigma \) can be used to calculate the mean WTP:
Mean WTP = \exp(\beta x'_i + \sigma^2/2) \quad (8)

3.3.4. Heckman two-step model

To correct the sample selection bias in the survey, the Heckman two-step model was adopted. The model was divided into two procedures. The first, the selection function, used a probit model to estimate whether the respondents are willing to pay (Withey et al., 2019). It is expressed as follows:

\[ Z^*_i = \alpha w'_i + \mu \quad (9) \]

where \( Z^*_i \) is the unobservable variable, \( w'_i \) is the vector of the independent variables affecting whether the respondents are willing to pay, and \( \mu \) is the residual term assumed to follow a normal distribution \( N(0, \sigma^2_\mu) \). The variables with a significant impact on WTP in the logistic model were included as independent variables. \( Z_i \) denotes a binary variable that takes the value “1” if an individual is willing to pay and “0” otherwise. This was modeled as follows:

\[ Z_i = \begin{cases} 1 & \text{if } \alpha w'_i + \mu > 0 \\ 0 & \text{if } \alpha w'_i + \mu \leq 0 \end{cases} \quad (10) \]

In the second procedure, the magnitude of the WTP is estimated with OLS. Whether the WTP amount is observed depends on the selection function; \( Y_i \) is observable if \( Z_i = 1 \). The valuation function that determines the magnitude of WTP is as follows:

\[ \ln (Y_i) = \beta x'_i + \varepsilon \quad (11) \]

\[ E(\ln(Y_i)|Y_i \text{ is observable}) = \beta x'_i + \rho \sigma \lambda (\alpha w'_i) \quad (12) \]
where \( Y_i \) is the amount that an individual is willing to pay, \( x'_i \) is the explanatory matrices for the valuation equation, \( \varepsilon \) is the residual term assumed to follow a normal distribution \( N(0, \sigma^2_\varepsilon) \), \( \beta \) represents the unknown coefficients, \( \rho \) is the correlation coefficient between \( \mu \) and \( \varepsilon \), \( \sigma \) is the standard deviation, \( \lambda(\alpha w'_i) = \frac{\phi(\alpha w'_i)}{\Phi(\alpha w'_i)} \) is the inverse of the Mills ratio, and \( \phi \) and \( \Phi \) are the standard normal density and standard normal functions, respectively. The selection and valuation equations could be estimated separately if \( \rho = 0 \). When \( \rho \neq 0 \), there is evidence that sample selection will be an issue in the model.

In this study, the independent variables consisted of four groups, including the respondents’ demographic characteristics, their perception of landscape benefits for physical health, their perception of landscape benefits for mental health, and their perception of landscape benefits for social health (Appendix Table S1). Therefore, four models were built for each estimated approach. Only the demographic characteristics were included as independent variables in Model 1. Then, Models 2 and 3 added the perception of landscape benefits for physical and mental health, respectively. Model 4, the complete model, further incorporated the perception of landscape benefits for social health. Statistical analysis was conducted with SPSS 22 (IBM Inc, Armonk, NY, USA) and Stata 14 (Stata Corp, College Station, TX, USA).

4. Results
4.1. Descriptive statistics

4.1.1. Socioeconomic characteristics of the participants

The demographic and socioeconomic characteristics of the 1,348 respondents are summarized in Appendix Table S2. Most of the sample (62.65%) was between 18 and 39 years old; 30.45% of the respondents were between 40 and 59 years old, and a few respondents (3.93%) were over 60 years old. There were more female (64.02%) than male (35.98%) respondents. Approximately 70.10% of the participants held a bachelor’s degree. Over half of the respondents (51.78%) earned a monthly income less than CNY 4,000 (USD 612), while 22.55% of the respondents earned CNY 4,001–8,000 (USD 612.15–1,224), 12.54% of the respondents earned CNY 8,001–12,000 (USD 1,224.15–1,836), and 13.13% of the respondents earned more than CNY 12,000 (1,836 USD). The participants’ occupational profiles showed that 23.07% of the sample had jobs related to the local environment. A relatively high proportion of respondents (34.45%) had three family members. More than half of the participants (58.09%) were living in the central city.

4.1.2. Analysis of non-WTP

Of the 1,348 valid responses to the online questionnaire, 842 respondents (62.46%) displayed a positive WTP and selected a preferred bid from the payment card, indicating their WTP for the construction and improvement of ROS. The reasons for respondents’ non-positive responses are presented in Table 1. Of the 506 zero WTP responses, 54.74% were genuine zero responses (due to economic constraints or failure to recognize the utility of ROS), while 45.26% were protest zero responses (due to concerns about the fairness of the payment). The main reasons for participants providing true zero responses were, “I cannot pay because of low
household income” (selected by 38.34% of the participants who were unwilling to pay), “I think the ROS is good enough and does not need further improvement” (12.45%), and “I am not interested in the construction of the ROS” (3.95%). Furthermore, 24.51% of the respondents that gave protest responses believed that the cost of residential landscape construction should be paid by the government or property management organization and 16.40% expressed distrust and concern regarding how the payment would be used.

Table 1. Respondents’ reasons for their unwillingness to pay.

<table>
<thead>
<tr>
<th>Response</th>
<th>Number</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Genuine zero responses</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cannot pay because of low household income.</td>
<td>194</td>
<td>38.34</td>
</tr>
<tr>
<td>The residential open space is good enough and does not need further improvement.</td>
<td>63</td>
<td>12.45</td>
</tr>
<tr>
<td>Not interested in the construction of the residential open space.</td>
<td>20</td>
<td>3.95</td>
</tr>
<tr>
<td><strong>Protest zero responses</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The government or the property management department should pay for the residential landscape construction.</td>
<td>124</td>
<td>24.51</td>
</tr>
<tr>
<td>Concerned the contributions would not be used to improve the residential landscape.</td>
<td>83</td>
<td>16.40</td>
</tr>
<tr>
<td>Other reasons.</td>
<td>22</td>
<td>4.35</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>506</td>
<td>100.00</td>
</tr>
</tbody>
</table>

4.2. Perceptions of landscape health benefits

As listed in Appendix Table S1, residents’ perceptions of the landscape’s benefits for physical, mental, and social health were measured. The respondents perceived the landscape as very capable of providing health benefits (scoring 3–4 out of 5). Generally, most respondents acknowledged the capacity of ROS to support mental health. Measured as constructs, the average scores for the perception of landscape benefits for physical, mental, and social health were 3.84,
The distribution of perceptions was visualized with violin plots (Fig. 2). For the perceived ability of ROS to provide specific health benefits, the average score for “facilitating stress recovery” was the highest (4.35), followed by “improving affect” (4.32), “facilitating attention-fatigue recovery” (4.27), and “improving sleep quality” (4.12). Among all variables, “reducing the risk of chronic disease” had the lowest mean score (3.56).

Fig. 2. Violin plots showing the distribution of the responses for the perception of landscape health benefits. The width and length of the violins indicate the data frequency and range. The median values are indicated with white circles. The interquartile ranges and 95% confidence intervals are plotted as black rectangles and lines, respectively.
4.3. Factors affecting the WTP and WTP value

Logistic regression models were employed to explore the determinants of WTP for ROS (Table 2). The results of Model 2 indicated that the perception of landscape benefits for improving physical function (“PHY_FUN”) had a significant positive relationship with WTP. The results of Model 3 indicated a positive and statistically significant relationship between the perception of landscape benefits for facilitating stress recovery (“STR”) and WTP. The results of Model 4 showed that the perception of landscape benefits for promoting communication among neighbors (“COM_NEI”) positively affected WTP. The perceptual variable for improving physical function (“PHY_FUN”) dropped out as a significant predictor in the full model but facilitating stress recovery (“STR”) remained significant. For any one-unit increase in the perceived capability of the landscape to facilitate stress recovery and promote communication among neighbors in Model 4, the probabilities of respondents’ WTP for ROS were 1.35 ($e^{0.30}$) and 1.82 ($e^{0.60}$) times greater, respectively, than that they refused to pay. Moreover, the Model 4 logistic results indicated that age, monthly income, and family size significantly affected respondents’ WTP for ROS.

Given the relatively high percentage of non-WTP responses among the samples, separate analyses for positive WTP responses alone and the full samples including zero-WTP responses were conducted to identify factors affecting the WTP value. The coefficients from the OLS (excluding non-WTP), interval regression, and Heckman two-step (including non-WTP) models are listed in Table 3. The OLS model results suggest that the perception of landscape benefits for improving sleep quality (“SLE”) and physical function (“PHY_FUN”) significantly and positively affected WTP value in Models 2 and 3, but physical function lost its significance in
Model 4. For respondents reporting positive WTP, education level and monthly income were positively and significantly correlated with the magnitude of their WTP.

The interval regression model results consistently indicated that the perception of landscape benefits for improving sleep quality (“SLE”), physical function (“PHY_FUN”), and facilitating stress recovery (“STR”) were significant predictors of the WTP value in Models 2–4. Furthermore, as the Model 4 interval regression results show, promoting communication among neighbors (“COM_NEI”) also significantly affected the WTP value. In other words, respondents who had greater confidence in the landscape’s capacity to improve sleep quality or physical function, aid stress recovery, and promote communication among neighbors were willing to pay more for ROS. However, the Heckman two-step models show that only one perceptual variable, improving sleep quality (“SLE”), increased the WTP value. Education level and monthly income affected the WTP value in both the interval regression and Heckman models. The coefficient of the inverse Mills ratio in the Heckman two-step model was insignificant, indicating no evident signs of sample selection bias in the model.
Table 2. Results of the logistic regression model for the WTP.

<table>
<thead>
<tr>
<th>Explanatory variables</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-1.00***</td>
<td>-2.24***</td>
<td>-2.80***</td>
<td>-3.26***</td>
</tr>
<tr>
<td>Demographic characteristics</td>
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<td></td>
</tr>
<tr>
<td>GEN</td>
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<td>0.17</td>
<td>0.16</td>
<td>0.15</td>
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<tr>
<td>EDU</td>
<td>0.66***</td>
<td>0.50**</td>
<td>0.39*</td>
<td>0.34</td>
</tr>
<tr>
<td>AGE_dum2</td>
<td>0.27</td>
<td>0.24</td>
<td>0.24</td>
<td>0.34*</td>
</tr>
<tr>
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Note: The dependent variable is the willingness to pay (WTP) for residential open spaces. *p < 0.05, **p < 0.01, ***p < 0.001.
<table>
<thead>
<tr>
<th>Explanatory variables</th>
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Note: The dependent variable is the log of the magnitude of the willingness to pay (WTP) for residential open spaces. *p < 0.05, **p < 0.01, ***p < 0.001.
4.4. Quantification of the WTP for ROS and different types of landscape elements

Table 4 shows the average WTP estimated with three models (OLS, interval regression, and Heckman two-step). The first column displays the average WTP values estimated by OLS for respondents who stated a positive WTP. The mean WTP of these respondents for overall ROS was estimated at CNY 68.98 or USD 10.81 per year. For all respondents, the estimate of the mean WTP for overall ROS was CNY 91.75 per year or USD 14.38 per year, based on the interval regression models, and CNY 86.28 per year or USD 13.52 per year according to the Heckman two-step model. The mean WTP for plants was the highest among the residential landscape elements in all models, followed by water features and rest facilities. The average WTP for activity space was the lowest in all models.

Table 4. Average WTP value calculated by the OLS, interval regression, and Heckman two-step models.

<table>
<thead>
<tr>
<th>Average WTP calculation method</th>
<th>OLS model (CNY/year)</th>
<th>Interval Regression model (CNY/year)</th>
<th>Heckman two-step model (CNY/year)</th>
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<tr>
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<td>91.75</td>
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<tr>
<td>Activity spaces</td>
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<td>55.96</td>
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</table>

5. Discussion

ROS is a crucial part of everyday therapeutic landscapes, fostering a diverse range of health effects that can enhance residents’ well-being and quality of life (Ruijsbroek et al., 2017; Min et al., 2021). To the best of our knowledge, this study is the first attempt to explore the association between the perception of landscape health benefits and the WTP for ROS in a
developing country. The findings provide insight for future residence construction, as the information concerning the value of ROS may illuminate residents’ preferences in terms of environmental health benefits.

5.1. Effects of perception and socioeconomic characteristics on the WTP

Overall, the current results showed that respondents’ perception of landscape health benefits significantly affected their WTP and the value of the WTP for ROS. The findings were consistent with previous studies’ reports that perception, beliefs, assessments, and satisfaction strongly affect the WTP and environment preferences (Hunter et al., 2012; Chen and Qi, 2018; Bravo-Vargas et al., 2019; Needham and Hanley, 2019; Tian et al., 2020; Xu et al., 2020; Zhang et al., 2021). The results also showed no evidence of selection bias. Therefore, an interval regression model is suitable for the interval-left-censored and interval-censored data in this study (Withey et al., 2019).

Specifically, the current results revealed that individuals who believe landscape plays an important role in improving the quality of sleep are willing to pay more for ROS. Previous studies have demonstrated that outdoor air pollution and traffic noise decrease sleep quality, especially if they are close to areas where people live (Smith et al., 2019; MacNell et al., 2021; Yu et al., 2021). Meanwhile, evidence suggested that higher residential greenery coverage can attenuate adverse effects on sleep quality, while a higher land-use mix is associated with shorter sleep duration (Chum et al., 2015; Astell-Burt and Feng, 2020). The findings are similar to previous studies (Istamto et al., 2014; Guo et al., 2020; Liu et al., 2020b), which found that individuals who are exposed to air pollution and noise or are aware of their potential health effects display a greater WTP for landscape improvement. The results also indicated that
individuals who are better informed about the landscape’s ability to promote physical function are willing to pay more for ROS. This finding is consistent with another study indicating that physical health benefits strongly affect park users’ WTP for parks (Henderson-Wilson et al., 2017). Some studies have found that the public greatly values improvements to their neighborhoods that provide health benefits in the form of physical activities (Longo et al., 2015; Papathanasopoulou et al., 2016; Zapata-Diomedi et al., 2016).

In addition, the findings indicated that residents who were aware of the landscape’s ability to aid recovery from stress and promote communication among neighbors were more willing to pay and were willing to pay more. This aligns with a previous study, which demonstrated that relaxing and socializing were the dominant reasons people behind which they were willing to pay for parks (Henderson-Wilson et al., 2017). Previous research has also shown that promoting mental and social health through the landscape may offer economic value (Buckley et al., 2019). This may be due to residents’ work pressures and stressful social environments driving greater demand for stress recovery and communication. Therefore, residents might be willing to pay more for ROS if they believed it could promote health.

Furthermore, the results of this study indicated that several socioeconomic characteristics affect residents’ WTP and the magnitude of their WTP. Residents’ monthly income positively affected both the WTP and its value, which accords with the findings of other studies on green spaces (Saz-Salazar and Rausell-Köster, 2008; Sabyrbekov et al., 2020). Respondents with larger families were likely to indicate a positive WTP. This may be because people with large families are more aware of environmental issues affecting their families’ health. Respondents with higher education levels were likely to be willing to pay more to improve ROS. This could be because
highly educated people tend to know more about the landscape’s health value and are thus willing to contribute more for those benefits.

5.2. Residents’ WTP for residential open spaces

In this study, the positive WTP rate was 62.46%, which was lower than that in other studies (Lo and Jim, 2010; Zhang et al., 2020). These results may reflect that the survey was conducted during the pandemic and citizens had experienced confinement. Concerns about safety and overcrowding in open spaces may have driven the low WTP for ROS. As the results indicated no evidence of selection bias, the discussion will focus on the estimations from the OLS and interval regression models. For respondents displaying a positive WTP, the estimated mean WTP for ROS was CNY 68.98 per year (USD 10.81 per year) per person. If all of the respondents were considered, the estimation of the mean WTP for ROS was CNY 91.75 per year (USD 14.38 per year). The estimated WTP is comparable to some other WTP studies for green space in China. For instance, Liu et al. (2020a) found that the individual WTP for residential green space was CNY 148.75 per year in Urumqi. Song et al. (2015) reported that Jinan residents were willing to pay CNY 81.8 per year to conserve urban green spaces. Residents in central China were found to have a higher average WTP of CNY 202.4 per year for urban green space (Tian et al., 2020). The estimated WTP in the current study is slightly higher than some relevant studies conducted in southern cities, such as Fuzhou (CNY 13.79 per person), Hangzhou (CNY 24.40 per year per household), Guangzhou (CNY 24.5 per year per household), and Hong Kong (approximately CNY 75.70) (Chen et al., 2006; Lo and Jim, 2010; Chen and Qi, 2018; and Zhang et al., 2020, respectively). However, the WTP values were lower than those reported in studies from Spain and Brazil, which estimated the WTP for urban parks at EUR 12.67 (USD
14.93) and BRL 40.04 (USD 22.85) per year (López-Mosquera et al., 2014 and Brandli et al., 2015, respectively). For respondents with a positive WTP, the WTP for specific landscape elements falls within CNY 45.87–59.89 per year (USD 7.18–9.38 per year), while the estimated WTP for all respondents ranged from CNY 55.96 to 75.06 per year (USD 8.76–11.75 per year).

The existing landscape conditions, economic development level, local management policies, and sociodemographic characteristics in these regions may have led to the differences in the WTP estimations. Along with increased consumption abilities, residents demand better quality of living and are more inclined to pay a premium to live in a neighborhood with, or close to, well-designed landscapes. Nevertheless, many respondents refused to pay because of their low incomes. Those who cannot afford a better living environment may still desire to be close to nature to promote their health.

5.3. Practical implications

The perception of the landscape’s health benefits was found to significantly influence the WTP for ROS and its values. Citizens evidently determine the value of ROS through their attitudes toward the healing functions of the landscape (Bell et al., 2018; Zhou, 2021). Thus, citizens’ understanding of the landscape’s potential to promote health must be reinforced through various media outlets to encourage certain behaviors. Given that the outdoor landscape can affect housing prices, some specific groups (such as elderly, low-income, or marginal groups) may struggle to afford a comfortable living environment and address their health needs. To address this, the government and local authorities should establish policies for the renewal and construction of residential landscapes for these groups. In addition, the physical and social features of urban residential renewal should be considered to optimize health outcomes during
the planning process. Furthermore, residents’ preferences for residential landscape elements can help decision-makers develop targeted health-promotion policies and plans (Aspinall et al., 2010; Lamb et al., 2020). The current findings indicated that residents prefer plants most and activity spaces least. Residential-landscape architects should prioritize plants, as they provide well-recognized health benefits such as purified air, reduced noise, and improved stress recovery (Markevych et al., 2017). In high-density urban areas, some neighborhoods lack room for activity and residents tend to use urban parks for activities (He, 2021). Neighborhood activity requires consideration, and the public’s WTP for corresponding spaces needs to be encouraged.

5.4. Limitations and recommendations for future research

This study has certain limitations that must be addressed in future research. First, the current data were skewed to women and young residents, and more research on the elderly would be valuable as elderly citizens may live in older residential areas that need improvement and spend more time in ROS. Second, a constrained payment scale was used in this study, and the respondents’ WTP may have been limited by the constraints, causing biased results (Wolff et al., 2020). To examine the validity of the estimation, other payment-elicitation methods, such as dichotomous choice, should be considered. Third, this study did not consider the effects of geographic features, housing type, or housing property rights on the WTP. Thus, future research should investigate differences in the WTP for ROS in various Chinese regions. The WTP for ROS is expected to be different for homeowners and tenants, which should be clarified in future studies. WTP responses from people living in different types of housing (such as commodity housing, public housing, work-unit housing, urban village housing, and replacement housing) should also be compared (Chen et al., 2021). Finally, this study did not investigate residents’
satisfaction with their neighborhood environment, length of residence, the frequency of outdoor activity, or psychological factors, such as an affective connection to nature and place attachment. These factors may influence perceptions and the WTP, and future research should explore these relationships.

6. Conclusion

Results demonstrated that more than half of the participants (62.46%) were willing to pay to construct ROS. The public perceived the residential landscape as being more beneficial for mental health than for physical or social health. Significant associations were found between the perception of landscape health benefits (e.g., the capacity of the landscape to improve sleep quality, promote physical function, aid in stress recovery, and promote communication among neighbors) and the WTP for ROS. Residents’ monthly income significantly influenced their WTP and the WTP value. For those displaying a positive WTP, the estimated mean individual WTP for ROS was CNY 68.89 per year (USD 10.81 per year), while for all respondents, the estimated mean individual WTP for ROS was CNY 91.75 per year (USD 14.38 per year). Furthermore, the estimated WTP for plants was the highest among the studied residential landscape elements, whereas the WTP for activity spaces was the lowest. This study’s findings provide valuable information that can inform the planning and management strategies of community designers, estate management companies, and neighborhood stakeholders.

References


He, J., 2021. Research on layout optimization strategy of public open space in residential area under block system——take the location of Xingfu road in Xi’an as an example. Xi’an University of Architecture and Technology.


MacNell, N.S., Jackson, C.L., Heaney, C.D., 2021. Relation of repeated exposures to air emissions from swine industrial livestock operations to sleep duration and awakenings in nearby residential communities. Sleep Heal. 000, 1–7. https://doi.org/10.1016/j.sleh.2021.05.001


