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Not all types of nature have an equal effect on urban residents' well-being: A structural equation model approach

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Abstract

A growing amount of research shows a positive association between urban nature and urban residents' psychological and physical well-being and quality of life. With its focus on specific dimensions of well-being and reliance either on large-scale objective data sets or experimental and comparative designs, prior research does not explicitly address the relationships between the various types of urban nature as experienced by citizens and their overall well-being. The present research proposes a model for the potential influence of the perceptions of the type and characteristics of nature close to urban residences and citizens' well-being via their frequency of exposure to, and their activities in, nature. Using WHOQOL-26 as a measure of well-being and constructing or adapting measurements for the other variables, a questionnaire was designed and administered among a sample of 2,500 French urban residents. Psychometric tests, structural equation modeling, and mediation analyses were conducted on the collected data. The results show that: (1) The perceived characteristics of nature near urban residences have both direct and indirect influences on the psychological, physical, environmental, and resources-related dimensions of citizens' well-being; (2) Less domesticated nature—forests, fields, and scrubland—contributes to psychological well-being by favoring light or calm activities in nature, and to physical well-being by supporting exposure to nature. Such wilder nature is also positively associated with the perceived quality of urban residences; (3) Small spots of nature, located close to one's residence—a balcony, a patio, or a roof garden—make a similar but smaller contribution to well-being; (4) Domesticated nature—city gardens and parks—contribute marginally to the physical and resources-related dimensions of well-being. These results complement past research on the perceived characteristics of nature by showing how nature, as experienced by urban citizens, refers to different vegetation spaces. They also invite urban planners and policymakers to acknowledge the positive association between “wilder” natural spaces and well-being.

Keywords: Quality of life, structural equation modeling, urban green areas, urban nature, quality of life, well-being, WHOQOL-26.

1 Introduction

A growing body of research has underlined the potential benefits of exposure to nature for urban residents' mental and physical health and well-being (see Kondo et al., 2018; Kuo, 2015; Lee, Jordan and Horsley, 2015; WHO, 2016). Prior research (Hunter et al., 2015) has demonstrated that regular exposure to green or blue spaces (e.g., rivers and lakes) is associated with lower distress and anxiety (Mitchell, 2013; van den Berg et al., 2010), cognitive relief and subsequent increased attention (Kondo et al., 2018; Kuo, 2015), the maintenance or renewed sense of self, opportunities for social relations (e.g., Bell et al., 2015; Birch, Rishbeth and Payne, 2020), and eudaimonic well-being (White et al., 2017). Partaking in physical activities in nature—from taking a stroll to cycling or running—is associated not only with lower anxiety and better cognitive recovery (Lawton et al., 2017) but also with reduced risks of cardiovascular or pulmonary disease and mortality (Kondo et al., 2018; Richardson and Mitchell, 2010). Other studies have outlined that access to nature near one's place of residence can moderate the incidence of unequal socioeconomic conditions on quality of life (see Rigolon et al., 2021 for a review). For instance, Pope et al. (2015) showed that people living in deprived areas reported reduced risks of psychological distress if they could relax in or use green spaces for recreation near their homes. A large-scale study conducted by Olsen et al. (2019a) in 66 European cities demonstrated how a more even distribution of land in cities is related to reduced inequalities in life satisfaction. Overall, a growing number of studies argue that more even access to nature near urban residences may be associated with better citizen well-being, understood as including both mental and physical dimensions and subjective assessments of the home environment.

While past research has contributed to demonstrating empirically the association between urban green spaces or nature and urban residents' well-being, and provided theoretical

explanations for it, such studies rarely consider the various types of nature and vegetation that urban spaces may host. With a few recent exceptions (e.g., Weber and Schneider, 2021 on green alleys; de Bell et al., 2020 on private gardens; Olsen et al., 2019b on different types of land cover; or Dzhambov et al., 2021 on indoor and outdoor greenery), empirical research conducted on the effects of urban nature has focused on green spaces. Although such areas may include spaces of various sizes and types (e.g., recreational, sports or nature parks, see Wood et al., 2017) and greatly contribute to urban residents' well-being and health, especially during crisis periods (see Poortinga et al., 2021), they do not represent all types of nature from which urban residents may benefit. Green alleys, small spots of greenery such as plants on a balcony, a patio, or a roof garden, or flowerbeds in streets offer opportunities of contact with nature in urban areas and could be associated with well-being. Being able to characterize or specify at least the *type* of nature that urban citizens have access or can be exposed to near their place of residence, and assessing whether and how those types of nature are associated with increased well-being, could help researchers to deepen their understanding of the association between nature and well-being (see also Barnes et al., 2019; Bratman et al., 2019; Sullivan et al., 2014).

This focus on urban green spaces can be related to the research designs and methods used to investigate the association between urban nature and residents' well-being. On the one hand, most studies use objective indicators of urban nature presence measured through satellite imagery as a proxy for exposure (Kondo et al., 2018), so small spots of greenery cannot be included. Those objective indicators usually measure the quantity or biodiversity (e.g., Maova et al., 2019) of urban green spaces at various distances from urban residences. When reported, the quality of those spaces is generally assessed by a technician (see Knobel et al., 2019). In those studies, neither the quality of the spaces as perceived by urban residents nor their actual exposure to them are considered. However, earlier studies showed that perceptions of security (Lee and Maheswaran, 2010; Lee et al., 2015; WHO, 2017), cleanliness and maintenance (Lee

et al., 2015), aesthetics (Kothencz et al., 2017; McCormack et al., 2010; Tomao et al., 2016), or the quality (Gelder et al., 2017; Pope et al., 2015) of natural spaces influence visiting. Cleary and al. (2019) noted that subjective measurements of green spaces, their incidence on urban residents' exposure and activities in nature, together with their association with residents' health and well-being, still need more research.

On the other hand, a few experimental or comparative studies conducted on specific urban areas have investigated the association between specific characteristics of urban green spaces in terms of fauna and flora biodiversity or “naturalness,” their perceived quality, and the psychological dimension of well-being (see Fisher et al., 2021; Meyer-Grandbastien et al., 2020; Southan et al., 2017; 2018). Some of those studies indicate a preference for wilder or more “natural” spaces (Grahn & Stigsdotter, 2010) and an association between the perceived biodiversity of those spaces and psychological well-being (Fisher et al., 2021). Those results invite us to deepen our understanding of how urban residents perceive urban nature and whether they differentiate between types of nature depending on their biodiversity, complexity, heterogeneity, or wildness.

Although experimental and large-scale studies contribute to our understanding of the relationships between the presence or specific characteristics of urban green spaces and specific dimensions of well-being, the literature, with some exceptions (e.g., van den Berg et al., 2010; Gelder et al., 2017), fails to address the variety of urban nature types and other well-being dimensions. While such a focus helps to disentangle the various mechanisms through which nature may contribute to well-being and health, it also leads to a partitioned view of well-being and of the person. Adopting a more comprehensive view—including not only the psychological and physical aspects but also how people see their immediate environment and the resources they have—may improve our understanding of the complex interrelationship between urban nature and residents' well-being. To capture the various dimensions of well-being that the

presence of nature may possibly influence, this research adopts the comprehensive definition of well-being proposed by the World Health Organization (WHO): “an individual’s perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards, and concerns. It is a broad-ranging concept affected in a complex way by the person’s physical health, psychological state, personal beliefs, social relationships, and their relationship to salient features of their environment” (The WHOQOL Group, 1998). That definition includes not only the psychological and physical dimensions of well-being but also the quality of one’s immediate environment and the different resources (in terms of finance, transport, information, or health services in particular) it offers.

The objective of this research is to deepen of our understanding of the association between various types, as perceived by the residents, of urban nature close to their homes and their well-being. It addresses the following questions: How are various types of nature, defined as perceived by urban residents, associated with their well-being? How are the perceived characteristics of those spaces related to the residents’ well-being? To what extent are those associations mediated by exposure to and activities conducted in those environments?

Well-being, defined as a holistic concept, is a complex and dynamic phenomenon that is shaped and influenced by numerous factors, among which age, income, health, and sex have been demonstrated to have a significant impact (see Dolan, Peasgood and White, 2008). While integrating those factors, the current study draws on past research and proposes a model that accounts for the influence of both the type and perceived characteristics of nature near urban residences on citizens’ well-being. A questionnaire assessing urban citizens’ well-being via the WHOQOL-26, their frequency of exposure to nature, of more or less intense activities practiced in nature, and the type and characteristics of nature near their residences was administered among a sample of 2,500 French urban citizens in September 2020. Structural Equation

Modeling (SEM) and mediation analyses were applied to test hypotheses and explore relationships among latent variables.

This research contributes to past studies in several ways: (1) It shows that perceived urban nature implies different types of vegetation spaces (namely “undomesticated,” “domesticated,” and “proximity”), which are associated with different aspects of well-being; (2) It establishes direct and indirect influence paths between nature and dimensions of well-being; (3) It confirms that the perceived characteristics, or quality, of nature close to residents’ homes are strongly associated with their well-being. By outlining how undomesticated urban nature spaces contribute to the different dimensions of well-being, not just the psychological aspects, this research extends prior studies on the potential benefits of biodiversity and vegetation complexity.

The remainder of this article is organized around the following sections. Section 2 draws on past research to propose a theoretical framework modeling the influence of nature near urban residences on citizens’ well-being. In Section 3, the variables and scales used to construct the questionnaire and the data collection method are detailed, then the various analyses completed to test the theoretical framework are described. Section 4 reports the results obtained from the SEM and mediation analyses. Section 5 discusses the contributions and limitations of the study. Section 6 summarizes the study findings and highlights avenues for further research.

2 Theoretical analysis and model

Exposure to and activities practiced in, or in relation to, nature may contribute to urban residents’ well-being in several ways. It may reduce harm related to urban nuisances - violence, perceived noise, and pollution hazards (see Markevych et al., 2017; Wu et al., 2020; Kondo et al., 2018), and so improve the perceived quality of urban residences. It can contribute to restoring emotional and cognitive capacities affected by an urban lifestyle. The presence of

nature also offers urban dwellers opportunities to maintain or build physical, social, and even spiritual capacities (see Markevych et al., 2017; Lachowycz and Jones, 2013). Those potential benefits of exposure and activities are dependent on the perceived characteristics of the spaces and, as recent research indicates, on the perceived types of nature—in terms of biodiversity and wildness—they host.

2.1. Exposure to urban nature

First, past research has shown how exposure to nature may restore psychological and physical capacities. Attention Restoration Theory (Kaplan, 1995) proposes that at least five minutes' exposure to nature favors cognitive relief and improves cognitive performance. Stress Reduction Theory (Ulrich et al., 1991) assumes that exposure to the rich stimuli of nature can trigger physiological and emotional responses leading to reduced stress and anxiety, and enhanced relaxation (as measured by physiological indicators, see Kondo et al., 2018; Kuo, 2015; WHO, 2016). Past research has demonstrated that even brief views of nature from home or while commuting can lead to more relaxed states and positive emotions. For instance, in a large-scale study on a representative sample of the English population, White et al. (2017) showed how a recent (“yesterday”) visit is associated with positive emotions and the frequency of such visits is associated with eudaimonic well-being. Investigating in more depth the relationship between “nature dose,” defined as the frequency, duration, and sometimes intensity of exposure to nature, research has shown that nature visits of at least 30 minutes per week are associated with lower risks of depression and high blood pressure (Shanahan et al., 2016). Weekly contact with nature of 120 minutes is associated with better reported health and well-being (White et al., 2019), and repeated exposure of 30 minutes on consecutive days in a natural environment leads to higher restorative effects than the same exposure in a built environment (Jones et al., 2021). Although that research is not focused on nature in residents' neighborhoods, it shows that exposure to nature is crucial for an urban population's cognitive, emotional, and

physical well-being in a context where urbanization reduces opportunities for contact with nature and receiving a “nature dose” (Cox et al., 2018). Such exposure is particularly important when experiencing negative life events (see the Poortinga et al., 2021 study conducted during and after the pandemic lockdown in the UK) and distress (Gelder et al., 2017).

2.2. Activities in urban nature

Second, the presence of green spaces and nature in town provide opportunities for physical activities and social relationships that may consolidate or build physical and social capacities while improving the perceived quality of residents’ environments. The benefits of more or less intense activities in nature are well documented. Experimental studies (e.g., walking in a forest vs. in an urban area without greenery) show that such activities trigger favorable physiological responses in the cardiovascular, anti-inflammatory, and immune systems, thus reducing risks of hypertension, obesity, and even cancer (Kuo, 2015). Through exposure to nature, regular physical activities in nature also reduce risks of anxiety syndrome, depression (see Mitchell, 2013), and burnout (Hyvönen et al., 2018). While partaking in activities in nature may also increase the risk of injuries, the benefits to the psychological and physical dimensions of well-being seem to outweigh the potential negative effects. Visiting green spaces also provides opportunities to maintain or build social relationships that may improve the perceived quality of neighborhoods, then of one’s residence and resources, be they social or informational (see Kondo et al., 2018; Markevych et al., 2017). Based on past research, one may then hypothesize that the frequency of exposure to and activities in nature will be associated with the psychological, physical, and possibly resources—in terms of energy and social relationships—dimensions of well-being.

2.3. Perceived characteristics of urban nature

Third, those potential benefits depend on how residents perceive those nature spaces. The mere presence of nature cannot guarantee that people will practice regular outdoor activities or be exposed to nature. The presence of blue and green spaces—even small spots of greenery such as house plants on a balcony—provides an opportunity for exposure to nature; an opportunity that people may or may not take. Prior work has indicated that, if present, green or blue spaces’ perceived characteristics—including perceptions of security, cleanliness, maintenance (e. g., Lee and Maheswaran, 2010; Lee et al., 2015), aesthetics (e.g., Tomao et al., 2016; Kothencz et al., 2017), quality (Gelder et al., 2017; Pope et al., 2015), and cost (see WHO 2017)—influence visiting.

It is then hypothesized that those perceived characteristics may contribute to urban citizens’ well-being in two ways: first, by indirectly increasing the frequency of exposure to, and activities in, nature if those characteristics are favorably assessed by urban citizens; second, by directly influencing urban citizens’ perceptions of the quality of their residences’ environment and the psychological dimension of well-being. In other words, a blue or green space perceived as being safe and of quality is more likely to favor restoration, relaxation, and a favorable perception of one’s environment than a space perceived as being unsafe or of poor quality.

2.4. Types of nature

Finally, recent studies on objective and perceived biodiversity in urban green spaces have shown that visitors are able to perceive different levels of flora or bird biodiversity in green spaces, that such biodiversity is associated with their perception of the quality or naturalness of that green area (see Southan et al., 2017; 2018 on vegetation biodiversity and Fisher et al., 2021 on vegetation and bird biodiversity), and that those qualities are related to the perceived restorativeness of the site (Fisher et al. 2021) or the feeling of being connected to nature (Southon et al., 2018). In investigating the incidence of different vegetation species (land

cover composition) and heights (land cover complexity), Meyer-Grandbastien et al. (2020) showed that if visitors perceive diversity and complexity in land cover, only complexity defined as the presence of different heights of vegetation, e.g., woodland, shrubs, meadows, or flowerbeds, is associated with perceived restorative effects.

From those results it is hypothesized that urban nature spaces or spots, with varying biodiversity levels and visual complexity, may constitute different types of nature space and that the different types of nature will show different associations with well-being dimensions. Further research is however needed to uncover what types of nature are associated with which dimensions of well-being.

Overall, frequency of exposure to and activities in nature are assumed to favor the mental, physical, environment, and possibly resources dimensions of well-being. Frequency is assumed to be associated with how the citizens perceive the characteristics of nature spaces (safety, maintenance, cleanliness, aesthetics, and facilities) near their residences and probably with their perceptions of the type of nature there. Moreover, those perceived characteristics are thought to have a direct influence on the psychological dimension of well-being and citizens' perceptions of the quality of urban residences. Finally, it is assumed that different types of nature have different influences on well-being, i.e., that their influence varies in terms of degree and dimensions of well-being, but the identification of those different types of nature needs to be explored. Figure 1 depicts hypothetical and exploratory influence pathways between the types and characteristics of nature near urban residences and their effects on citizens' well-being.

INSERT FIGURE 1 ABOUT HERE

3 Methods

3.1 Research design

Data were collected through a questionnaire designed to assess individual urban residents' well-being, their perception of the types and characteristics of nature close to their residence, and the frequency of residents' exposure to, and activities practiced in, that nature. Control variables recognized as having a significant influence on individual well-being (age, health status, household income, and sex) complemented the questionnaire. SEM was chosen as the analytical strategy, as it allows the understanding of the influence of nature on urban citizens' well-being to be refined by identifying both direct and indirect effects between latent variables rather than their composite measures. Such effects reflect more correctly the relations between items and their constructs. Moreover, SEM has been acknowledged as a relevant approach for testing mediation, as it helps in controlling estimate biases and suppression effects (Cheung and Lau, 2008; MacKinnon, Lockwood, and Williams, 2004). Finally, SEM may be used not only to test the initial theoretical framework but also to explore in more depth the pathways from multiple independent variables to multiple outcomes (VanderWeele, 2012). In our research, that analytical strategy was used both to test prior hypotheses and to explore the relationships between the different types of, frequency of exposure to, and activities in nature, on the one hand, and well-being dimensions on the other.

3.2 Data collection and sample procedures

Questionnaires were made available to 72,000 participants in a panel established by MIS Group—a member of ESOMAR—between September 14th and September 25th, 2020 via an electronic platform. The participants lived in cities of high and intermediate density. A total of 3,122 people answered the questionnaire, and we used a final sample of 2,500 urban respondents aged over 15 years old, with a collective profile similar to that of the total French urban population in terms of age, sex, regional distribution, and income level for our research.

The quotas applied (age, sex, region of residence, and occupation) were taken from the 2016 census published by the French census bureau (*Institut National de la Statistique et des Etudes Economiques*, INSEE) for the population living in cities of high and intermediate density. Following the Eurostat methodology, a town is considered dense if more than 50% of the population lives in the center. An urban center is defined by aggregates of 1 km² areas containing 1,500 or more residents each and totaling a minimum of 50,000 inhabitants. A town is considered to have intermediate density if more than 50% of its population lives in the center or in a cluster defined by aggregates of 1 km² areas containing 300 to 1,499 residents and totaling a minimum of 5,000 inhabitants. Table 1 shows the descriptive statistics and statistical means of the sample from which the data were collected.

INSERT TABLE 1 ABOUT HERE

Respondents were instructed to consider the previous week when answering the questionnaire and to report their personal experiences and feelings. They were also assured that there were no right or wrong answers and that their individual responses would remain confidential. In September 2020, when the data were collected, no lockdown or restrictions had been applied in France since June, when the first lockdown was lifted. Therefore, while we cannot be completely certain that the pandemic did not impact the results, the most obvious potential effect of the lockdown—that it may increase urban residents' need for contact with nature—can be reasonably excluded.

3.3 Variables

3.3.1 Outcome variable: Well-being

The French version of the WHOQOL-26 partially validated by Baumann et al. (2010) was used to measure well-being (e.g., “How much do you need any medical treatment to function in your daily life?”). The questionnaire included two additional items inviting respondents to

assess how healthy they find the environment of their residence from the WHOQOL-100 (“How satisfied are you with your physical environment (e.g., pollution, climate, noise, and attractiveness)?” and “How concerned are you with the noise in the area you live in?”). Respondents were invited to answer on a 5-point scale (1 = not at all to 5 = an extreme amount; 1 = very dissatisfied to 5 = very satisfied; 1 = not at all to 5 = completely).

3.3.2 Independent variable: Nature near residences

A second scale was constructed to evaluate respondents’ perceptions of the types of nature found in the immediate vicinity of their residence, i.e., that they could see from home or access in less than a 15-minute walk. The scale described 19 types of nature, including large green or blue spaces (e.g., forests, pastures, rivers, coasts, parks), intermediate areas (e.g., individual, roof, or public gardens), and small spots of greenery (e.g., isolated trees in the street, flower beds, plants on a patio or balcony). Using the 5-point scale (1 = not at all present, 5 = extremely present), respondents were invited to indicate the extent to which these different types of nature were present in the immediate environment of their residence.

3.3.2 Independent variable: Perceived characteristics of nature

Drawing on prior studies, a scale of ten items was designed to collect the respondents’ levels of satisfaction (1 = not at all satisfied, 5 = very satisfied) with the safety, cleanliness, opening hours, signage, accessibility, maintenance, costs, aesthetics, and facilities (2 items) of these blue or green spaces.

3.3.3 Mediator: Frequency of exposure to nature

An additional scale was constructed to assess how often respondents had been exposed to nature for at least 5 minutes in the previous week. The scale comprised seven types of nature: trees or woodland, views of natural elements near one’s residence, a private garden, views of natural landscapes, house plants, pets, and representations of nature (e.g., pictures or movies,

documentaries, or video games). While peripheral to the research interest, and in need of further investigation, the representation items were included to reflect recent research results showing potential but limited restorative benefits of exposure to “virtual” nature (Matthew et al., 2020; White et al., 2018). The response options were standardized on a 5-point scale (1 = not this week, 5 = every day).

3.3.4 Mediator: Frequency of practicing activities in nature

Finally, a scale was devised to indicate how often respondents practiced activities in nature for at least 15 minutes in the previous week. The scale comprised nine types of activity in nature: meeting other people; practicing a cultural activity, e.g., reading or painting; observing nature; resting; gardening; lying down in nature or seeing it from a car or train; and practicing light, intermediate, or intense exercise. The response options were standardized on a 5-point scale (1 = not this week, 5 = every day).

3.3.5 Control variables

The sociodemographic characteristics were sex, annual household income (\leq €10,999, €11,000–25,999, €26,000–40,999, €41,000–55,999, or \geq €56,000), age, and health status. Respondents were asked whether they had any of the health problems among the 14 items listed in the WHOQOL-100 or any other health problems. Multiple responses were possible. Answers were coded as “Yes” if at least one illness was indicated and “No” if none were indicated.

3.6 Data analysis

As the factorial structure of the French version of WHOQOL-26 has not been established and psychometrically validated, and because the other measures in the questionnaire were created or adapted for this research, a two-step procedure was followed to analyze the data. First, psychometric tests were conducted on every variable to identify latent variables and

define the set of items by best fit. Second, SEM and mediation analyses were conducted to test our theoretical framework and identify pathways between latent variables. Data analysis was completed using Rstudio (Version 4) software and the psych (Revelle, 2019), lavaan (Rosseel, 2012), paran (Dinno, 2012), and semtools (Jorgensen et al., 2019) packages.

3.6.1 Psychometric tests

The Mahalanobis distance criterion, measured using every item response except sociodemographics, led to 187 potential outliers being removed. Then, parallel analyses (Jorgensen et al., 2019), principal component analyses (PCA), and confirmatory factor analyses (CFA) using maximum likelihood estimations were conducted on each scale. Those analyses allowed assessment of the number of dimensions for each scale, removal of items with low (< .3) or similar loadings on different dimensions, identification of the items defining each dimension's best fit, and assessment of the fit of the final model with the data (see supplementary material, Table 2). A CFA was performed to validate the final model structure.

3.6.2. SEM

In conducting SEM, latent constructs for well-being represented dependent variables; the types and characteristics of nature identified as being close to urban citizens' residences were independent variables; and the frequency of exposure to and of activities practiced in nature were considered as mediators.

As the main objective of the study was to assess the potential association between the characteristics and types of nature near urban citizens' residences and the various well-being latent variables, control variables (sex, annual household income, age, and health) were not considered as potential confounders of the mediation pathways but as directly influencing well-being variables. Therefore, control variables were included in each structural equation. A first test of the model gave moderate fit indices, so the dimensions comprising only two items

(“sports in nature” and “exposure to virtual nature”) were removed from the final model, as we did not have theoretical certainties that those dimensions were exhaustively assessed with only two items (Kenny, Kashy, & Bolger, 1998).

Finally, mediation analyses were completed using the Monte Carlo procedure (Bauer, Preacher and Gil, 2006; Tofighi and MacKinnon, 2016) to identify potential mediation effects between the various characteristics of nature and well-being latent variables. Following that procedure, a mediation is full only if indirect components paths—measured as the product of the Beta coefficient of an independent variable on a mediator and the Beta coefficient of that same mediator on a latent variable—are significant (see Table 4 for results).

Following Hu and Bentler’s (1999) suggestions on indices and cutoff criteria in covariance structure models, Chi-square (although this criterion is usually significant with large samples), comparative fit index (CFI), Tucker-Lewis Index (or non-normed fit index, NNFI), root mean square error of approximation (RMSEA), and standardized root mean residual (SRMR) were used to assess the fit of CFA and SEM models (see also Schreiber et al., 2006). The fit indices are summarized in Table 2.

INSERT TABLE 2 ABOUT HERE

4 Results

4.1 Sample descriptive statistics

Table 1 reports the sample characteristics and mean levels of the four factors that assess well-being. Men and people aged 45–65 years old report higher levels of well-being, while low-income populations and people living with health problems report lower levels of well-being. In the supplementary material, Table 1 presents the means, standard deviation, and regression coefficients of control variables according to well-being dimensions resulting from the SEM analysis.

4.2 Measurement model testing

Well-being measured through the WHOQOL-26 comprises four dimensions contributing to 54% of the variance. The first dimension (Dim1, called “psychological well-being”) comprises nine items that indicate the respondents’ psychological well-being (e.g., to accept one’s self and one’s body; not to have negative feelings such as low mood, despair, anxiety, or depression; to enjoy one’s life). The second dimension (Dim2, called “environment”) comprises three items and is defined by the quality of the residence’s environment: to live in a healthy place, to live somewhere where one is not disturbed by noise, and to be satisfied with one’s residence. The third dimension (Dim3, called “physical well-being”) comprises four items that describe respondents’ perceived physical health (e.g., to have to take daily medication, to live with physical pain). The fourth dimension (Dim4, called “resources”) groups four items that indicate respondents’ level of satisfaction with how much finance, time, information, and energy they have for conducting their lives.

The measure of the types of nature near urban citizens’ residences retained three dimensions that explain 65% of the variance. The first dimension (called “undomesticated”) comprises four items—forests, roadsides, scrubland, and fields; this describes nature that is wilder or less domesticated than the two other dimensions. Indeed, the second dimension (called “proximity”) comprises five items, including a balcony or a patio with flowers or vegetables, flower beds, roof gardens, and hanging baskets. The third dimension (called “domesticated”) comprises three items defined by the presence of parks, city gardens, or playgrounds.

The frequency of exposure to nature measurement includes two dimensions explaining 58% of the variance. While a first dimension (called “exposure to nature”) contains four items that refer to exposure to animals, house plants, a garden, or landscape views, the second dimension has only two items that describe exposure to virtual nature (called “exposure to virtual nature”) through photos or films and video games. The frequency of activities practiced

in or in relation to nature also contains two dimensions (called “activities in nature” and “sport,” respectively) that distinguish between calm and contemplative activities—like resting, walking, fishing, observing nature, or practicing a light exercise such as yoga—and more intense exercises like biking or running.

Finally, the items that assess the characteristics of nature near respondents’ residences represent one dimension only that contains all features: security, cleanliness, maintenance, aesthetics, opening hours, signage, accessibility, facilities (2 items), and costs. The final CFA conducted on all measurements after removing dimensions comprising only two items (exposure to virtual nature and sport) and including correlations between latent construct items shows satisfactory fit indices (see Table 3).

INSERT TABLE 3 ABOUT HERE

4.3 SEM testing

SEM was conducted considering the four well-being latent constructs as dependent variables, the three latent constructs describing the types of nature near urban residences and citizens’ perceived characteristics of that nature as independent variables, and the frequency of exposure to and practicing of activities (light or contemplative) in nature as mediators. Sociodemographic variables (i.e., sex, health status, age, and annual household income) were included in each regression equation to account for their potential influence on every well-being latent construct.

Figures 2a and 2b represent the final model, which explains at least 32% of the variance of each dimension of well-being (R^2 Dim1 = .33, R^2 Dim2 = .44, R^2 Dim3 = .52, R^2 Dim4 = .44) and whose fit indices indicate robustness (see Table 2).

4.3.1. Perceived characteristics of nature

The perceived characteristics of nature have a significant and direct influence on each well-being latent construct (see Figure 2a). That influence is also indirect not only for psychological well-being—as the characteristics of nature may increase the frequency of calm and contemplative activities therein, with a resulting contribution to psychological well-being—but also for the other constructs of well-being, as perceived characteristics influence the frequency of exposure to nature. This indirect influence on the latent constructs “environment,” “resources,” and “physical” dimensions of well-being via exposure to nature is however much lower than the direct contribution of these perceived characteristics on the latent constructs. For instance, a mediation analysis (see Table 4) gives standardized coefficients of .02 for the indirect influence of the perceived characteristics of nature on the physical construct of well-being via the frequency of exposure to nature and of .20 for the total influence (direct and via the frequency of exposure to nature).

INSERT FIGURES 2 ABOUT HERE

4.3.2. Types of nature

The types of nature near urban residences show varying influences on citizens’ well-being (see Figure 2b). Both the “undomesticated” and “proximity” nature types significantly influence the frequency of contemplative or light activities and exposure to nature compared with the influence of the “domesticated” nature type. “Undomesticated” and “proximity” also have an indirect influence on the psychological construct of well-being via the frequency of contemplative or calm activities that such environments allow, with standardized coefficients of .05 and .03, respectively. A similar indirect effect of the “undomesticated” nature type is also observed on the “resources” construct of well-being via both the frequency of light activities practiced in nature and of exposure to nature. Finally, less domesticated nature contributes both directly and indirectly via the frequency of exposure to nature on citizens’ perceived quality of the environment around their residences.

INSERT TABLE 4 ABOUT HERE

The contributions of the “proximity” and “domesticated” nature types to urban residents’ well-being are also significant, albeit to a lesser extent. The “proximity” nature type favors both the psychological and the resources constructs of well-being in allowing light or calm activities. It also marginally contributes to the “physical” and the “environment” dimensions of well-being through the frequency of exposure to nature, with a standardized coefficient of .01.

The significant influence of the “undomesticated” and, to a lesser degree, the “proximity” nature types on the psychological, environment, and resources dimensions of well-being should be contrasted with that of the “domesticated” nature type. While marginally influencing the perception of the quality of one’s environment via the frequency of exposure to nature, the “domesticated” nature type mainly contributes to the physical and resources well-being constructs. The presence of parks and city gardens seems to favor physical well-being indirectly through exposure to nature but contributes directly to the perceptions of one’s resources. Those last results should be interpreted with caution, as they may be influenced by the confounding effect of the location of public gardens and parks close to French city centers, where residences are also more expensive than in more peripheral areas.

4.3.3. Socio-demographics

As indicated in past literature, age, health, and income level significantly influence well-being (see Figure 2a and Table 1 in the supplementary material). While higher income favors all dimensions of well-being, living with a health problem has a negative influence on those same dimensions. Age is associated with higher levels of psychological well-being and people’s perceptions of resources (in terms of time, finance, information, and energy): As people get

older, they tend to have higher levels of psychological well-being and more favorable perceptions of resources.

5 Discussion

The research first aimed to assess the potential influence of the characteristics and types of nature near urban residences on the residents' well-being and, second, to explore whether different types of nature had differing effects on well-being. In sum, the study shows that, via the frequency of exposure to and/or of activities completed in nature, the perceived characteristics of nature both directly and indirectly enhance all dimensions of well-being. It also reveals that respondents distinguish between nature types and that the different types of nature show different associations with well-being dimensions. A “wilder” type of nature—and, to a lesser extent, nature in the more “nearby” form of a patio or a balcony—has a higher influence on well-being than city gardens or parks.

5.1 Research contributions

Past research on the potential influence of nature near citizens' residences on well-being has mainly investigated the association between nature and specific dimensions of well-being, such as its psychological (e.g., Mitchell, 2013; Pope et al., 2015; van den Berg et al., 2010; White et al., 2017; Wood et al., 2017) or physical (Olsen et al., 2019b; Richardson and Mitchell, 2010) aspects, or between nature and quality of life (Olsen et al., 2019a). To our knowledge, the potential effects of nature on well-being as a comprehensive concept have not been investigated. In considering the psychological, physical, environment, and resources-related dimensions of well-being, this study allows a broader view of the potential influence of nature. The majority of large-scale studies examining the relationships between nature and well-being use geographical and health census data. A few studies conducted on specific urban green spaces have assessed the influence of objective characteristics of such nature spaces on their

visitors' perceptions and psychological well-being. Complementing past research, our study investigates urban citizens' perceptions of their close environment and well-being. That enabled the inclusion in the study of both urban green spaces and small spots of nature—such as house plants on a balcony, a patio, or a roof garden—that are generally excluded from empirical studies.

This research contributes to past studies in three related ways. First, it confirms that citizens' perceptions of the characteristics of nature close to their urban residence are associated with mental and physical health benefits, both directly, by promoting relaxation, feelings of calmness, and psychological restoration (cf. Pope et al., 2015), and indirectly, by encouraging both exposure to nature and the practice of light or contemplative activities therein (cf. McCormack et al., 2010). A natural environment close to one's residence that is perceived as safe, clean, well maintained, aesthetic, accessible, and well equipped is not only more likely to favor exposure to, or practice of, light activities but also to trigger or convey feelings of serenity, fulfillment, and relaxation which affect one's mental and physical well-being.

Advancing past research, this study shows how the characteristics of nature near urban homes contribute directly to citizens' perceived quality of their residential environment and to the various resources available to them. These results are consistent with the Olsen et al. (2019a) results showing that a more even distribution of land in cities reduces differences in quality of life by mitigating the negative impact of socioeconomic inequalities. Overall, the results indicate that the perceived quality of nature in residential settings is a fundamental ingredient in how French citizens perceive and assess both their immediate environment and, through a halo effect, the level of finance, time, and energy they possess.

Contrary to what was expected, the frequency of practicing light or calm activities in nature is negatively associated with the physical dimension of well-being. A possible interpretation of this result is that the items capturing the physical dimension of well-being

mainly reflect diminished capabilities, such as having to take daily medication or having difficulty moving. In other words, physical difficulties may be amplified through movement, even gentle movement; more research is needed for a deeper understanding of this result.

Second, the study deepens our understanding of the association between the “nature of nature” and well-being. The recent research conducted by Olsen et al. (2019b) outlines differing associations between various urban land types and uses and mortality rates in European cities. Of particular interest is their finding that “wilder” green spaces such as forests, semi-natural areas, and wetlands were associated with lower mortality rates. Our study complements that prior research by revealing the contrasting effects of various larger and smaller urban natural spaces on exposure, activity, and well-being dimensions as experienced by urban citizens. While indirectly confirming the positive association between a “wilder” or less domesticated nature and health, our study shows that wilder environments contribute to residents’ well-being both directly and indirectly through the frequency of exposure to, and practicing of activities in, nature. With its heterogeneous stimuli—sounds, smells, and visual elements (Kuo, 2015; Meyer-Grandbastien et al., 2020; Southan et al., 2017; 2018)—and higher biodiversity (Mavoia et al., 2019), undomesticated nature is more likely than city parks or public gardens to favor contemplative or light activities, with their associated emotional and cognitive benefits. Moreover, following past research (see Kondo et al., 2018; Wu et al., 2020), one may hypothesize that undomesticated nature, if implying woodlands in particular, is more liable both to buffer or reduce urban nuisances—air or noise pollution, violence, and crime—and to increase the perceived aesthetics of the site. Those two aspects that may contribute to the observed increase in citizens’ perceived quality of their urban home environment. These results are consistent with Grahn and Stigsdotter’s (2010) study demonstrating that urban citizens prefer “natural” (as opposed to more managed) urban green spaces.

Having a balcony, roof garden, or patio also favors contemplative activities and exposure to nature, although the observed associations are much weaker than those observed with undomesticated nature. As access to a small nature space, a balcony, or a patio can serve as a first shield against urban nuisances and provide opportunities to connect with nature, such small nature areas also increase real estate values, which may explain why their presence is associated with the resources dimensions of well-being.

Third, the city nature type—the presence of parks or public gardens—is marginally associated with the physical and resource-related dimensions of well-being. Both those associations and the absence of relationships with contemplative or light activities could be interpreted as resulting from the location and configuration of parks and city gardens in France. Such spaces are generally small—compared with London parks, for instance—and highly frequented, thus making them less conducive to calm or contemplative activities. As city center residences are also more expensive in France, living near a park may also suggest that one has greater resources, i.e., higher income and easier access to information than when one lives in a peripheral urban area. Overall, the relationship between the presence of a park or city garden near one’s residence and the physical and resources-related well-being dimensions should be interpreted with caution. Finally, the absence of association between that type of nature and the mental dimension of well-being are not inconsistent with Olsen et al.’s (2019b) conclusion that “pockets of green in and among urban developments may be insufficient to offset the adversity of living in dense residential and commercial environments” (p. 8).

In sum, this research reveals that not all types of urban nature have an equal effect on urban residents’ well-being. While the characteristics of nature are associated with all dimensions of well-being, the presence of undomesticated nature near one’s residence, or of a balcony or patio, seem to have more benefits for well-being than the domesticated nature of parks and public gardens. Theoretically, these results outline the need to distinguish among

different types of urban nature when investigating their association with well-being. They highlight how undomesticated nature, probably because it offers higher levels of biodiversity and vegetation complexity, is more liable to reduce harm related to urban nuisances and contribute to well-being.

5.2 Limitations

This research has several limitations that need to be addressed in any further research. The research applies SEM on cross-sectional data, so it cannot account for the passing of time needed to demonstrate causality. The use of time series data would be recommended in future research to show causal pathways from urban green spaces and nature to residents' well-being.

Second, the study uses a questionnaire, which may imply contamination effects between responses (Bollen, 2013). The questionnaire was available online in French, so we cannot guarantee that the observed associations are generalizable to people with low digital or French literacy. Further research could use observational data to investigate the effects of both objective and perceived characteristics of nature on well-being. Complementing large-scale studies, future research could focus on specific urban areas with various types of nature and assess their association with citizens' well-being.

Third, data were collected during the pandemic, so we cannot be certain that, among other factors such as periods of drought or heatwaves, such circumstances do not increase urban residents' awareness of the potential well-being benefits of increased contact with nature. However, this research indirectly confirms the findings of studies conducted before the COVID-19 crisis. We can therefore be reasonably confident that our results, though perhaps exaggerated by the pandemic, are not directly caused by it.

Finally, conducting in-depth interviews could deepen our understanding of why and how urban residents experience the various nature types identified in the study. In-depth

interviews could also deepen our understanding of how past experiences and cultural backgrounds may lead urban residents to have different perceptions of the same type of nature.

6 Conclusion

To date, the associations between citizens' perceptions of nature types near their urban residences, the characteristics of nature, and residents' well-being—including mental, physical, environment, and resources-related dimensions—have not been investigated. This study models and assesses the influence of nature as perceived by urban residents and their well-being. The results show that:

1. The perceived characteristics of nature near urban residents are positively associated with all dimensions of well-being.
2. The presence of undomesticated nature—forests, fields, or scrubland—shows higher association with frequency of light activities and well-being benefits than city parks or public gardens.
3. The presence of a balcony, patio, or roof garden shows similar but weaker associations to those of undomesticated nature.
4. City parks or gardens are mainly associated with the resources and physical dimensions of well-being.

Though further research is needed, these results invite urban planners and policymakers to consider protecting existing wild natural spaces or to adopt a “close to nature” approach to the management of existing natural spaces.

References

- Barnes, M. R., Donahue, M. L., Keeler, B. L., Shorb, C. M., Mohtadi, T. Z., & Shelby, L. J. (2019). Characterizing nature and participant experience in studies of nature exposure for positive mental health: an integrative review. *Frontiers in Psychology, 9*(2617), 73-80. <https://doi.org/10.3389/fpsyg.2018.02617>
- Bauer, D. J., Preacher, K. J., & Gil, K. M. (2006). Conceptualizing and testing random indirect effects and moderated Mediation in multilevel models: New procedures and recommendations. *Psychological Methods, 11*(2), 142-163. <https://doi.org/10.1037/1082-989X.11.2.142>
- Baumann, C., Erpeling, M-L., Régat, S., Collin, J-F., & Briançon, S. (2010). The WHOQOL-BREF questionnaire: French adult population norms for the physical health, psychological health and social relationship dimensions. *Revue d'Epidémiologie et de Santé Publique, 58*(1), 33-39. <https://doi.org/10.1016/j.respe.2009.10.009>
- Bell, S. L., Phoenix, C., Lovell, R., & Wheeler, B. W. (2015). Seeking everyday wellbeing: The coast as a therapeutic landscape. *Social Science & Medicine, 142*, 56-67. <https://doi.org/10.1016/j.socscimed.2015.08.011>
- Birch, J., Rishbeth, C., & Payne, S. R. (2020). Nature doesn't judge you – how urban nature supports young people's mental health and wellbeing in a diverse UK city. *Health & Place, 62*, <https://doi.org/10.1016/j.healthplace.2020.102296>
- Bollen, K., & Pearl, J. (2013). Eight myths about causality and structural equation models. In *Handbook of Causal Analysis for Social Research*. Springer, 301-328.
- Bratman, G. N., Anderson, C. B., Berman, M. G., Cochran, B., Vries, S. de, Flanders, J., Folke, C., Frumkin, H., Gross, J. J., Hartig, T., Jr., P. H. K., Kuo, F., Lawler, J. J., Levin, P. S., Lindahl, T., Meyer-Lindenberg, A., Mitchell, R. J., Ouyang, Z., Roe, J., ... Daily, G. C. (2019). Nature and mental health: An ecosystem service perspective. *Science Advances, 5*(7), eaax0903. <https://doi.org/10.1126/sciadv.aax0903>
- Browning M. HEM., Shipley N., McAnirlin O., Becker D., Yu C-P., Hartig T. & Dzhambov A.M. (2020). An Actual Natural Setting Improves Mood Better Than Its Virtual Counterpart: A Meta-Analysis of Experimental Data. *Frontiers in Psychology, 11*, <https://10.3389/fpsyg.2020.02200>
- De Bell, S., White, M., Griffiths, A., Darlow, A., Taylor, T., Wheeler, B., & Lovell, R. (2020). Spending time in the garden is positively associated with health and wellbeing: Results

from a national survey in England. *Landscape and Urban Planning*, 200. <https://doi.org/10.1016/j.landurbplan.2020.103836>

Dzhambov, A.M., Lercher, P., Browning, M. H.E.M., Stoyanov, D., Petrova, N., Novakov, S., & Dimitrova, D. D. (2021). Does greenery experienced indoors and outdoors provide an escape and support mental health during the COVID-19 quarantine?, *Environmental Research*, 196. <https://doi.org/10.1016/j.envres.2020.110420>.

Calogiuri G., Litleskare S., Fagerheim, K. A., Rydgren, T. L., Brambilla, E., & Thurston, M. (2018). Experiencing Nature through Immersive Virtual Environments: Environmental Perceptions, Physical Engagement, and Affective Responses during a Simulated Nature Walk. *Frontiers in Psychology*, 8:2321, 205-218. <https://doi.org/10.3389/fpsyg.2017.02321>

Cheung, G.W., & Lau R.S. (2008). Testing Mediation and Suppression Effects of Latent Variables: Bootstrapping With Structural Equation Models. *Organizational Research Methods*, 11, 296-325. <https://doi.org/10.1177/1094428107300343>

Cleary, A., Roiko, A., Burton, N. W., Fielding, K. S., Murray, Z., & Turrell, G. (2019). Changes in perceptions of urban green spaces are related to changes in psychological well-being: Cross-sectional and longitudinal study of mid-aged urban residents. *Health & Place*, 59, 2019. <https://doi.org/10.1016/j.healthplace.2019.102201>

Cox, D. T. C., Shanahan, D. F., Hudson, H. L., Fuller, R. A. & Gaston, K. J. (2018). The impact of urbanisation on nature dose and the implications for human health. *Landscape and Urban Planning*, 179, 72-80. <https://doi.org/10.1016/j.landurbplan.2018.07.013>

Cumming, G. (2014). The new statistics: Why and how. *Psychological science*, 25(1), 7-29.

Dinno, A. (2012). *paran: Horn's Test of Principal Components/Factors*. R package version 1.5.1. <https://cran.r-project.org/web/packages/paran/>

Dolan, P., Peasgood, T., & White, M. (2008). Do we really know what makes us happy? A review of the economic literature on the factors associated with subjective well-being, *Journal of Economic Psychology*, 29, 94–122. <https://doi.org/10.1016/j.joep.2007.09.001>

Fisher, J. C., Irvine, K. N., Bicknell, J. E., Hayes, W. M., Fernandes D., Mistry, J., & Davies, Z. G. (2021). Perceived biodiversity, sound, naturalness and safety enhance the restorative quality and wellbeing benefits of green and blue space in a neotropical city. *Science of the Total Environment*. 755. <https://doi.org/10.1016/j.scitotenv.2020.143095>

Gelder, R., Koster, E. M., van Buren, L. P., van Ameijden, E. J., Harrison, A., Birt, C. A., et al. (2017). Differences in adults' health and health behaviour between 16 European urban areas and the associations with socio-economic status and physical and social environment.

European Journal of Public Health, 27 (Supplement 2), 93–99.
<https://doi.org/10.1093/eurpub/ckv141>

Grahn, P., & Stigsdotter, U. K. (2010). The relation between perceived sensory dimensions of urban green space and stress restoration. *Landscape and Urban Planning*, 94, 264-275.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in co- variance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling*, 6(1), 1–55. <https://doi.org/10.1080/10705519909540118>

Hunter, R. F., Christian, H., Veitch, J., Astell-Burt, T., Hipp, J. A., & Schipperijn, J. (2015). The impact of interventions to promote physical activity in urban green space: a systematic review and recommendations for future research. *Social Science & Medicine*, 124, 246-256. <https://doi.org/10.1016/j.socscimed.2014.11.051>

Hyvönen, K., Törnroos, K., Salonen, K., Korpela, K., Feldt, T., & Kinnunen, U. (2018). Profiles of nature exposure and outdoor activities associated with occupational well-being among employees. *Frontiers in Psychology*, 9(754), 41-53. <https://doi.org/10.3389/fpsyg.2018.00754>

Jones, M. V., Gidlow, C. J., Hurst, G., Masterson, D., Smith, G., Ellis, N., Clark-Carter, D., Tarvainen, M. P., Braithwaite, E. C. & Nieuwenhuijsen, M. J. (2021). Psycho-physiological responses of repeated exposure to natural and urban environments. *Landscape and Urban Planning*, 209, 104061. <https://doi.org/10.1016/j.landurbplan.2021.104061>

Jorgensen, T. D., Pornprasertmanit, S., Schoemann, A. M., Rosseel, Y., & Miller, P. (2019). *semTools: Useful tools for structural equation modeling*. R package version 0.5-2. <https://CRAN.R-project.org/package=semTools>

Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology*, 15(3), 169-182. [https://doi.org/10.1016/0272-4944\(95\)90001-2](https://doi.org/10.1016/0272-4944(95)90001-2)

Kenny, D. A., Kashy, D. A., & Bolger, N. (1998). Data analysis in social psychology. In D. T. Gilbert, S. T. Fiske, & G. Lindzey (Eds.), *The Handbook of Social Psychology* (4th ed., pp. 233–265). New York: Oxford University Press.

Knobel, P., Dadvand, P. & Maneja-Zaragoza, R. (2019). A systematic review of multi-dimensional quality assessment tools for urban green spaces. *Health & Place*, 59, 102198. <https://doi.org/10.1016/j.healthplace.2019.102198>

Kondo, M. C., Fluehr, J. M., McKeon, T., Brnas, C. C. (2018). Urban green space and its impact on human health. *International Journal of Environmental Research and Public Health*, 15, 445. <https://doi:10.3390/ijerph15030445>

Kothencz, G., Kolcsár, R., Cabrera-Barona, P., & Szilass, P. (2017). Urban green space perception and its contribution to well-being. *International Journal of Environmental Research and Public Health*, 14(766), 1-14. <https://doi.org/10.3390/ijerph14070766>

Kuo M. (2015). How might contact with nature promote human health? Promising mechanisms and a possible central pathway. *Frontiers in Psychology*, 6(1093), 1-8. <https://doi.org/10.3389/fpsyg.2015.01093>

Lachowycz, K., & Jones, A. P. (2013). Towards a better understanding of the relationship between greenspace and health: Development of a theoretical framework. *Landscape and Urban Planning*, 118, 62-69. <http://dx.doi.org/10.1016/j.landurbplan.2012.10.012>

Lawton, E., Brymer, E., Clough, P., & Denovan, A. (2017). The Relationship between the Physical Activity Environment, Nature Relatedness, Anxiety, and the Psychological Well-being Benefits of Regular Exercisers. *Frontiers in Psychology*, 8(1058), 62-72. <https://doi.org/10.3389/fpsyg.2017.01058>

Lee, A. C., & Maheswaran, R. (2010). The health benefits of urban green spaces: a review of the evidence. *Journal of Public Health*, 33(2), 212–222. <https://doi.org/10.1093/pubmed/fdq068>

Lee, A. C., Jordan, H. C., & Horsley, J. (2015). Value of urban green spaces in promoting healthy living and wellbeing: prospects for planning. *Risk Management and Healthcare Policy*, 8, 131–137. <https://doi.org/10.2147/rmhp.s61654>

MacKinnon, D. P., Lockwood C. M., & Williams, J. (2004). Confidence Limits for the Indirect Effect: Distribution of the Product and Resampling Methods. *Multivariate behavioral Research*, 39. https://doi.org/10.1207/s15327906mbr3901_4

Markevych, I., Schoierer, J., Hartig, T., Chudnovsky, A., Hystad, P., Dzhambov, A., de Vries, S., Triguero-Mas, M., Brauer, M., Nieuwenhuijsen, M. J., Lupp, G., Richardson, E. A., Astell-Burt, T., Dimitrova, D., Feng, X., Sadeh, M., Standl, M., Heinrich, J., & Fuertes, E. (2017). Exploring pathways linking greenspace to health: Theoretical and methodological guidance, *Environmental Research*, 158, 301-317. <https://doi.org/10.1016/j.envres.2017.06.028>

Mavoia, S., Davern, M., Breed, M., & Hahs, A. (2019). Higher levels of greenness and biodiversity associate with greater subjective wellbeing in adults living in Melbourne, Australia. *Health & Place*, 57, 321-329. <https://doi.org/10.1016/j.healthplace.2019.05.006>

McCormack, B., Dewing, J., Breslin, L., Coyne-Nevin, A., Kennedy, K., Manning, M., et al. (2010). Developing person-centred practice: nursing outcomes arising from changes to the

care environment in residential settings for older people. *International Journal of Older People Nursing*, 5(2), 93-107. <https://doi.org/10.1111/j.1748-3743.2010.00216.x>

Meyer-Grandbastien, A., Burel, F., Hellier, E., & Bergerot, B. (2020). A step towards understanding the relationship between species diversity and psychological restoration of visitors in urban green spaces using landscape heterogeneity. *Landscape and Urban Planning*, 195, 1-11. <https://doi.org/10.1016/j.landurbplan.2019.103728>

Mitchell, R. (2013). Is physical activity in natural environments better for mental health than physical activity in other environments? *Social Science & Medicine*, 91, 130-134. <https://doi.org/10.1016/j.socscimed.2012.04.012>

Olsen, J. R., Nicholls, N., & Mitchell, R. (2019a). Are urban landscapes associated with reported life satisfaction and inequalities in life satisfaction at the city level? A cross-sectional study of 66 European cities. *Social Science & Medicine*, 226, 263-274. <https://doi.org/10.1016/j.socscimed.2019.03.009>

Olsen, J. R., Nicholls, N., Moon, G., Pearce, J., Shortt, N., & Mitchell, R. (2019b). Which urban land covers/uses are associated with residents' mortality? A cross-sectional, ecological, pan-European study of 233 cities. *BMJ Open*. <http://dx.doi.org/10.1136/bmjopen-2019-033623>

Pope, D., Tisdall, R., Middleton, J., Verma, A., van Ameijden, E., Birt, C., Macherianakis, A., et al. (2015). Quality of and access to green space in relation to psychological distress: results from a population-based cross-sectional study as part of the EURO-URHIS 2 project. *European Journal of Public Health*, 28(1), 35-38. <https://doi.org/10.1093/eurpub/ckv094>

Poortinga, W., Bird, N., Hallingberg, B., Phillips, R., & Williams, D. (2021). The role of perceived public and private green space in subjective health and wellbeing during and after the first peak of the COVID-19 outbreak, *Landscape and Urban Planning*, 211, <https://doi.org/10.1016/j.landurbplan.2021.104092>

Reise, S. P. (2012). The rediscovery of bifactor measurement models. *Multivariate Behavioral Research*, 47(5), 667–696. <https://doi.org/10.1080/00273171.2012.715555>

Revelle, W. (2019). *psych: Procedures for Personality and Psychological Research*. Northwestern University, Evanston, Illinois, USA. R package version 1.9.12. <https://CRAN.R-project.org/package=psych>

Richardson, E., & Mitchell, R. (2010). Gender differences in relationships between urban green space and health in the United Kingdom. *Social Science & Medicine*, 71, 568-575. <https://doi.org/10.1016/j.socscimed.2010.04.015>

Rigolon, A., Browning, M., McAnirlin, O. & Yoon, H. (2021). Green space and health equity: A systematic review on the potential of green space to reduce health disparities.

International. *Journal of Environmental Research and Public Health*, 1-29.
<https://www.mdpi.com/1660-4601/18/5/2563>

Rodriguez, A., Reise, S. P., & Haviland, M. G. (2016). Evaluating bifactor models: Calculating and interpreting statistical indices. *Psychological Methods*, 21(2), 137–150.
<https://doi.org/10.1037/met0000045>

Rosseel, Y. (2012). lavaan: An R Package for Structural Equation Modeling. *Journal of Statistical Software*, 48(2), 1-36. <http://dx.doi.org/10.18637/jss.v048.i02>

Schreiber, J. B., Nora, A., Stage, F. K., Barlow, E. A., & King, J. (2006). Reporting structural equation modeling and confirmatory factor analysis results: A review. *Journal of Educational Research*, 99(6), 323–338. <https://doi.org/10.3200/JOER.99.6.323-338>

Shanahan, D. F., Bush, R., Gaston, K. J., Lin, B. B., Dean, J., Barber, E. & Fuller, R. A. (2016). Health benefits from nature experiences depend on dose. *Scientific Reports*, 6(1), 28551. <https://doi.org/10.1038/srep28551>

Shanahan, D. F., Fuller, R. A., Bush, R., Lin, B. B. & Gaston, K. J. (2015). The health benefits of urban nature: How much do we need? *BioScience*, 65(5), 476-485.
<https://doi.org/10.1093/biosci/biv032>

Southon, G. E., Jorgensen, A., Dunnett, N., Hoyle, H., & Evans, K. L. (2017). Biodiverse perennial meadows have aesthetic value and increase residents' perceptions of site quality in urban green-space. *Landscape and Urban Planning*, 158, 105-118.
<http://dx.doi.org/10.1016/j.landurbplan.2016.08.003>

Southon, G. E., Jorgensen, A., Dunnett, N., Hoyle, H., & Evans, K. L. (2018). Perceived species-richness in urban green spaces: Cues, accuracy and well-being impacts. *Landscape and Urban Planning*, 172, 1-19. <https://doi.org/10.1016/j.landurbplan.2017.12.002>

Sullivan, W. C., Frumkin, H., Jackson, R. J. & Chang, C.-Y. (2014). Gaia meets Asclepius: Creating healthy places. *Landscape and Urban Planning*, 127, 182-184.
<https://doi.org/10.1016/j.landurbplan.2014.03.005>

The WHOQOL Group. (1998). *Measuring Quality of Life – The World Health Organization Quality of Life Instruments*. Geneva: WHO.
https://www.who.int/mental_health/media/68.pdf

Tomao, A., Secondi, L., Corona, P., Carrus, G., & Agrimi, M. (2016). Exploring individuals' well-being visiting urban and peri-urban green areas: a quantile regression approach. *Agriculture and Agricultural Science Procedia*, 8, 115–122.
<https://doi.org/10.1016/j.aaspro.2016.02.015>

Tofighi, D., & MacKinnon, D. P. (2016). Monte Carlo Confidence Intervals for Complex Functions of Indirect Effects. *Structural Equation Modeling*, 23(2), 194–205. <https://doi.org/10.1080/10705511.2015.1057284>

Ulrich, R., Simon, R., Losito, B., Fiorito, E., Miles, M., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments' *Journal of Environmental Psychology*, 11, 201-230.

Van den Berg, A. E., Maas, J., Verheij, R. A., & Groenewegen, P. P. (2010). Green space as a buffer between stressful life events and health. *Social Science & Medicine*, 70, 1203-1210. <https://doi.org/10.1016/j.socscimed.2010.01.002>

VanderWeele, T. J. (2012). Invited commentary: Structural Equation Models and Epidemiological Analysis. *American Journal of Epidemiology*, 176(7), 608-612. <https://doi.org/10.1093/aje/kws213>

Weber, E., & Schneider, I. E. (2021). Blooming alleys for better health: Exploring impacts of small-scale greenspaces on neighborhood wellbeing. *Urban Forestry & Urban Greening*, 57. <https://doi.org/10.1016/j.ufug.2020.126950>

White, M. P., Alcock, I., Grellier, J., Wheeler, B. W., Hartig, T., Warber, S. L., Bone, A., Depledge, M. H. & Fleming, L. E. (2019). Spending at least 120 minutes a week in nature is associated with good health and wellbeing. *Scientific Reports*, 9(1), 7730. <https://doi.org/10.1038/s41598-019-44097-3>

White, M. P., Pahl, S., Wheeler, B. W., Depledge, M. H., & Fleming, L. E. (2017). Natural environments and subjective wellbeing: Different types of exposure are associated with different aspects of wellbeing. *Health & Place*, 45, 77-84. <https://doi.org/10.1016/j.healthplace.2017.03.008>

White, M. P., Yeo, N. L., Vassiljev, P., Lundstedt, R., Wallergård, M., Albin, M. Löhmus, M. (2018). A prescription for "nature" - The potential of using virtual nature in therapeutics. *Neuropsychiatric Disease and Treatment*. 14, 3001-3013. <https://10.2147/NDT.S179038>

Wood, L., Hooper, P., Foster, S., & Bull, F. (2017). Public green spaces and positive mental health – investigating the relationship between access, quantity and types of parks and mental wellbeing. *Health & Place*, 48, 63-71. <https://doi.org/10.1016/j.healthplace.2017.09.002>

World Health Organization. (2017). *Urban green space interventions and health: a review of impacts and effectiveness*. Copenhagen: WHO Regional Office for Europe. https://www.euro.who.int/_data/assets/pdf_file/0010/337690/FULL-REPORT-for-LLP.pdf

World Health Organization. (2016). *Urban green spaces and health: a review of evidence*. Copenhagen: WHO Regional Office for Europe. https://www.euro.who.int/data/assets/pdf_file/0005/321971/Urban-green-spaces-and-health-review-evidence.pdf?ua=1

Wu, W., Yun, Y, Hu, B., Sun, Y., & Xiao, Y (2020). Greenness, perceived pollution hazards and subjective wellbeing : Evidence from China. *Urban Forestry & Urban Greening*, 56. <https://doi.org/10.1016/j.ufug.2020.126796>

Table 1: Descriptive statistics and means of well-being

	n	%	Mean	sd
Sex				
Men	1,092	47	3.64	.53
Women	1,250	53	3.55	.52
Age				
15–25	346	14.8	3.63	.44
26–35	382	16.3	3.59	.55
36–45	373	15.9	3.55	.56
46–55	370	15.8	3.52	.57
56–65	341	14.6	3.65	.53
66–75	490	20.9	3.61	.49
≥ 76	40	1.7	3.48	.44
Annual household income (€)				
≤ 10,999	279	11.9	3.35	.56
11,000–25,999	676	28.9	3.52	.51
26,000–40,999	787	33.6	3.64	.51
41,000–55,999	409	17.5	3.68	.50
≥ 56,000	191	8.2	3.81	.47
Health problems				
No	1,321	56	3.75	.47
Yes	1,021	44	3.42	.53

Table 2: Summary of models testing

	X ²	df	<i>p</i>	CFI	NNFI	RMSEA	SRMR
Stage 1: Measurement models fit							
Well-being: 4 latent constructs	1,153	158	<.001	.933	.919	.052	.043
Nature type: 3 latent constructs	633	45	<.001	.951	.928	.075	.05
Frequency of exposure to nature: 2 latent constructs	35.8	10	<.001	.993	.986	.033	.018
Frequency of activities in nature: 2 latent constructs	228	21	<.001	.962	.935	.065	.033
Characteristics of nature: 1 dimension							
Final measurements' models	6,328		<.001	.902	.895	.041	.05
Stage 2: SEM Model							
Final model	7,216	1,476	<.001	.962	.959	.041	.047

Table 3: Means, standard deviations, correlations with confidence intervals, and Cronbach's alphas

Variable	<i>M</i>	<i>SD</i>	1	2	3	4	5	6	7	8	9	10
1. Dim1	3.49	0.65	(.84)									
2. Dim2	3.70	0.77	.41** [.38, .44]	(.65)								
3. Dim3	4.03	0.76	.38** [.35, .41]	.21** [.17, .25]	(.69)							
4. Dim4	3.28	0.66	.58** [.56, .61]	.36** [.32, .40]	.33** [.29, .36]	(.70)						
5. Undomesticated	2.72	1.05	.21** [.17, .24]	.36** [.32, .39]	.08** [.04, .12]	.20** [.16, .24]	(.81)					
6. Proximity	2.25	0.85	.23** [.20, .27]	.24** [.21, .28]	.08** [.04, .12]	.27** [.23, .30]	.54** [.51, .57]	(.81)				
7. Domesticated	3.02	0.95	.27** [.23, .30]	.24** [.21, .28]	.14** [.10, .18]	.31** [.27, .35]	.38** [.34, .41]	.50** [.46, .53]	(.82)			
8. Exposure to nature	3.36	1.05	.21** [.17, .25]	.30** [.26, .34]	.09** [.05, .13]	.22** [.19, .26]	.46** [.43, .49]	.39** [.36, .43]	.30** [.26, .33]	(.68)		
9. Activities in nature	2.69	0.85	.26** [.23, .30]	.27** [.23, .30]	.03 [-.01, .07]	.27** [.23, .31]	.43** [.40, .46]	.42** [.39, .46]	.31** [.27, .35]	.51** [.47, .53]	(.79)	
10. Perceived characteristics	3.57	0.71	.32** [.28, .35]	.40** [.37, .44]	.21** [.17, .25]	.35** [.31, .38]	.35** [.31, .38]	.34** [.31, .38]	.43** [.40, .46]	.31** [.28, .35]	.31** [.27, .35]	(.92)

Notes: *M* and *SD* represent mean and standard deviation, respectively. Values in parentheses are Cronbach's alphas. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation (Cumming, 2014). * indicates $p < .05$; ** indicates $p < .01$.

Table 4: Results of mediation analysis

Mediation paths	Standard coeff.	Lower CI	Upper CI
(P) Perceived characteristics → activities in nature → psychological well-being	.02	.001	.031
Perceived characteristics → psychological well-being	.22	.171	.270
(P) Perceived characteristics → exposure to nature → environment well-being	.02	.010	.035
Perceived characteristics → environment well-being	.31	.261	.362
(P) Perceived characteristics → exposure to nature → physical well-being	.02	.009	.031
Perceived characteristics → physical well-being	.20	.154	.252
(P) Perceived characteristics → exposure to nature → resources well-being	.01	.001	.019
Perceived characteristics → resources well-being	.21	.162	.252
(P) Perceived characteristics → activities in nature → resources well-being	.01	.006	.024
Perceived characteristics → resources well-being	.21	.165	.257
(I) Undomesticated → activities in nature → psychological well-being	.03	.018	.052
(P) Undomesticated → exposure to nature → environment well-being	.05	.028	.076
Undomesticated → environment well-being	.21	.157	.256
(I) Undomesticated → exposure to nature → physical well-being	.05	.022	.069
(I) Undomesticated → exposure to nature → resources well-being	.02	.002	.044
(I) Undomesticated → activities in nature → resources well-being	.03	.012	.041
(I) Proximity → activities in nature → psychological well-being	.03	.014	.043
(P) Proximity → activities in nature → resources well-being	.02	.009	.034
Proximity → resources well-being	.07	.021	.112
(I) Proximity → exposure to nature → physical well-being	.01	.003	.023
(I) Proximity → exposure to nature → environment well-being	.01	.004	.026
(P) Domesticated → exposure to nature → environment well-being	.01	.002	.020
(P) Domesticated → exposure to nature → physical well-being	.01	.002	.018
Domesticated → physical well-being	.08	.035	.122

Notes: (P) indicates partial mediation so that the relationship between two variables is both indirect and direct. In such cases, the indirect effect is presented followed by the total effect (direct plus indirect via the stated mediator). (I) indicates mediation so that the relationship between two variables is indirect only.

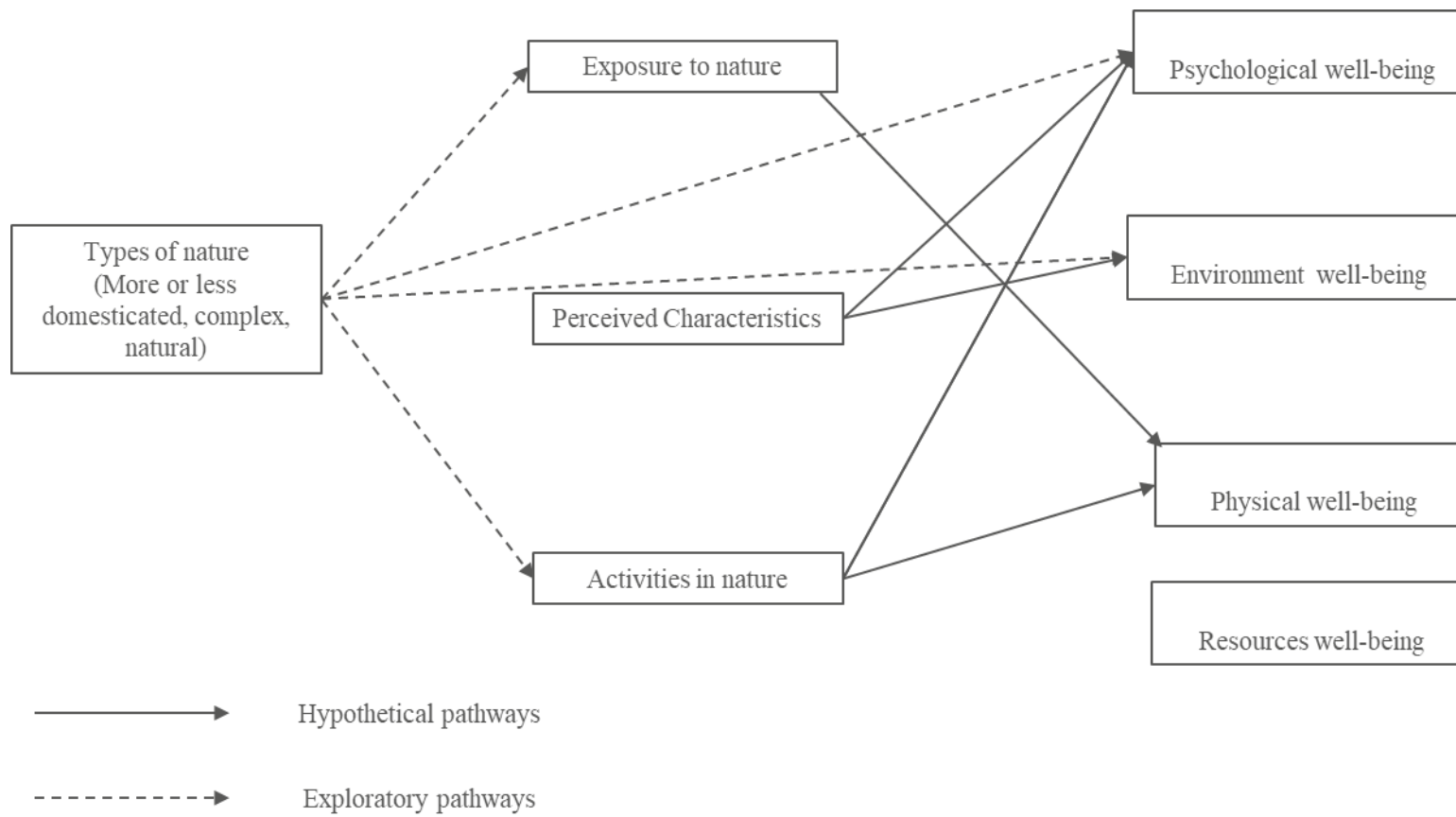


Figure 1: Hypothetical and exploratory influence pathways between the types and characteristics of nature near urban residences and their effects on citizens' well-being.

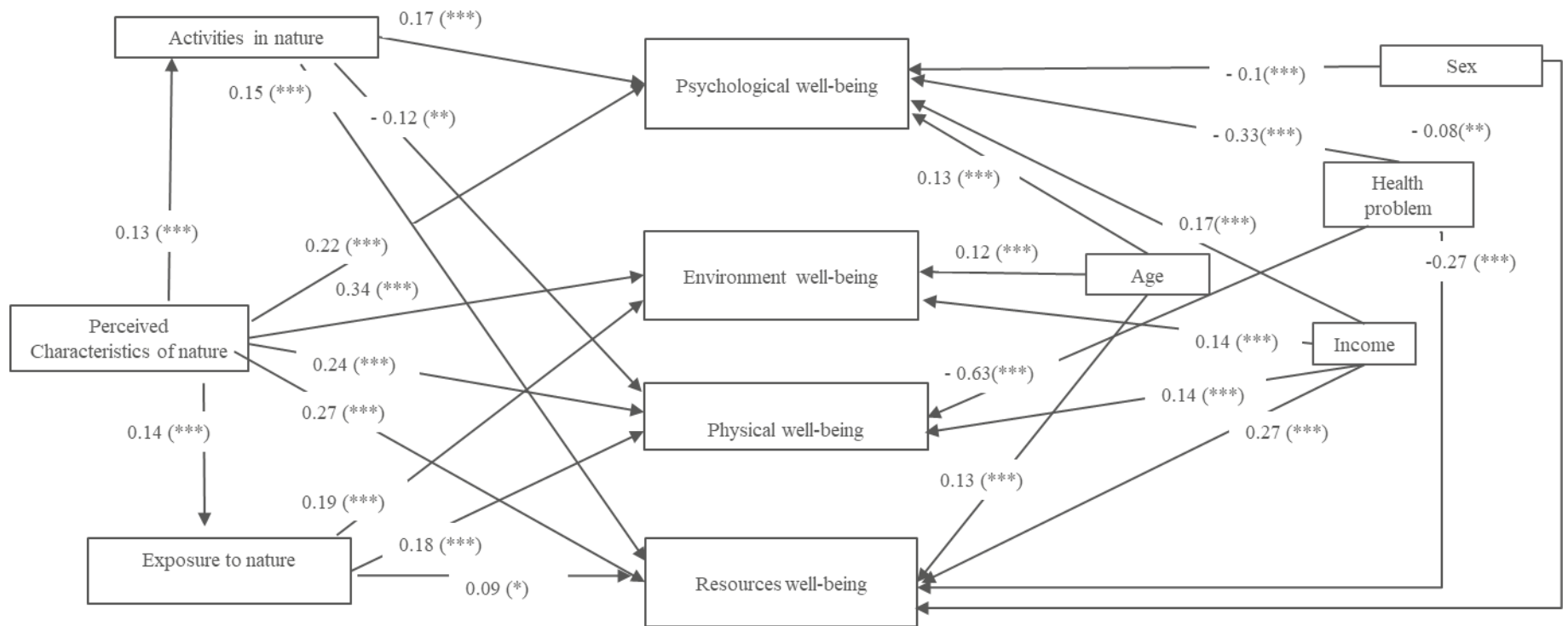


Figure 2a: Results of SEM path diagram with standardized Beta coefficients.

Notes: (*) $p < .05$, (**) $p < .01$, (***) $p < .001$

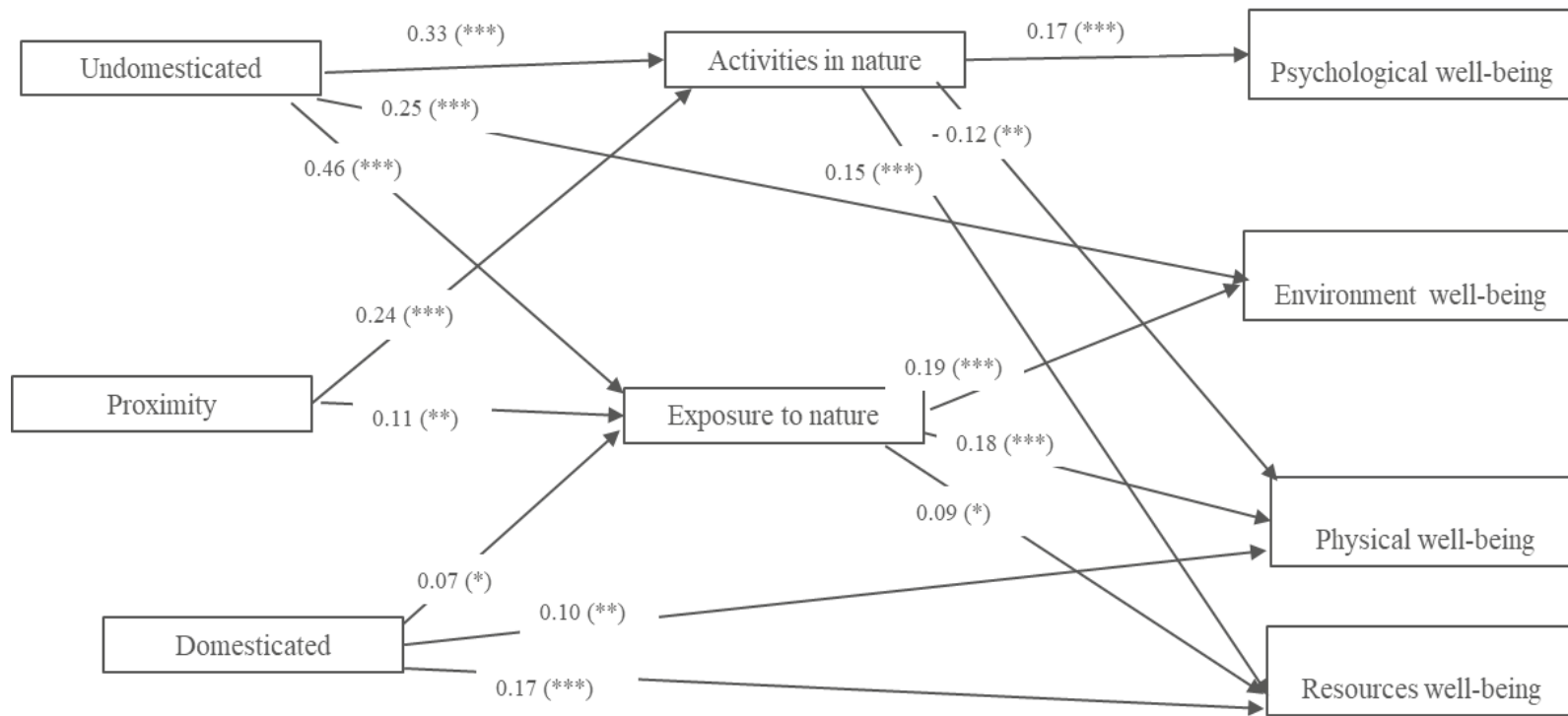


Figure 2b: Results of SEM path diagram with standardized Beta coefficients.

Notes: (*) $p < .05$, (**) $p < .01$, (***) $p < .001$